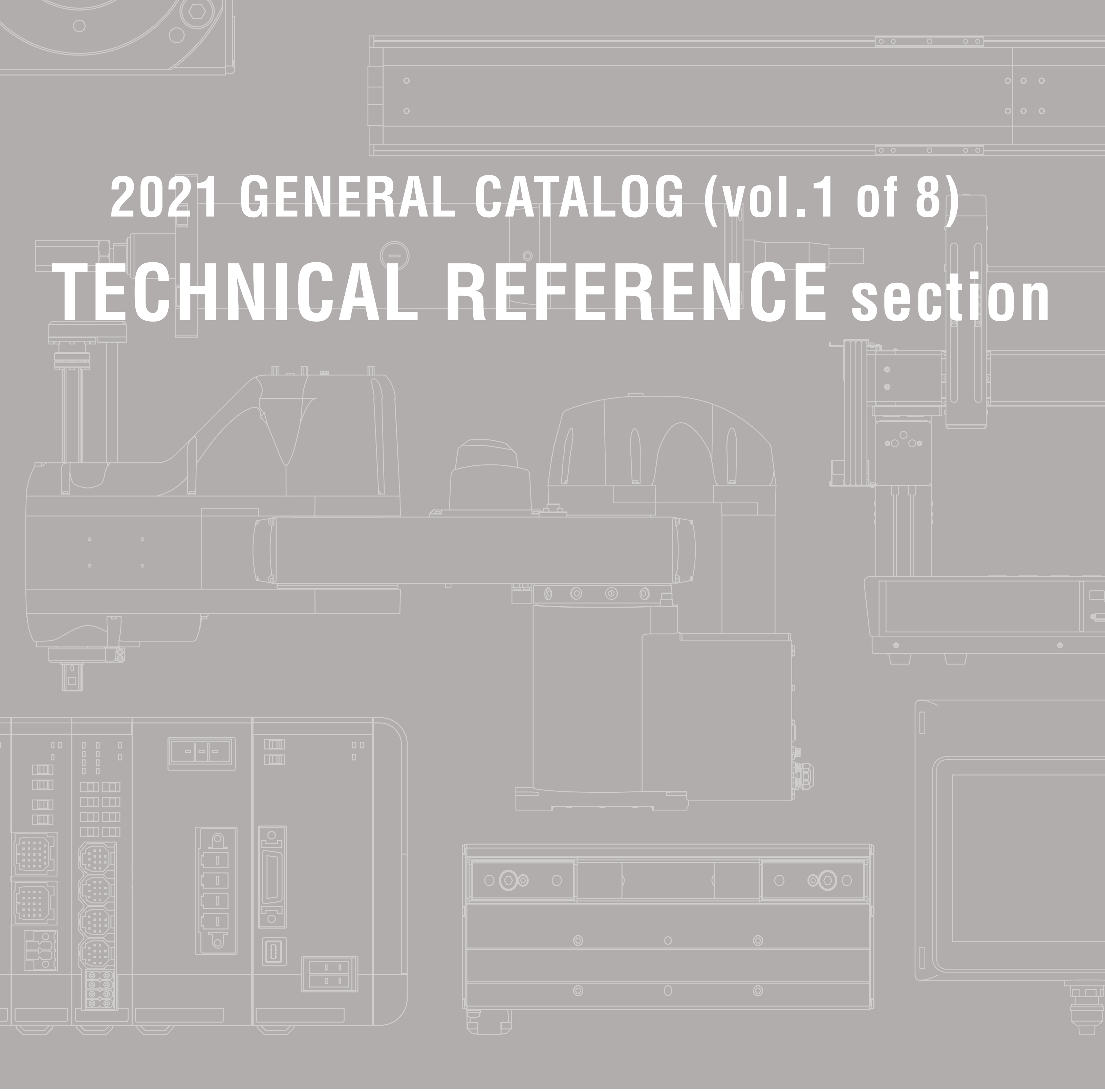
2021 GENERAL CATALOG (vol.1 of 8)

TECHNICAL REFERENCE section



IAI

Quality and Innovation

www.intelligentactuator.com

Technical Reference

About Industrial Robots

Laws and regulations on industrial robots

For safety measures of machinery, ISO stipulates the following four items in ISO/DIS12100 "Safety of Machinery" as a general guideline.

Safety measures
- Intrinsic safety design
- Protection ·········· Safety fence, etc.
- Additional safety measures ·········· Emergency stop device, etc.
- Usage information ·········· Warning lights - emergency stop device, etc.

Based on these, various ISO/IEC standards are constructed by class. The safety standards of industrial robots are as follows:

Standard for Type C (individual safety standard) → ISO10218 (Manipulating industrial robots - Safety)
→ JIS B 8433 (industrial manipulating robots - safety)

In addition, **laws in Japan** for industrial robots are stipulated as follows.

Industrial Safety and Health Law — Article 59

A mandatory special education is required for workers who are engaged in dangerous or hazardous works.

Ordinance on Industrial Safety and Health

Article 36······Businesses requiring special education
- Clause 31 (teaching, etc.) ········Teaching works, etc. for industrial robots (exceptions exist).
- Clause 32 (inspection, etc.)········Inspections, repairs, adjustments, etc. of industrial robots (exceptions exist).

Clause 150········Actions that industrial robot operators should take

Requirements by the Ordinance on Industrial Safety and Health for industrial robots

Work area	Working conditions	Shutoff of the driving force	Action	Regulation
Out of working range	During automatic operation	No to shutoff	Signals for operation start	Clause 104
			Installation of a fence and an enclosure	Clause 150, Item 4
Inside the working range	During teaching, etc.	Shut off (including operation stop)	Display that work is in progress etc.	Clause 150, Item 3
		Not to shut off	Establishing work regulations	Clause 150, Item 3
			Action for an immediate operation stop	Clause 150, Item 3
			Display that work is in progress etc.	Clause 150, Item 3
			Conducting a special education	Clause 36, Item 31
			Checking before operation start, etc.	Clause 151
	During working for inspection, etc.	Shut off	Shut off after operation stop	Clause 150, Item 5
			Display that work is in progress etc.	Clause 150, Item 5
		Not to shut off (in case of inevitable work during operation)	Establishing work regulations	Clause 150, Item 5
			Action for an immediate operation stop	Clause 150, Item 5
			Display that work is in progress etc.	Clause 150, Item 5
			Conducting a special education (except for cleaning and lubrication)	Clause 36, Item 32

About Industrial Robots

IAI products that fall under the category of industrial robots

According to the public notification No. 51 of the Ministry of Labor in Japan and Notice No. 340 of the Labor Standards Bureau in Japan, the following products are excluded from industrial robots.

(1) Single-axis robots that have a motor wattage of 80W or less.

In case of multi-axis combined robots with more than 2 motors and multi-axis robots such as SCARA robots, the products that have the maximum wattage of each motor is 80W or less.

(2) Multi-axis combined robots whose X, Y and Z axes are 300mm or less, and the maximum operation range including the tip is within 300 cubic mm or less.

(3) Transfer equipment that moves based on the information of a fixed sequence control device and that moves only horizontally and vertically with its vertical operation range of 100mm or less.

(4) Articulated robots with radius of motion and z-axis within 300mm.

(5) Machinery whose manipulator tip performs simple straight reciprocating motions only. (However, products that fall under the above (3) are excluded).

Among the IAI products listed in our catalogs, the applicable robots that fall under the category of industrial robots are as follows.
However, when the tip of a manipulator performs simple straight reciprocating motions only, the equipment that uses 1. single-axis ROBO Cylinder, 2. single-axis robot or 3. Linear servo actuator is excluded from the category of industrial robots.

1. Single-axis ROBO Cylinder

RCS2/RCS2CR-SS8☐,RCS3/RCS3CR/RCS3P/RCS3PCR,RCS4/RCS4CRthat have greater than 300mm stroke.

(Note) The maximum capacity of the stepper motor used in the RCP5-RA10☐ exceeds 80W.

Therefore, it may be categorized as an industrial robot when used for a combination robot.

2. Single-axis robot

The following models that have a stroke of over 300mm and whose motor capacity exceeds 80W.

ISA/ISPA,ISB/ISPB,SSPA,ISDA/ISPDA,ISWA/ISPWA,IF,FS,NS,NSA

3. Linear servo actuator

All the models with a stroke of over 300mm.

4. Cartesian robot

Any of the models listed above 1 to 3 that have even one axis and CT4.

5. IX SCARA robots and IXA SCARA robots

All the models with the arm length of over 300mm.

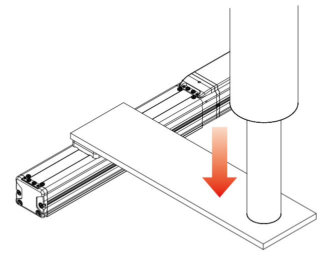
(All the models except for IXA-3NNN1805/4NNN1805,IX-NNN1205/1505/1805/2515,NNW2515,NNC1205/1505/1805/2515)

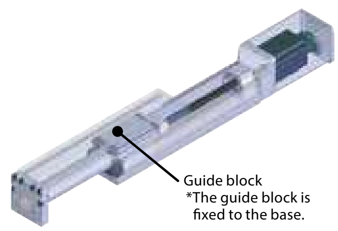
Allowable Moment

The allowable moment of a single-axis actuator represents the load capability of the built-in linear guide, and there are the 2 types indicated below, the allowable static moment and the allowable dynamic moment.

Static allowable moment

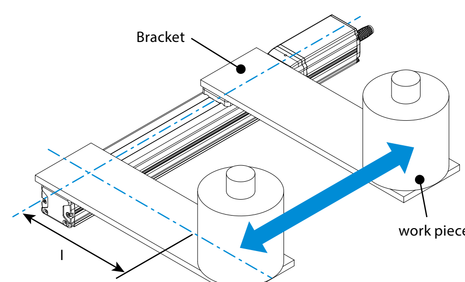
The allowable static moment is an index for damage and is the maximum moment that can be applied to a single-axis actuator at rest.
This index is calculated based on the condition where an indentation is made on the track of the built-in linear guide (basic rated static load) and the durability of used parts. If a moment greater than this value acts on the actuator, movement defects and damages can occur. Since our allowable static moment also takes into account the durability of the parts, it cannot be compared to a moment that is calculated only based on the basic rated static load (static rated moment). The durability of the parts is inspected by testing and analyzing them, so the product can be used safely if the allowable value is not exceeded.
However, please avoid excessive vibrations and impacts to the product.
(Cautions on the table type)
Allowable static moment of the table type is the allowable value of the linear guide at right above the guide block.
The right above the guide block is right above the allowable moment offset reference position. Refer to individual product pages for the offset reference position. When the point of moment load is located at a distance, excessive deflection and torsion take place on the table, causing potential damages.





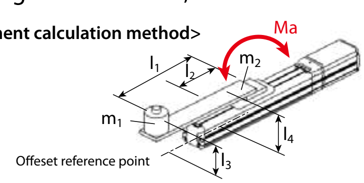
Dynamic allowable moment

The allowable dynamic moment is an index for service life and is the value through which our standard rated life of a single-axis actuator is calculated. Our company has set the standard rated life of a ROBO Cylinder as 5,000 km and the standard rated life of a single-axis robot as 10,000 km (excludes some models).
This index is calculated based on the condition where the track of the built-in linear guide flakes due to wear (basic rated dynamic load). If a moment greater than this value acts on the actuator, service life can become less than the standard value.
Since our allowable dynamic moment also takes into account the decrease in life due to operating conditions (standard load coefficient), it cannot be compared to a moment that is calculated only based on the basic rated dynamic load (dynamic rated moment).
Under normal usage environment, the life can be calculated with a simple formula.
There are 3 directions, Ma (pitching), Mb (yawing), Mc (rolling), on which moments act on a single-axis actuator, and allowable moments are calculated for each direction.

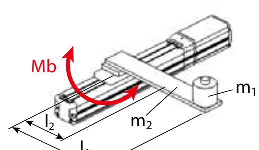


Moment M= m x 1
m : Load weight (include work piece and bracket)
l : Load length (he center of gravity including work piece and length)

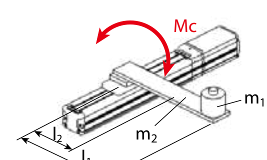
<Moment calculation method>



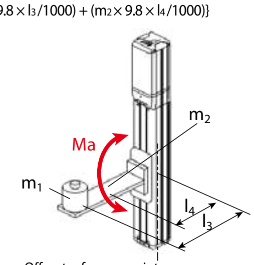
$Ma = (m_1 \times 9.8 \times l_1/1000) + (m_2 \times 9.8 \times l_2/1000)$
$+a\{(m_1 \times 9.8 \times l_3/1000) + (m_2 \times 9.8 \times l_4/1000)\}$



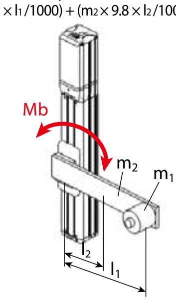
$Mb = a\{(m_1 \times 9.8 \times l_1/1000) + (m_2 \times 9.8 \times l_2/1000)\}$



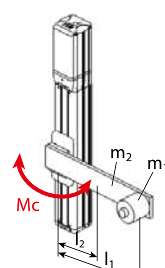
$Mc = (m_1 \times 9.8 \times l_1/1000) + (m_2 \times 9.8 \times l_2/1000)$



$Ma = (m_1 \times 9.8 \times l_3/1000) + (m_2 \times 9.8 \times l_4/1000)$
$+a\{(m_1 \times 9.8 \times l_3/1000) + (m_2 \times 9.8 \times l_4/1000)\}$



$Mb = (m_1 \times 9.8 \times l_1/1000) + (m_2 \times 9.8 \times l_2/1000)$
$+a\{(m_1 \times 9.8 \times l_1/1000) + (m_2 \times 9.8 \times l_2/1000)\}$



- a : acceleration (G)
- m_1 : mass of work (kg)
- m_2 : mass of bracket (kg)
- l_1 : Distance from center of slider to center of gravity of work (mm)
- l_2 : Distance from center of slider to center of gravity of bracket (mm)
- l_3 : Distance from offset reference point to center of gravity of work (mm)
- l_4 : Distance from offset reference point to center of gravity of bracket (mm)

Operational Life

Operational life of a linear guide represents the total distance that can be traveled, without flaking, by 90% of a group of products that are operated separately under the same conditions. The operational life calculation method is as follows.

Operational life calculation method

Operational life of a linear guide can be calculated with the following formula using the allowable dynamic moment that is determined for each model.

$$L = \left(\frac{C_M}{M}\right)^3 \cdot URL$$

L: Operational Life (km), C_M: Allowable Dynamic Moment (N·m),
M: Acting moment (N·m), URL: Standard rated life (km)

For applications where the operational life may be decreased from vibrations and installation conditions, the operational life is calculated with the following formula.

$$L = \left(\frac{C_M}{M} \cdot \frac{f_{WS}}{f_W} \cdot \frac{1}{f_\alpha}\right)^3 \cdot URL$$

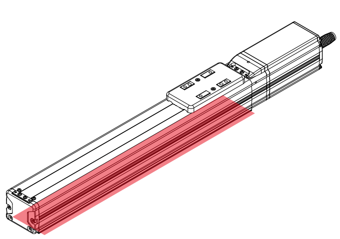
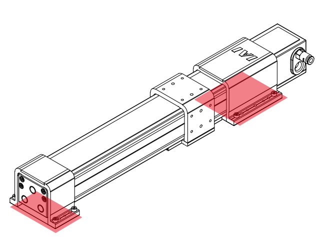
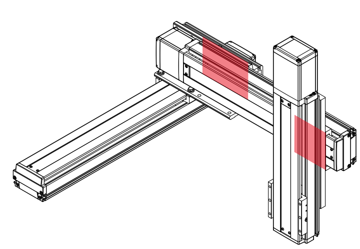
L: Service Life (km), C_M: Allowable Dynamic Moment (N·m), M: Acting moment (N·m),
f_{WS}: Standard load coefficient, f_W: Load coefficient, f_α: Attachment coefficient, URL: Standard rated life

The load coefficient f_W is a coefficient for taking into account the decrease in life from operating conditions. The standard load coefficient f_{WS} is a standard value of the load coefficient that is determined for each model. This coefficient is generally 1.2, but in the case that it is not 1.2, it is indicated in the specification of that model. The attachment coefficient $f\alpha$ is a coefficient for taking into account the decrease in life from the attachment condition of the actuator.

Load Coefficient

Operating Condition	Load coefficient f_W	Acceleration/Deceleration Guideline
Little vibration/impact, slow operation	1.0-1.5	(Less than 1.0G)
Moderate vibration/impact, sudden braking/acceleration	1.5-2.0	1.0G-2.0G
Large vibration/impact with sudden acceleration/deceleration	2.0-3.0	(Greater than 2.0G)

Attachment Coefficient

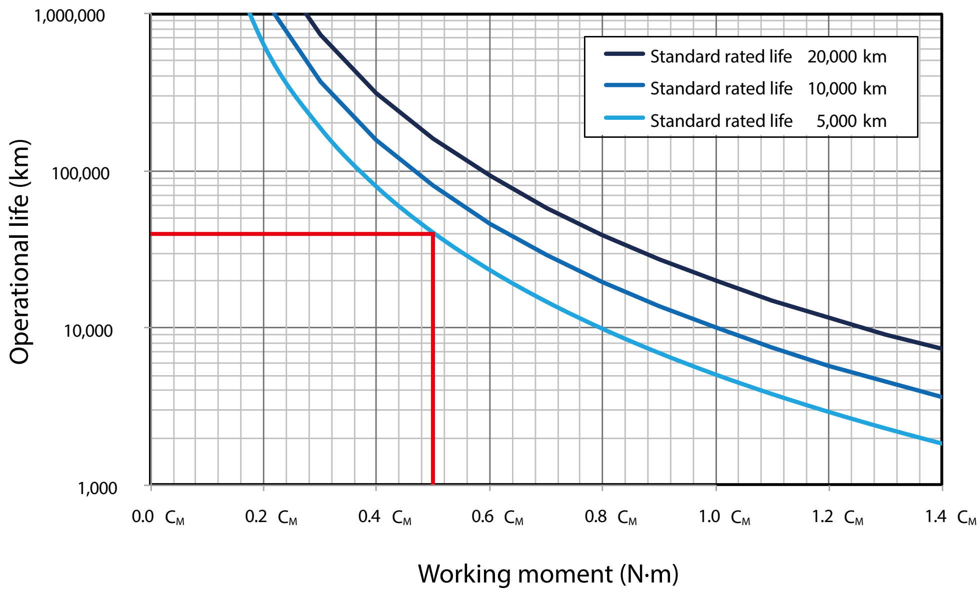
Attachment Condition	 Fixing entire surface	 Fixing at both ends	 Fixing sections
Attachment coefficient Fα	1.0	1.2	1.5

* As a general rule, please use every tapped hole on the mounting surface.
* Even when mounting the entire surface, please use the attachment coefficients of 1.2 or 1.5 depending on the length of the bolt for fixing.

Operational Life

The formula shows that the service life depends on the acting moment. With a light load, the service life will be longer than the standard rated life. For example, when a moment of $0.5C_M$ (half of the allowable dynamic moment) acts on a model with a standard rated life of 5,000 km, the diagram below shows that the service life becomes 40,000 km, which is 8 times the standard rated life.

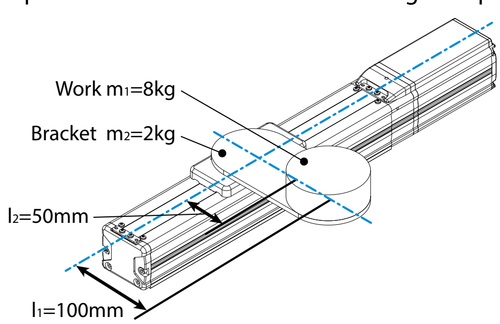
Relationship between working moment and operational life



* It is assumed that $f_{WS}=f_W$ and $f\alpha=1.0$, and C_M indicates allowable dynamic moment.

Example calculation of service life

An example service life will be calculated using the operation conditions below.



Model	RCP5-SA6C-WA-42P-6
Installation Condition	Horizontal Installation
Attachment Condition	Fixing entire surface
Controller	PowerCON specification
Acceleration/Deceleration	0.5G

m_1: mass of work
m_2: mass of bracket
l_1: Distance to the center of gravity of the work
l_2: Distance to the center of gravity of the bracket

Since moment acting in the Mc direction of the actuator is the dominant one, calculation will be made using the moment acting in the Mc direction. Moment acting in the Mc direction is calculated as follows.

$$M = \left(m_1 \times 9.8 \times \frac{l_1}{1{,}000}\right) + \left(m_2 \times 9.8 \times \frac{l_2}{1{,}000}\right) = \left(8 \times 9.8 \times \frac{100}{1{,}000}\right) + \left(2 \times 9.8 \times \frac{50}{1{,}000}\right) = 8.82\ \text{N·m}$$

The load coefficient will be 1.25 since acceleration/deceleration is 0.5G. The attachment coefficient will be 1.0 since the attachment condition is fixing the entire surface. For this model, the allowable dynamic moment in the Mc direction is 24.6 N·m, the standard rated life is 5,000km, and the standard load coefficient is 1.2, so the service life is calculated as follows.

$$L = \left(\frac{C_M}{M} \cdot \frac{f_{WS}}{f_W} \cdot \frac{1}{f_\alpha}\right)^3 \cdot URL = \left(\frac{24.6\ \text{N·m}}{8.82\ \text{N·m}} \times \frac{1.2}{1.25} \times \frac{1}{1}\right)^3 \times 5{,}000\ \text{km} = 95{,}980\ \text{km}$$

This shows that the service life for the above operation conditions is 95,980 km.

Caution when Using a Guide with a Rod Type

Rod type actuators are classified into two main categories of "Radial cylinder type" and "Anti-rotation" type. Depending on the type, methods for dealing with radial loads and cautionary notes will be different, as indicated below.

Radial Cylinder Type

· A ball-rotating linear guide mechanism is built inside the actuator.
It can manage radial load without an external guide.
<Applicable Models>

· EC-(D)RR □ (W)
· RCP4(W)-RA □
· RCP6(W)-RRA □
· RCS4-RRA □
· RCP5(W)-RA □
· RCS3-RA15R/RA20R

Radial load →

Radial load < Allowable radial load
External guide unnecessary

Radial load > Allowable radial load
Use an external guide

Anti-rotation rod type

· An anti-rotation mechanism is built inside the actuator.
An external guide needs to be used if radial load is to be applied.
<Applicable models>

· EC-(D)R □ (W)
· RCS4-RA □
· RCP6(W)-RA □
· RCS2-RA □
· RCP3-RA □
· RCD-RA1DA
· RCA-RA □

Radial load →

Use an external guide

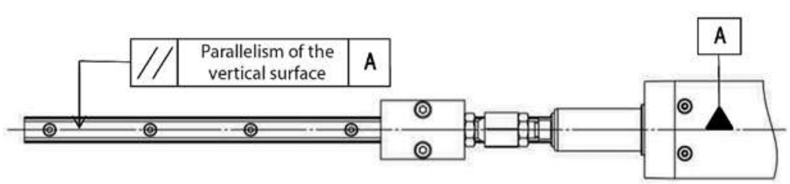
[Caution when using an external guide with a rod type]

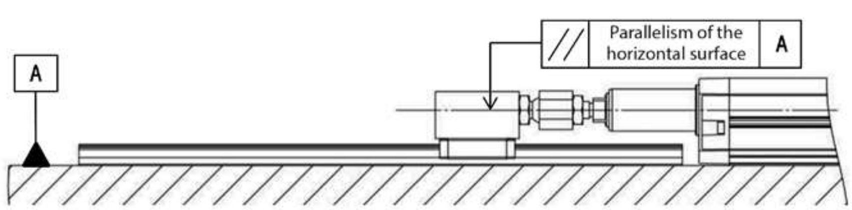
· Parallelism of the actuator and the external guide

When using an external guide, if there is a deviation in the level of parallelism between the actuator and the external guide (either the horizontal or vertical surfaces), operation defects or early actuator damage may occur.

When the external guide is attached, adjustments have to be made to align the actuators and the guides. Then the uniformity of the sliding resistance throughout the entire stroke has to be checked.

This is done by checking the uniformity of the current value through the current monitoring function of the controller.





Caution when Using a Guide with a Rod Type

· External guide mounting method

The method for mounting the external guide differs by type.

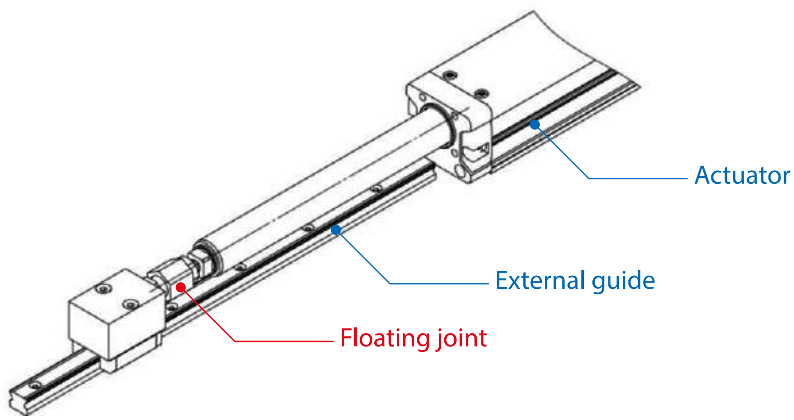
Even if the parallelism between the guide and the actuator could be adjusted, please be careful as there is a danger of accidental damage of the actuator with the incorrect mounting method.

Radial Cylinder type

For mounting the external guide for a radial cylinder type, a floating joint mount is recommended.

The floating joint compensates for the deviation in the parallelism of the built-in guide and the external guide, and this makes adjustments easy.

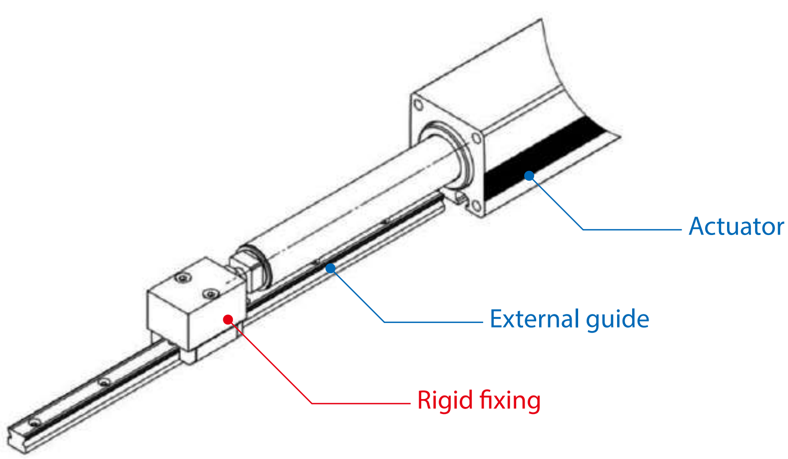
With rigid mounting, adjusting the parallelism of the built-in guide and the external guide is difficult, and even a slight deviation causes stress on the guide and can lead to early damaging.



Anti-rotation rod type

For mounting the external guide for an anti-rotation rod type, rigid mounting is recommended. Since the anti-rotation rod type cannot handle force in the rod rotation direction, it is necessary to regulate the rod rotation direction.

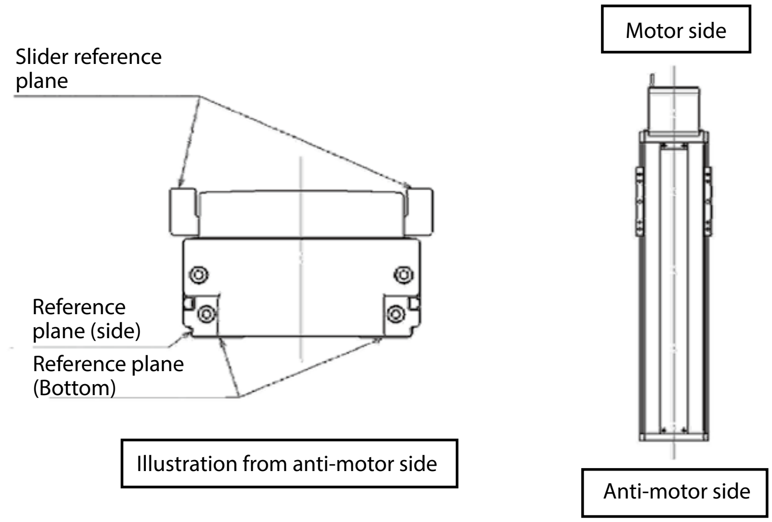
The rod rotation direction is not regulated with the floating joint, so force in the rod rotation direction could be applied to the anti-rotation mechanism during actuator operation, and this could cause early wearing of the anti-rotation mechanism. (There is no problem if it is a floating joint whose direction of rotation is regulated.)



Caution when Using a Guide with a Slider Type

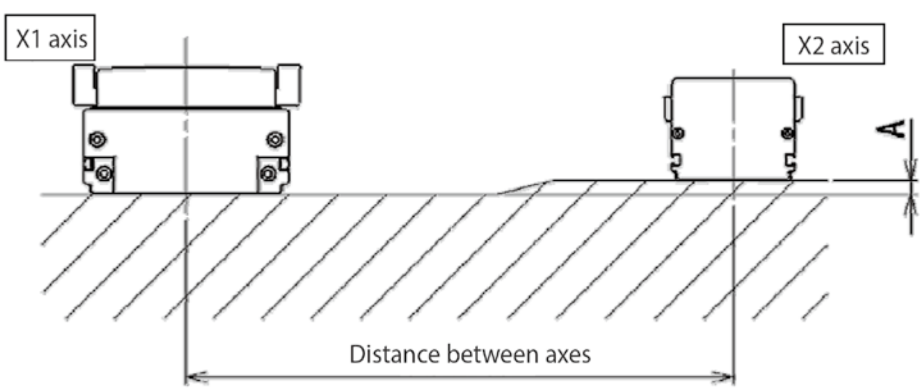
Installation reference surface of X-axis

When installing an actuator, please mount by using the reference surface below.



Height of the attaching surface of the X1 and X2 axes

Please keep the height difference of the mounting surfaces for the X1 and X2 axes below 0.05mm per 500mm distance between the axes (measurement A on the diagram below).

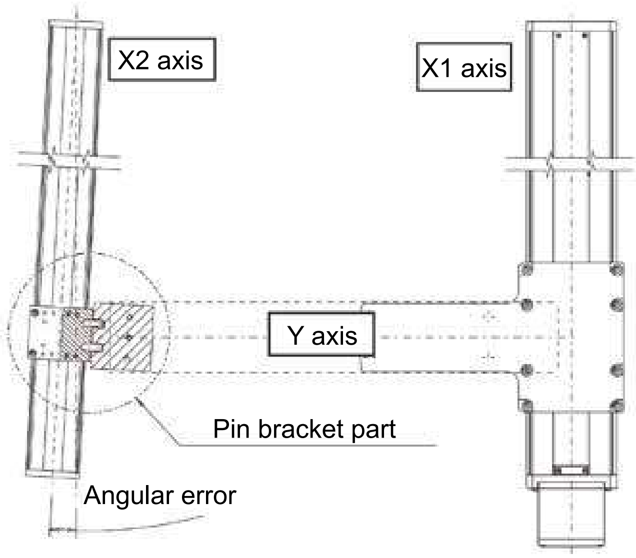


Caution when Using a Guide with a Slider Type

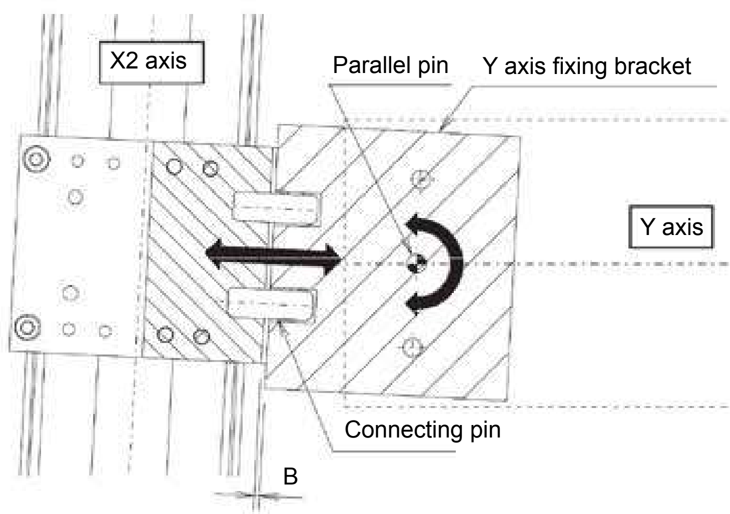
Parallelism when X1 and X2 axes are installed

The connection between the X2 axis and the Y axis is a pin bracket structure (*1). The base-installing parallelism of the X1 and X2 axes should be within 2+/-1mm over the entire stroke (measurement B on the diagram below).

<Gantry assembly top view>



<Pin bracket section details>



*1 Pin bracket structure

This structure absorbs any parallelism errors between the X1 axis and X2 axis.

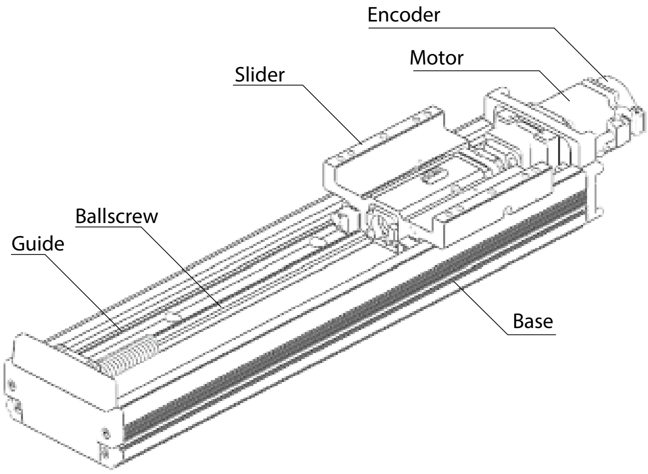
- X1 axis and Y axis are rigidly fixed.
- The Y axis mounting bracket is positioned with the center of the Y-axis using 1 parallel pin, and this allows adjustment in the rotation direction, which makes it possible to absorb the angle deviation between the X1 and X2 axes.
- The Y-axis and the X2-axis are linked with 2 connecting pins, and this allows sliding in the direction of the axes, which absorbs the variations in the distance between the X1-axis slider and the X2-axis slider.

Structure and Principles of Movement of a Single-Axis Robot

The actuator basically has the structure as shown in the figure below.

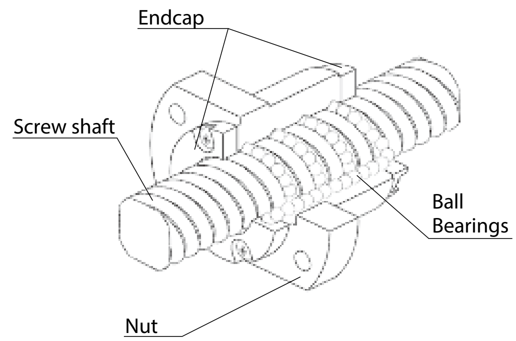
The ballscrew rotates when the motor rotates, and this causes the slider to move.

The amount of movement and speed are detected by the encoder, positioning is performed by controlling the rotation of the motor (ballscrew).



■ Ballscrew

Since the screw and the slider are in contact with the ball bearings as shown in the figure below, the ballscrew can rotate with less frictional resistance like a bearing.



Ballscrew Accuracy

The lead accuracy of IAI's ball screw is equivalent to the accuracy class C5 or C10 of JIS standard (JIS B 1192).

The accuracy of C10 is defined as ± 210 μm for the typical transfer amount error (see figure below) for 300mm.

The accuracy of the C5 (the typical transfer amount error and the allowance value of the variation) is as follows.

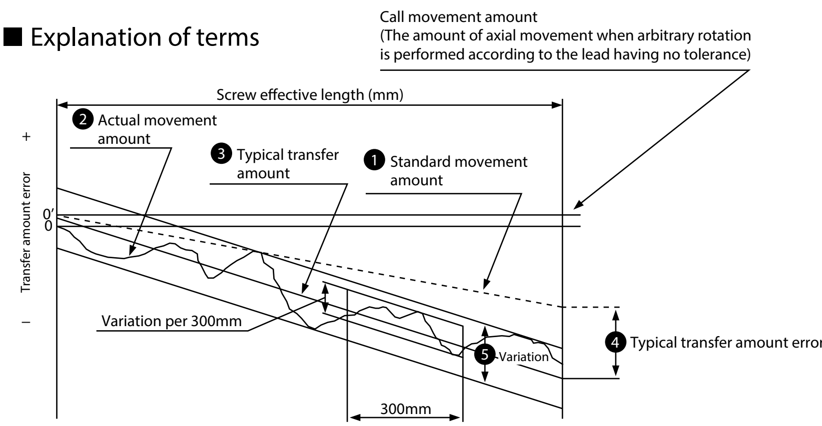
Note: The numbers in the table below are reference values, and absolute positioning accuracy is not guaranteed.

■ Typical transfer amount error

Units: μm

Items		Typical transfer amount error	Variation
Screw effective length (mm)			
Over	Below		
—	315	23	18
315	400	25	20
400	500	27	20
500	630	30	23
630	800	35	25
800	1000	40	27
1000	1250	46	30
1250	1600	54	35
1600	2000	65	40
2000	2500	77	46
2500	3150	93	54

■ Explanation of terms



1. Standard movement amount: The amount of movement in the axis direction when a standard lead (lead without tolerance) is rotated an arbitrary number of times.
2. Actual movement amount: The measured value of actual movement in the axis direction
3. Typical transfer amount: A straight line representing the trend of the actual movement amount. It is determined by the least squares method from the curve showing the actual moving amount.
4. Typical transfer amount error: Difference between the typical movement amount and the standard movement amount.
5. Variation: The maximum width of the actual movement amount curve between two straight lines parallel to the typical movement amount line.

Intermediate Support Structure

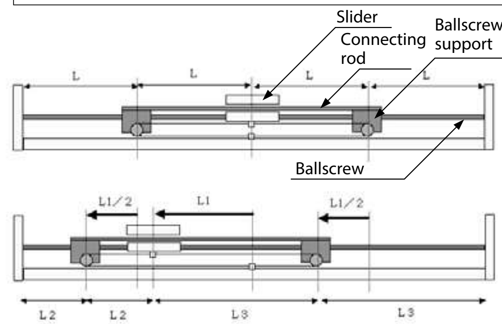
The intermediate support is an innovative structure that significantly improves the maximum speed of a long stroke type by adding a ballscrew support system that moves with the slider in order to limit the vibration of the ballscrew and increase the critical speed of the actuator.

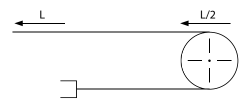
The structure of the intermediate support is fixed with the ball screw supports fixed at the connecting rod (half the length of the stroke) penetrating the slider through a wire as shown in the right figure.

One end of the wire is fixed on the middle section of the stroke of the base, and is fixed to the slider with the pulley of the ballscrew support.

This mechanism moves the ball screw support by only 1/2 of the slider movement, and the ball screw support always supports the ball screw halfway between the position of the slider and the stroke end, resulting in suppressing the deflection of the ball screw.

Intermediate support models
ISB/ISPB-MXMX/LXMX/LXUWX
ISA/ISPA-MXMX/LXMX/LXUWX/WXMX
ISDB/ISPDB-MX/LX
NS-MXMXS/LXMXS





(Note) Horizontal installation is standard. If you install the main unit vertically or vertically, the wire may come off. Install vertically only.

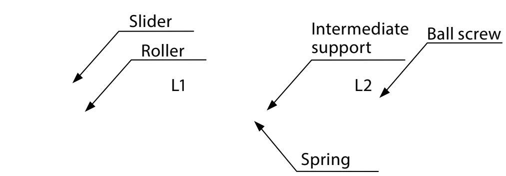
Spring-type intermediate support (patent pending)

The liftable type intermediate mechanism supports the ball screw by using spring force.
When the slider moves on the spring support, the rollers installed on the slider push down the spring and the slider goes over the support part.
The number of supports is determined by the stroke length.
The intermediate support is a single unit so that the whole unit can be removed and replaced.
Operations with high-acceleration/deceleration are possible, which was limited for the wire type support.
* The actuator can be operated faster when the maximum supporting distance of the ball screw, L2, is shorter.

Stroke (mm)	900-1550	1600-2550	2600-3000
Number of supports	1 set	2 sets	3 sets

Models that employ the spring-type intermediate support
ISB/ISPB-WXMX

Structure of the spring-type intermediate support



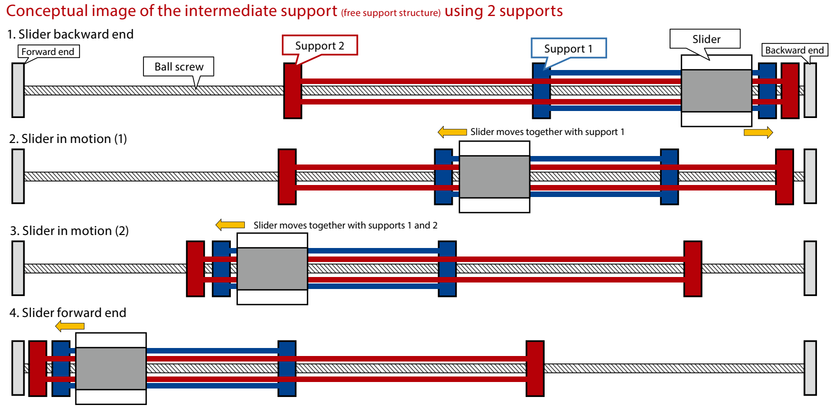
Movement of the slider that goes over the support

Free-support type intermediate support (patent pending partially)

Adding an intermediate support mechanism (ball screw support mechanism that moves together with the slider) reduces vibration even for the long-stroke ball screw and greatly increases the maximum speed.
The intermediate support comprises of a connecting rod that goes through the slider and a support block.

Models that employ the free-type intermediate support
EC-S10X/S13X/S15X/RR6X/RR7X

Conceptual image of the intermediate support (free support structure) using 2 supports



Types of Robot Feedback Control

Commanding to do operations in order to check whether the robot is moving as commanded and to correct if there are deviations is called feedback control, and there are a few methods to do this.

IAI's single-axis robots, ROBO Cylinders, ELECYLINDERs, SCARA robots, and Cartesian robots use the semi-closed loop control.

This is a general servo control method, and the actuator movement is detected by the encoder and fed back.

In contrast to this, the open loop control and the full closed loop control have the following characteristics.

Open loop control

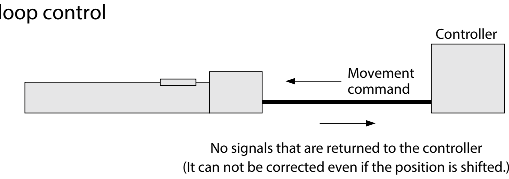
This is a general stepper motor method, and is inexpensive since there is no encoder, but cannot make corrections when there are deviations between the operation commands and the movement because it is not a feedback control.

Full closed loop control

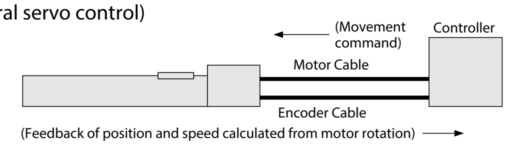
The slider position can be determined accurately because the absolute position of the slider is measured and fed back. (Due to actuator accuracy errors, for semi-closed loop, there will be errors within a set range between the actual actuator position and the position information that is fed back from the encoder.)

Types of feedbacks

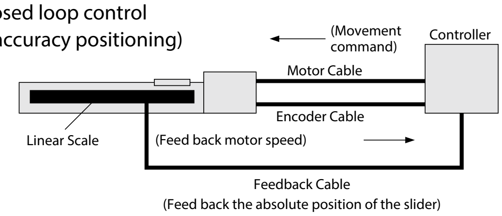
■ Open loop control



■ Semi-closed control
(General servo control)



■ Full closed loop control
(High accuracy positioning)



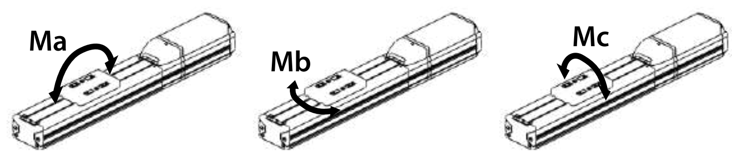
Double Slider Allowable Dynamic Moment/Overhang Load Length

Double slider (addition of a second slider carriage)) can be chosen as an option for the following models.
The allowable dynamic moment and the overhang load length vary depending on the span between the sliders.
A representative example follows after the specifications tables, so please use it for reference.

Allowable dynamic moment direction diagram

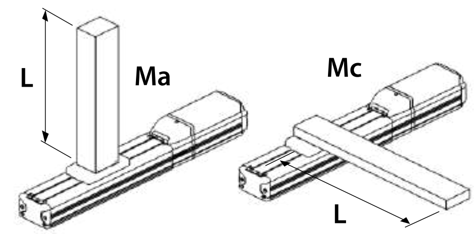
■ The value of the allowable dynamic moment assumes a standard rated life.
Please note that when using beyond the moment specification value, the life of the guide will decrease.

Moment direction



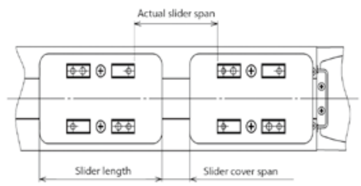
Overhang load length diagram

■ When using beyond the overhanging allowance value of each model, vibration may occur, so please be sure to use within the allowable value.

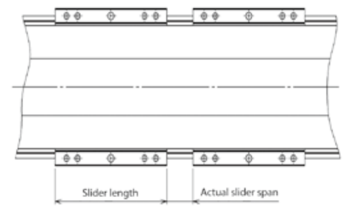


Double slider diagram

■ With slider cover



■ Without slider cover



■ Cautions when using double slider

(1) When the double slider option is specified, calculate the effective stroke (actually operable stroke) by subtracting A (slider length + slider actual span or slider cover span) from the nominal stroke (stroke shown as the model number).
Make sure to select a stroke that is greater than the necessary stroke plus (A).
The "necessary stroke" should be greater than the minimum effective stroke for the double slider.

Nominal stroke ≧ Effective stroke + (A)
(Stroke shown an the model number) (Actually operable stroke)

Example: RCP6-SA4C
Necessary stroke: 350mm, (A): 100mm
350mm + 100mm = 450mm. Place an order for the model of 450mm.

Selectable effective stroke of double slider (mm)	(A) Slider length + slider cover span (mm)
50~400 (Nominal stroke 150-500)	100
50Z650 (Nominal stroke 200-800)	150

(2) The double slider payload quantity is the maximum value obtained by subtracting the slider mass to be added from the catalog specification value.
(3) Please note that the maximum speed can not be set depending on the stroke.
(4) For the clean (CR) type double slider specification, the suction amount does not include the influence of piping resistance.
Please note that piping resistance is caused by piping length and piping diameter, causing loss of flow rate.

[RCP6(S) Double slider specification]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Lead (mm)	Allowable dynamic moment						Overhang load length (mm)	*1 Conveying mass compensation value A (kg)	*1 Conveying mass compensation value B (kg)	*1 Conveying mass compensation speed (mm/s)	Slider length (mm)	Effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
			Standard rated life (km)	Slider span (mm) Actual slider span	Slider span (mm) Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Ma direction, Mb·Mc directions						
RCP6(S)	SA4C(R)	10	5000	60	24	44.6	63.6	15.7	420	0.6	2	350	76	50~400 (Nominal stroke 150-500)	100
		5										215			
		2.5										105			
	SA6C(R)	12	5000	90	40	106	152	40	630	1.2	2	320	110	50~650 (Nominal stroke 200-800)	150
		6										280			
		3										140			
	SA7C(R)	16	5000	70	20	285	285	145	810	1.7	5	280	130	50~650 (Nominal stroke 200-800)	150
		8										140			
		4										70			
	SA8C(R)	20	5000	120	35	565	565	237	1200	7 (*2)	–	–	165	50~900 (Nominal stroke 250-1100)	200
		10										–			
		5										–			

[RCP6(S) CR double slider specification]

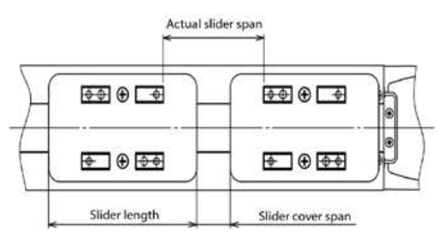
Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Lead (mm)	Allowable dynamic moment						Overhang load length (mm)	Cleanroom specification suction volume (Nℓ/min)	*1 Conveying mass compensation value A (kg)	*1 Conveying mass compensation value B (kg)	*1 Conveying mass compensation speed (mm/s)	Slider length (mm)	Effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
			Standard rated life (km)	Slider span (mm) Actual slider span	Slider span (mm) Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Ma direction, Mb·Mc directions							
RCP6(S) CR	SA4C	10	5000	60	24	44.6	63.6	15.7	420	60	0.6	2	350	76	50~400 (Nominal stroke 150-500)	100
		5								30			215			
		2.5								20			105			
	SA6C	12	5000	90	40	106	152	40	630	110	1.2	2	320	110	50~650 (Nominal stroke 200-800)	150
		6								60			280			
		3								35			140			
	SA7C	16	5000	70	20	285	285	145	810	100	1.7	5	280	130	50~650 (Nominal stroke 200-800)	150
		8								50			140			
		4								40			70			
	SA8C	20	5000	120	35	565	565	237	1200	170	7 (*2)	–	–	165	50~900 (Nominal stroke 250-1100)	200
		10								90			–			
		5								40			–			

[Double slider unavailable list]

Series name	Type name	Lead (mm)	Double slider can not be selected Horizontal installation	Double slider can not be selected Vertical installation
RCP6(S)	SA4C(R)	16	×	×
		10		×
	SA6C(R)	20	×	×
		12		×
	SA7C(R)	24	×	×
		16		×
	SA8C(R)	30	×	×
		20		×
RCP6(S)CR	SA4C	16	×	×
		10		×
	SA6C	20	×	×
		12		×
	SA7C	24	×	×
		16		×
	SA8C	30	×	×
		20		×

[Double sliders span diagram]



*1 In the double slider specification (except RCP6(CR)-SA8), to obtain the allowable payload of the actuator when traveling at speeds up to the payload compensation speed, subtract the value in payload compensation weight A from the standard payload rating of the actuator.
When traveling at speeds that exceed the payload compensation speed, subtract the value in payload compensation weight B from the standard payload rating of the actuator in order to obtain the allowable payload of the actuator.
As to the maximum speed, refer to the nominal stroke specification value (stroke for the single slider).

*2 In the double slider specification of RCP6(CR)-SA8, to obtain the allowable payload of the actuator when traveling at any speed, subtract the value in payloads compensation weight A from the standard payload rating of the actuator.
As to the maximum speed, refer to the nominal stroke specification value (stroke for the single slider).

Note
- Calculate the double slider payload capacity in the above specification table and "Payload Table by speed / acceleration" (on each product page). Confirm the maximum speed from calculated payload capacity. (Refer to the instruction manual for details)
- Double sliders can not be selected depending on the lead. Check the "Double slider unavailable list."
- When selecting double slider specification and reverse homing specification at the same time, make sure to perform a home return operation after connecting the drive slider and the free slider.

Double Slider Allowable Dynamic Moment/Overhang Load Length

[RCS4 Double slider specification]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Lead (mm)	Allowable dynamic moment						Overhang load length (mm)	* Conveying mass compensation value A (kg)	Slider length (mm)	Selectable effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
			Standard rated life (km)	Slider span (mm) Actual slider span	Slider span (mm) Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Ma direction, Mb·Mc directions				
RCS4	SA4C(R)	16 10 5 2.5	5000	60	24	44.6	63.6	15.7	420	1	76	50~400 (Nominal stroke 150-500)	100
	SA6C(R)	20 12 6 3	5000	90	40	106	152	40	630	2	110	50~650 (Nominal stroke 200-800)	150
	SA7C(R)	24 16 8 4	5000	70	20	285	285	145	810	2	130	50~650 (Nominal stroke 200-800)	150
	SA8C(R)	30 20 10 5	5000	120	35	565	565	237	1200	2.5	165	50~900 (Nominal stroke 250-1100)	200

[RCS4CR Double slider specification]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Lead (mm)	Allowable dynamic moment						Overhang load length (mm)	Cleanroom specification suction volume (Nℓ/min)	* Conveying mass compensation value A (kg)	Slider length (mm)	Selectable effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
			Standard rated life (km)	Slider span (mm) Actual slider span	Slider span (mm) Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Ma direction, Mb·Mc directions					
RCS4CR	SA4C	10	5000	60	24	44.6	63.6	15.7	420	60	1	76	50~400 (Nominal stroke 150-500)	100
		5								30				
		2.5								20				
	SA6C	12	5000	90	40	106	152	40	630	110	2	110	50~650 (Nominal stroke 200-800)	150
		6								60				
		3								35				
	SA7C	16	5000	70	20	285	285	145	810	100	2	130	50~650 (Nominal stroke 200-800)	150
		8								50				
		4								40				
	SA8C	10	5000	120	35	565	565	237	1200	120	2.5	165	50~900 (Nominal stroke 250-1100)	200
		5								50				

* In the double slider specification, the payload specification is the value obtained by subtracting the payload compensation value from the standard specification payload.
(Note) The lead not listed in the table does not have a double slider setting.

[EC Double slider specification]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Type name	Allowable dynamic moment						Overhang load length (mm)	Slider mass (kg)	Slider length (mm)	Selectable effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
	Standard rated life (km)	Slider span (mm) Actual slider span	Slider span (mm) Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Ma direction, Mb·Mc directions				
(D)S6(R)	5000	90	40	106	152	37.9	440	0.27	110	50~250 (Nominal stroke 200-400)	150
(D)S7(R)	5000	73	24	119	171	56.7	560	0.45	126	50Z350 (Nominal stroke 200-500)	150
(D)S6□AH(R)	5000	90	40	167	199	89.8	600	0.43	110	50Z650 (Nominal stroke 200-800)	150
(D)S7□AH(R)	5000	73	24	316	376	218	600	0.73	126	50Z650 (Nominal stroke 200-800)	150

[Double sliders unavailable list]

Type name	Lead (mm)	Double slider cannot be selected Horizontal installation	Double slider cannot be selected Vertical installation
(D)S6(R)	S	×	×
	H	○	×
	M	○	○
	L	○	○
(D)S7(R)	S	×	×
	H	○	×
	M	○	○
	L	○	○

Type name	Lead (mm)	Double slider cannot be selected Horizontal installation	Double slider cannot be selected Vertical installation
(D)S6□ AH(R)	S	×	×
	H	○	×
	M	○	○
	L	○	○
(D)S7□ AH(R)	S	×	×
	H	○	×
	M	○	○
	L	○	○

[Other models Double slider specification (standard specification)]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Allowable dynamic moment: Standard rated life (km)	Slider span (mm): Actual slider span	Slider span (mm): Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Overhang load length (mm): Ma direction, Mb·Mc directions	Slider mass (kg)	Slider length (mm)	Selectable effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
RCP4	SA5C(R)	5000	60	6	52.6	75.2	24.1	450	0.6	94	50~700 (Nominal stroke 150~800)	100
RCA	SA5C(R)	5000	60	6	52.6	75.2	24.1	450	0.6	94	50~400 (Nominal stroke 150~500)	100
	SA6C(R)		90	35	106	152	40.0	660	1	115	50~450 (Nominal stroke 200~600)	150
RCS3(P)	SA8C(R)	10000	72		174	249	103	1140	1.5	78	50~950 (Nominal stroke 200~1100)	150
	SS8C(R)		110	30	342	342	148	1350	2.5	170	50~800 (Nominal stroke 250~1000)	200
RCS2	SA5C(R)	5000	60	6	52.6	75.2	24.1	450	0.6	94	50~400(Nominal stroke 150~500)	100
	SA6C(R)		90	35	106	152	40.0	660	1	115	50~450(Nominal stroke 200~600)	150
	SA7C(R)		90	24	187	268	92.1	690	1	126	50~650(Nominal stroke 200~800)	150
IS(P)B	SXM	10000	Min. 30	–	140	200	125	1050	1.5	90	100~980(Nominal stroke 250~1100)*	120
			Max. 90	–	228	325	125	1350			100~920(Nominal stroke 250~1100)*	180
	SXL		Min. 30	–	188	269	145	1250		110	130~940(Nominal stroke 280~1080)*	140
			Max. 90	–	286	409	145	1550			130~880(Nominal stroke 280~1080)*	200
	MXM	10000	Min. 35	–	332	475	307	1375	2.5	120	100~1145(Nominal stroke 300~1300)*	155
			Max. 120	–	561	801	307	1800			100~1060(Nominal stroke 300~1300)*	240
	MXL		Min. 35	–	481	687	368	1675		150	120~1085(Nominal stroke 320~1270)*	185
			Max. 120	–	743	1060	368	2100			120~1000(Nominal stroke 320~1270)*	270
	LXM	10000	Min. 35	–	481	687	473	1675	3.5	150	100~1115(Nominal stroke 300~1300)	185
			Max. 150	–	845	1210	473	2250			100~1000(Nominal stroke 300~1300)	300
	LXL		Min. 35	–	616	880	532	1975		180	120~1055(Nominal stroke 370~1270)	215
			Max. 150	–	1010	1450	532	2550			120~940(Nominal stroke 370~1270)	330
IS(P)A	WXM	10000	Min. 35	–	616	880	739	1975	4	180	100~1085(Nominal stroke 350~1300)	215
			Max. 180	–	1130	1610	739	2700			100~940(Nominal stroke 350~1300)	360
IS(P)DB	S	10000	110	46	259	370	125	1050	1.5	154	100~600(Nominal stroke 300~800)	200
	M		Min. 80	6	448	640	307	1375	2.5	194	100~900(Nominal stroke 300~1100)	200
			Max. 120	46	561	801	307	1800			100~860(Nominal stroke 300~1100)	240
	L		Min. 100	26	678	968	473	1675	3.5	224	100~1050(Nominal stroke 350~1300)	250
			Max. 150	76	845	1210	473	2250			100~1000(Nominal stroke 350~1300)	300
IF-SA		10000	Min. 45	–	160	229	125	1125	1.5	90	150~1865(Nominal stroke 300~2000)	135
			Max. 60	–	182	260	125	1200			150~1850(Nominal stroke 300~2000)	150
IF-MA		10000	Min. 55	–	382	546	307	1475	2.5	120	100~2325(Nominal stroke 300~2500)	175
			Max. 80	–	448	640	307	1600			100~2300(Nominal stroke 300~2500)	200

* The maximum stroke varies depending on the motor wattage.

[Other models Double slider specification (cleanroom specification)]

Effective stroke: actually operable stroke
Nominal stroke: stroke shown as the model number

Series name	Type name	Allowable dynamic moment: Standard rated life (km)	Slider span (mm): Actual slider span	Slider span (mm): Slider cover span	Ma direction (N·m)	Mb direction (N·m)	Mc direction (N·m)	Overhang load length (mm): Ma direction, Mb·Mc directions	Cleanroom maximum speed (mm/sec)	Cleanroom specification suction volume (Nℓ/min)	Slider mass (kg)	Slider length (mm)	Selectable effective stroke for double slider (mm)	(A) Slider length + slider cover span (mm)
RCP4CR	SA5C	5000	60	10	52.6	75.2	24.1	450	1000	80	0.6	90	50~700 (Nominal stroke 150~800)	100
RCACR	SA5C	5000	60	10	52.6	75.2	24.1	450	1000	85	0.6	90	50~400 (Nominal stroke 150~500)	100
	SA6C		90	35	106	152	40.0	660	1000	90	1	115	50~450 (Nominal stroke 200~600)	150
RCS3(P) CR	SA8C	10000	84	18	174	249	103	1140	1000	200	1.5	132	50~950 (Nominal stroke 200~1100)	150
	SS8C		110	30	342	342	148	1350	1000	165	2.5	170	50~800 (Nominal stroke 250~1000)	200
RCS2CR	SA5C	5000	60	10	52.6	75.2	24.1	450	1000	85	0.6	90	50~400 (Nominal stroke 150~500)	100
	SA6C		90	35	106	152	40.0	660	1000	90	1	115	50~450 (Nominal stroke 200~600)	150
	SA7C		90	22	187	268	92.1	690	800	110	1	128	50~650 (Nominal stroke 200~800)	150
IS(P) DBCR (-ESD)	S	10000	110	46	259	370	125	1050	960	110	1.5	154	100~600 (Nominal stroke 300~800)	200
	M		Min. 80	6	448	640	307	1375	1000	180	2.5	194	100~900 (Nominal stroke 300~1100)	200~240
			Max. 120	46	561	801	307	1800						
	L		Min. 100	26	678	968	473	1675	1000	200	3.5	224	100~1050 (Nominal stroke 350~1300)	250~300
			Max. 150	76	845	1210	473	2250						
IS(P) DACR	W	10000	Min. 90	30	683	976	678	2050	1000	100	4.0	220	100~1050 (Nominal stroke 300~1300)	250~320
			Max. 160	100	922	1320	678	2250						

Actuator Installation Method

The mounting method varies depending on the model of the actuator. The following table shows the mounting methods for each model.
* For mounting using options, refer to each product page.

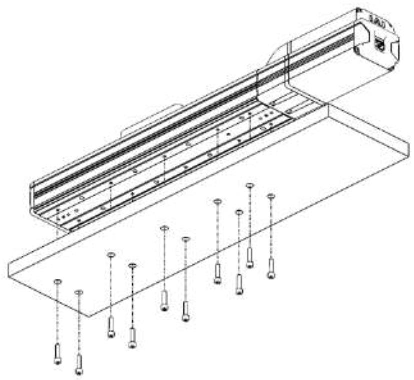
Classification	Series	Type	Threaded mounting holes on the bottom of the base	Counterbored through holes on the base	T-slot mounting	Fixed the main unit front	Fixed the main unit side	Fixed the main unit back
Slider Type	EC	(D)S3/(D)S4/(D)S6/(D)S7	—	—	○	—	—	—
		(D)WS10/(D)WS12	—	○	—	—	—	—
		(D)S6□AH/(D)S7□AH	○	○	—	—	—	—
		(D)B6/(D)B7	—	○	—	—	—	—
		S10/S10X/S13/S13X/S15/S15X	—	○	—	—	—	—
	RCP6(S)	SA4/SA6/SA7	○	○	—	—	—	○ (side-mounted)
		SA8	○	—	—	—	—	○ (side-mounted)
		WSA	—	○	—	—	—	○ (side-mounted)
	RCP5	BA	—	○	—	—	—	—
	RCP4	SA	○	○	—	—	—	○ (side-mounted-OP)
	RCP3	SA	○	—	—	—	—	—
	RCA	SA4/SA5	○	△ (*1)	—	—	—	—
		SA6	○	—	—	—	—	—
	RCS4	SA4/SA6/SA7	○	○	—	—	—	○ (side-mounted)
		SA8	○	—	—	—	—	○ (side-mounted)
		WSA	—	○	—	—	—	○ (side-mounted)
	RCS3/RCS3P	SA8/SS8	○	—	—	—	—	—
		CT8	○	—	—	—	—	—
	RCS2	SA4/SA5	○	△ (*1)	—	—	—	—
		SA6	○	—	—	—	—	—
		SA7	○	○	—	—	—	—
	ISB/ISPB	SXM/SXL/MXM/MXL/LXM/LXL	○	○	—	—	—	—
		MXMX/LXMX/LXUWX	—	○	—	—	—	—
		WXM	—	○	—	—	—	—
		WXMX	—	○	—	—	—	—
	SSPA	S/M/L	○	○	—	—	—	—
	ISA	WXM	○	—	—	—	—	—
		WXMX	○	—	—	—	—	—
	ISDB/ISPDB	S/M/L	○	—	—	—	—	—
		MX/LX	○	—	—	—	—	—
	NSA	M/L/W	—	○	—	—	—	—
	NS	All models	—	○	—	—	—	—
	IF	SA/MA	—	○	—	—	—	—
Rod Type	EC	(D)R7/(D)R7	—	—	—	○	—	—
		(D)RR3/(D)RR4/(D)RR6/(D)RR7	—	—	○	○	—	—
		(D)RR6□AH/(D)RR6□X□AH/(D)RR7□AH/(D)RR7□X□AH	○	○	—	○	—	—
		RP4	—	—	—	P388	—	—
		RP5	○	—	—	—	○	—
		GS4/GD4/GD5	○	—	—	—	○ (GS)	—
	RCP6(S)	RA	—	—	○	○	—	○ (side-mounted)
		RRA	○	○	—	○	—	○ (side-mounted)
		WRA	—	○	○ (Side)	○	—	○ (side-mounted)
	RCP5	RA10	○	—	—	○	—	○ (side-mounted)
	RCP4	RA	○	○	—	○	—	○ (side-mounted-OP)
	RCP3	RA2	○	—	—	○	—	—
	RCP2	SR	○	—	—	○	○	○
	RCD	RA	—	—	—	1-267	—	—
	RCA2	RN/RP	—	—	—	1-268	—	○ (without B)
		GS/GD	—	—	—	—	○ (4 faces)	○ (without B)
		SD	—	—	—	—	○ (3 faces)	—
	RCA	RA	—	—	—	○	—	○ (side-mounted)
	RCP4	RA	—	—	○	○	—	○ (side-mounted)
		RRA	○	○	—	○	—	○ (side-mounted)
		WRA	—	○	○ (Side)	○	—	○ (side-mounted)
	RSC3	RA15/RA20 (without load cell)	—	—	—	○	—	—
	RCS2	RA5	—	—	○	○	—	—
		RN/RP	—	—	—	1-268	—	○ (without B)
		GS/GD	—	—	—	—	○ (4 faces)	○ (without B)
		SD	—	—	—	—	○ (3 faces)	—
		RGS/RGD	—	—	○	○	—	—
		SRA/SRGD/SRGS	○	—	—	○	—	○
Table type	EC	TC4/TW4/TC5/TW5	○	—	—	—	○ (TC)	—
	RCP6(S)	TA	○	○	—	—	—	○ (side-mounted)
	RCP3	TA	○	—	—	—	—	—
	RCA2	TCA/TWA/TFA	○	—	—	—	—	○ (without B)
	RCS4	TA	○	○	—	—	—	○ (side-mounted)
	RCS3/RCS3P	CTZ5C	○	○	—	—	—	—
	RCS2	TCA/TWA/TFA	○	—	—	—	—	○ (without B)
Linear servo	LSA	S6/S8/S10	○	—	—	—	—	—
		N10/N15	○	—	—	—	—	—
		W21	○	○	—	—	—	—
	LSAS	N10/N15	○	—	—	—	—	—

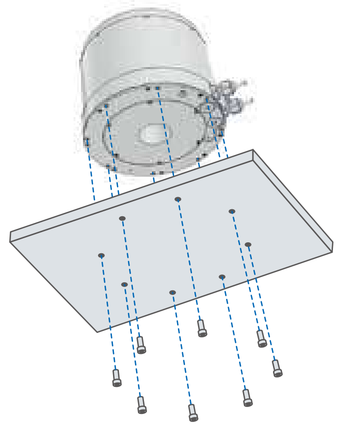
Classification	Series	Type	Threaded mounting holes on the bottom of the base	Counterbored through holes on the base	T-slot mounting	Fixed the main unit front	Fixed the main unit side	Fixed the main unit back
Pulse press	RCP6	RRA4/RRA6/RRA7	○	○	—	○	—	○
Servo press	RCS3	RA4/RA6/RA7	○	○	—	○	—	○
		RA8/RA10	○	—	—	○	—	○
		RA15/RA20	—	—	—	○	—	—
	RCS2	RA13	○	—	—	○	—	—
Gripper	EC	GRB8/GRB10/GRB13	○	○	—	—	○	—
	RCP6	GRST6/GRST7	○	—	—	—	—	○ (side-mounted)
		GR7T	○	—	—	—	○	—
	RCP4	GR	○	—	—	—	○	—
	RCP2	GR	○	—	—	—	○	—
	RCD	GRSNA	○	○	—	—	—	—
Solenoid gripper	GRS	SEG/MEG	○	—	—	—	○	—
		SIG/MIG	○	—	—	—	○	—
Rotary chuck	RCP6	RTCKSPE/RTCKMPE	○	—	—	^a	○	—
		RTCKSPI/RTCKMPI	○	—	—	^a	○	—
		RTCKSRE/RTCKMRE	○	—	—	—	○	—
		RTCKSRI/RTCKMRI	○	—	—	—	○	—
Rotary	EC	RTC9/RTC12	○	○	—	—	—	—
	RCP6	RTFML	○	—	—	—	—	—
	RCP2	RT	○	—	—	○	○ (2 faces)	—
	RCS2	RTC	○	—	—	—	○	—
Direct drive motor	DDA	LT/LH	○	—	—	—	—	—
Rotation	RS		—	—	—	—	—	1-260
Stopper cylinder	EC	ST15	○	○	○	—	—	○
	RCP4	ST	△ (Using option)	○	—	—	—	—
Vertical/Rotation	ZR	S/M	—	—	—	—	—	1-260
Cleanroom	EC	(D)S3□CR/(D)S4□CR/(D)S6□CR/(D)S7□CR	—	—	○	—	—	—
		(D)S6□AHCR/(D)S7□AHCR	○	○	—	—	—	—
	RCP6CR(S)	SA	○	○	—	—	—	—
		WSA	—	○	—	—	—	—
	RCP4CR	SA	○	○	—	—	—	—
	RCP2CR	GR	○	—	—	—	○	—
		RT	○	—	—	—	○	—
	RCA2CR	RN/RP	—	—	—	1-268	—	—
		GS/GD	—	—	—	—	○ (4 faces)	—
		SD	—	—	—	—	○ (3 faces)	—
	RCACR	SA4/SA5	○	△ (*1)	—	—	—	—
		SA6	○	—	—	—	—	—
	RCS4CR	SA	○	○	—	—	—	—
		WSA	—	○	—	—	—	—
	RCS3CR	SA/SS	○	—	—	—	—	—
	RCS2CR	SA/SS	○	—	—	—	—	—
		RN/RP	—	—	—	1-268	—	—
		GS/GD	—	—	—	—	○ (4 faces)	—
		SD	—	—	—	—	○ (3 faces)	—
	DDACR	LT/LH	○	—	—	—	—	—
	ISDBCR	S/M/L	○	—	—	—	—	—
	ISPDBCR	MX/LX	○	—	—	—	—	—
	SSPDACR	S/M/L	○	—	—	—	—	—
	ISDACR	W	○	—	—	—	—	—
	ISPDACR	WX	○	—	—	—	—	—
Dust-proof and splash-proof	EC	R6□W/R7□W	—	—	—	○	—	—
		RR6□W/RR7□W	○	—	—	○	—	—
	RCP6W	RA	—	—	○	○	—	○ (side-mounted)
		RRA4/RRA6/RRA7	—	—	○	○	—	○ (side-mounted)
		RRA8	○	—	—	○	—	○ (side-mounted)
		WRA	—	○	○ (Side)	○	—	○ (side-mounted)
	RCP5W	RA10	○	—	—	○	—	—
	RCP4W	SA (1-204)	○ ○ (Using option)	○ ○ (Using option)	—	—	—	—
	RCP2W	GR	○	—	—	—	○	—
		RT	○	—	—	○	○	—
	RCA2W	RN/RP	—	—	—	1-268	—	—
		GS/GD	—	—	—	—	○ (4 faces)	—
		SD	—	—	—	—	○ (3 faces)	—
	RCS2W	RN/RP	—	—	—	1-268	—	—
		GS/GD	—	—	—	—	○ (4 faces)	—
		SD	—	—	—	—	○ (3 faces)	—
	DDW	LH	○	—	—	—	—	—
	ISWA/ISPWA	S/M/L	○	—	—	—	—	—

(*1) SA4's stroke should be less than 200mm stroke and SA5's should be less than 300mm.

Actuator Installation Method

Threaded mounting holes on the bottom of the base

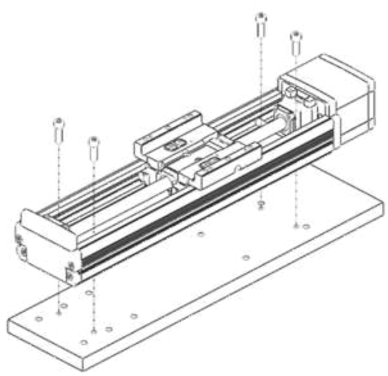




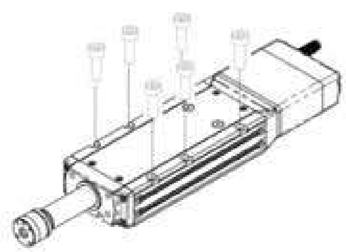
*Refer to the dimensions diagram of the product page for the sizes of the screw holes.

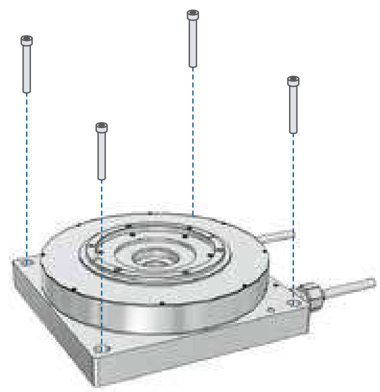
Mounted using the counterbored through holes on the top of the base

Installing from the top removing the cover



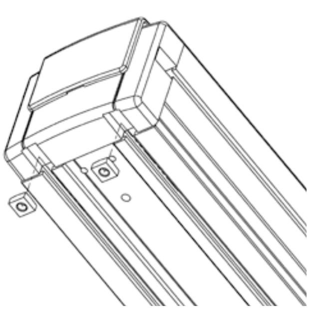
Installing from the top without removing the cover

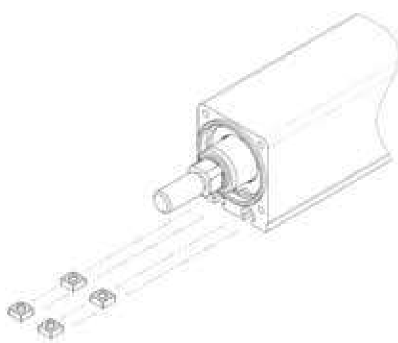


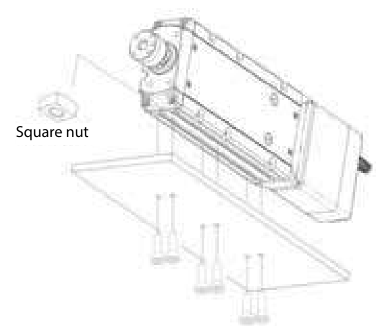


*Refer to the dimensions diagram of the product page for the sizes of the screw holes.

Mounted using the T-slot



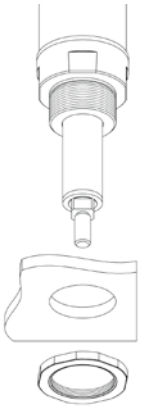


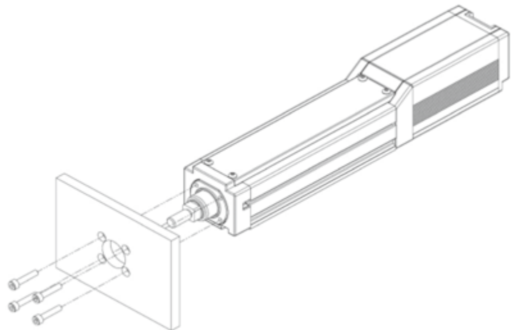


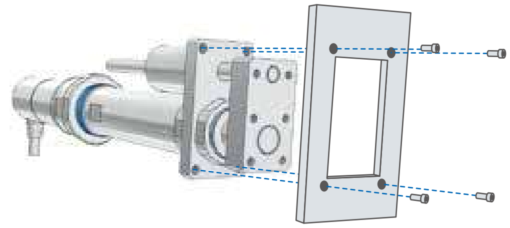
*Refer to the dimensions diagram of the product page for the sizes of the T-slots.

Fixed at the main unit front

It is possible to fix using the tapped holes of the bracket.



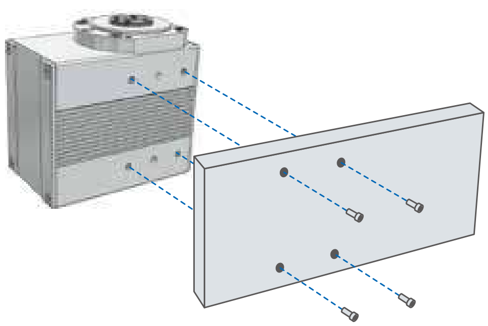


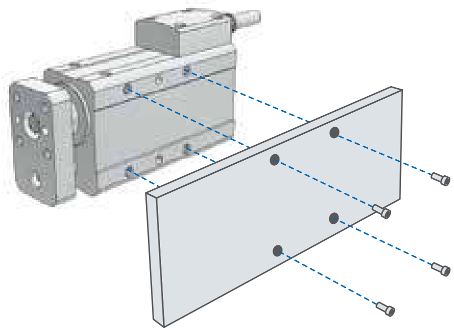


*Refer to the dimensions diagram of the product page for the sizes of the screw holes.

Fixed the main unit side

Actuator side mounting is possible.

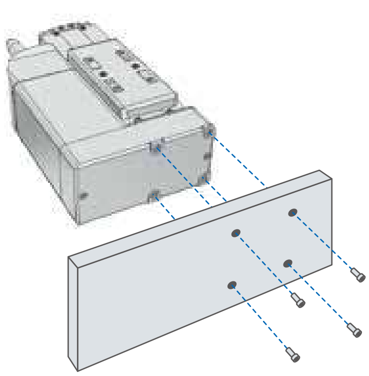


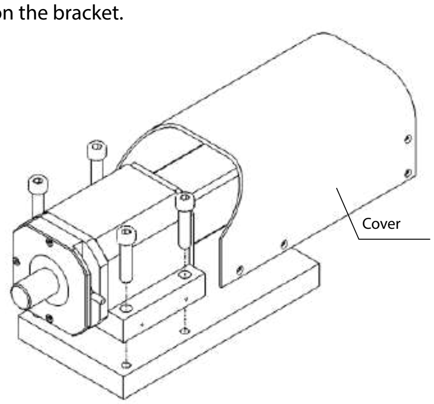


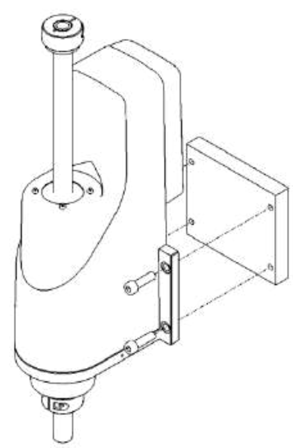
*Refer to the dimensions diagram of the product page for the sizes of the screw holes.

Fixed the main unit rear

The side-mounted motor can be fixed using the tap holes on the bracket.







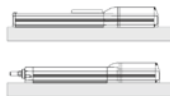
*Refer to the dimensions diagram of the product page for the sizes of the screw holes.

*Refer to the dimensions diagram of the product page for the sizes of the through holes.

Actuator Installation Orientation

Depending on the actuator model, there are Installation orientations that cannot be used or require caution.
Please check the details of the Installation orientations of each model on the table below before using.

○: Can be installed　△: Required daily checking　×: Can not install

			Installation Orientation			
						
Classification	Series	Type	Horizontal flat plane installation	Vertical installation (*1)	Sideways installation	Ceiling installation
Slider Type	EC	(D)S3/(D)S4/(D)S6/(D)S7	○	○	△ (*2)	△ (*2)
		(D)WS10/(D)WS12	○	○ (Not selectable for CS option, Leads S and H))	△ (*2) (Not selectable for CS option)	△ (*2) (Not selectable for CS option)
		(D)S6□AH/(D)S7□AH	○	○	△ (*2)	△ (*2)
		(D)B6/(D)B7	○	○	△ (*2)	△ (*2)
		S10/S10X/S13/S13X/S15/S15X	○	○	△ (*2)	△ (*2)
	RCP6(S)	SA/WSA	○	○	△ (*2)	△ (*2)
	RCP5	BA	○	×	△ (*2) (*3) (Only for strokes less than 1000mm)	△ (*2) (*3) (Only for strokes less than 1000mm)
	RCP4	SA	○	○	△ (*2)	△ (*2)
	RCP3	SA2	○	×	×	×
		SA3	○	○	○	△ (*2)
		SA4/SA5/SA6	○	○	△ (*2)	△ (*2)
	RCA	SA	○	○	△ (*2)	△ (*2)
	RCS4	SA/WSA	○	○	△ (*2)	△ (*2)
	RCS3/ RCS3P	SA	○	○	○ (*4)	○ (*4)
		SS	○	○	△ (*2)	△ (*2)
		CT8	○	×	×	○
	RCS2	SA4	○	○	○	△ (*2)
		SA5/SA6SA7	○	○	△ (*2)	△ (*2)
	ISB/ISPB	SXM/SXL/MXM/MXL/LXM/LXL	○	○	○ (*6)	○ (*7)
		MXMX/LXMX/LXUWX	○	×	×	△ (*7) (Only for strokes less than 1300mm)
		WXM WXMX	○	×	×	×
	SSPA	S/M/L	○	○	○ (*6)	○ (*7)
	ISA	WXM	○	○	○ (*6)	△ (*7) (Only for strokes less than 1300mm)
		WXMX	○	×	×	△ (*7) (Only for strokes less than 1300mm)
	ISDB/ISPDB	S/M/L	○	○	△ (*2)	△ (*2)
		MX/LX	○	×	×	×
	NSA	MXMS/MXMM/LXMS/LXMM/WXMS/WXMM LXMXS/LMXM/WXMXS/WXMXM	○	×	○	○
	NS	SXMX/SXMM/MXMS/MXMM/LXMS/LXMM	○	×	×	○ (*8) (Only for strokes less than 1600mm)
		SZMS/SZMM/MZMS/MZMM/LZMS/LZMM	×	○	×	×
		MXMXS/LXMXS	○	×	×	×
	IF	SA/MA	○	×	×	○ (*7)
Rod Type	EC	(D)R7/(D)R7	○	○	○	○
		(D)RR3/(D)RR4/(D)RR6/(D)RR7	○	○	○	○
		(D)RR6□AH/(D)RR6□X□AH/(D)RR7□AH/(D)RR7□X□AH	○	○	○	○
		RP4	○	○	○	○
		RP5	○	○	○	○
		GS4/GD4/GD5	○	○	○	○
	RCP6(S)	RA/RRA/WRA	○	○	○	○
	RCP5	RA	○	○	○	○
	RCP4	RA (*10)	○	○	○	○
	RCP3	RA2	○	○	○	○
	RCP2	SR	○	○	○	○
	RCD	RA	○	○	○	○
	RCA2	RN/RP/GS/GD	○	○	○	○
		SD	○	○ (*11)	○	○
	RCA	RA	○	○	○	○
	RCS4	RA/RRA/WRA	○	○	○	○
	RCS3	RA15/RA20 (without load cell)	○	○	○	○
	RCS2	RA/RN/RP/GS/GD/SR/RG	○	○	○	○
		SD (*12)	○	○ (*11)	○	○

○: Can be installed △: Required daily checking ×: Can not install

Classification	Series	Type	Horizontal flat plane installation	Vertical installation (*1)	Sideways installation	Ceiling installation
Table Type	EC	TC4/TW4/TC5/TW5	○	○	○	○
	RCP6(S)	TA (*13)	○	○	○	○
	RCP3	TA	○	○	○	○
	RCA2	TCA/TWA/TFA	○	○	○	○
	RCS4	TA	○	○	○	○
	RCS3/RCS3P	CTZ5C	○	○	×	×
	RCS2	TCA/TWA/TFA	○	○	○	○
Linear servo	LSA	S6/S8/S10	○	×	○	×
		N10/N15	○	×	×	×
		W21	○	×	×	×
	LSAS	N10/N15	○	×	×	×
Pulse press	RCP6	RRA4/RRA6/RRA7	○	○	○	×
Servo press	RCS3	RA4/RA6/RA7/ R8/R10	○	○	○	×
		RA15/RA20	○	○	×	×
	RCS2	RA13	○	○	○	○
Gripper	EC	GRB8/GRB10/GRB13	○	○	○	○
	RCP6	GRST6/GRST7	○	○	△ (*2)	△ (*2)
		GR7T	○	○	○	○
	RCP4	GR	○	○	○	○
	RCP2	GR	○	○	○	○
	RCD	GRSNA	○	○	○	○
Solenoid gripper	GRS	SEG/MEG	○	○	○	○
		SIG/MIG	○	○	○	○
Rotary chuck	RCP6	RTCKSPE/RTCKMPE	○	○	○	○
		RTCKSPI/RTCKMPI	○	○	○	○
		RTCKSRE/RTCKMRE	○	○	○	○
		RTCKSRI/RTCKMRI	○	○	○	○
Rotary	EC	RTC9/RTC12	○	○	○	○
	RCP6	RTFML	○	○	○	○
	RCP2	RT	○	○	○	○
	RCS2	RTC	○	○	○	×
Direct drive motor	DDA	LT/LH	○	○	○	○
Rotation	RS		○	○	○	○
Stopper cylinder	EC	ST15	○	○	○	○
	RCP4	ST	×	○ (Only rod up)	×	×
Vertical/ Rotation	ZR	S/M	×	○ (Refer to 1-264)	×	×
Cleanroom	EC	(D)S3□CR/(D)S4□CR/ (D)S6□CR/(D)S7□CR	○	○	△ (*2)	△ (*2)
		(D)S6□AHCR/(D)S7□AHCR	○	○	△ (*2)	△ (*2)
	RCP6CR(S)	SA/WSA	○	○	△ (*2) (*9)	△ (*2) (*9)
	RCP4CR	SA	○	○	△ (*2) (*9)	△ (*2) (*9)
	RCP2CR	GR	○	○	○	○
		RT	○	○	○	○
	RCACR	SA	○	○	△ (*2) (*9)	△ (*2) (*9)
	RCA2CR	RN/RP/GS/GD	○	○	○	○
		SD	○	○ (*11)	○	○
	RCS4CR	SA/WSA	○	○	△ (*2) (*9)	△ (*2) (*9)
	RCS3CR	SA/SS	○	○	△ (*2) (*9)	△ (*2) (*9)
	RCS2CR	SA/SS	○	○	△ (*2) (*9)	△ (*2) (*9)
		RN/RP/GS/GD	○	○	○	○
		SD (*12)	○	○ (*11)	○	○
	DDACR	LT/LH	○	○	○	○
	ISDBCR/ ISPDBCR	S/M/L	○	○	△ (*2) (Only for strokes less than 400mm)	△ (*2) (Only for strokes less than 400mm)
		MX/LX	○	○	×	×
	SSPDACR	S/M/L	○	—	—	—
	ISDACR/ ISPDACR	W	○	○	△ (*2) (Only for strokes less than 400mm)	△ (*2) (Only for strokes less than 400mm)
		WX	○	×	×	×
Dust-proof and splash-proof	EC	R6□W/R7□W	○	○	○	○
		RR6□W/RR7□W	○	○	○	○
	RCP6W	RA/RRA/WRA	○	○	○	○
	RCP5W	RA	○	○	○	○
	RCP4W	SA	○	×	○ (*5)	○ (*5)
	RCP2W	GR	○	○	○	○
		RT	○	○	○	○
	RCA2W	RN/RP/GS/GD	○	○	○	○
		SD	○	○ (*11)	○	○
	RCS2W	RN/RP/GS/GD	○	○	○	○
		SD (*12)	○	○ (*11)	○	○
	ISWA/ISPWA	S/M/L	○	×	×	×
	DDW	LH	○	○	○	×

Actuator Installation Orientation

Cautions about installation orientation

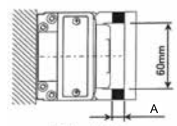
(*1) In the case of the motor straight type, install it so that the motor is on top.
There is a risk of base oil flowing into the motor after being separated from grease, causing failures of the controller and the motor/encoder. Therefore, it is not recommended to install the actuator with the motor on the lower side. When the motor must be installed on the lower side, consider a side-mounted motor type.

(*2) Although it is possible to install the actuator sideways, in that case there is a possibility of slack and slippage in the stainless sheet. When continuing to be used this way, malfunctions like broken stainless sheets may occur. Therefore, please perform daily inspections, and make adjustments if the stainless sheet is slack or displaced.

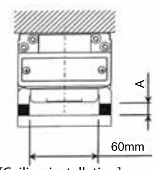
(*3) Sideways and ceiling installation for the RCP5 belt types are options.
It is not possible to install the horizontal/ceiling specifications in a sideways orientation.
It is not possible to install the sideways specification in the horizontal or ceiling orientations.
Please do not install in a slanted or vertical orientation since it will cause operation failures.

(*4) If RCS3 - SA8C / SA8R is used in a sideways / ceiling installation, the screw cover may bend and interfere with the slider installation. Therefore, please keep the distance between the slider mounting surface and the work as shown in the table below.

Stroke	Distance between slider mounting surface and work
At least 400mm, less than 800 mm	At least 5mm
At least 800mm, less than 1100 mm	At least 7mm
At least 1100mm (for custom order)	At least 10mm



[Sideways installation]



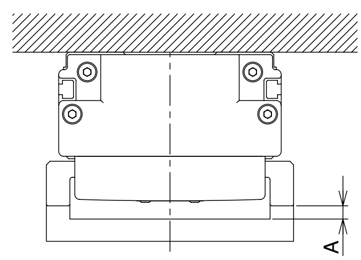
[Ceiling installation]

(*5) Optional mounting bracket is required when RCP4W slider type is used in a sideways and ceiling orientation.
When installing ceiling-mounted and sideways with a different bracket, splash-proof performance can not be guaranteed, so please be sure to use the correct optional bracket.
See P1-266 for the mounting posture in case an optional bracket is used.

(*6) Oil separated from the grease may drip from the opening on the side of the actuator.
There is a possibility that parts dropped from the inside of the equipment will enter the opening of the actuator side face.
If necessary, please attach protective parts.

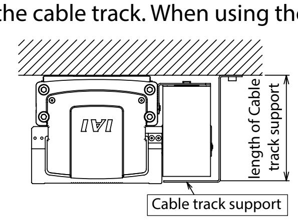
(*7) Since ceiling mounting a screw cover type actuator may cause the screw cover to bend and interfere with the work, please install the work away from the top of the slider.
The distance A from the slider mounting surface is as follows.

Series	Stroke	Distance A
ISB/ISPB ISA/ISPA	At least 600mm, less than 1000mm	At least 5mm
	At least 1000mm, less than 1300mm	At least 10mm
SSPA	At least 800mm, less than 1500mm	At least 5mm
IF	At least 900mm, less than 1400mm	At least 5mm
	At least 1400mm, less than 2100mm	At least 10mm
	At least 2100mm, less than 2400mm	At least 15mm
	At least 2400mm, less than 2500mm	At least 20mm



(*8) When the NS actuators are suspended from the ceilings, the cable track may hang and become damaged. If a cable track support is installed, ceiling mounting becomes possible. For the standard cable track specifications for the LXMSA and LXMMA, ceiling mounting is not possible, because the cable wiring box sticks out about the cable track. When using the LXMSA or LXMMA with ceiling mounting, please use the extended cable track option.

Type	Cable track support size (units: mm)
SXMSA, SXMMA	89
MXMSA, MXMMA	109
LXMSA, LXMMA (Expanded bare OP)	155



(*9) There may be cases where maintaining cleanroom class 10 can not be maintained if slack or slippage occurs in the stainless sheet, when installing in a in sideways and ceiling mount. Therefore, please perform daily inspections, and make adjustments if the stainless sheet is slack or displaced.

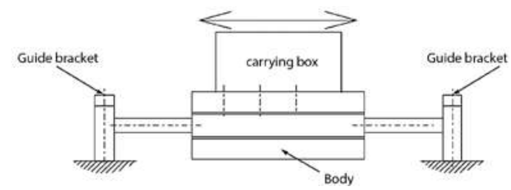
(*10) Motor types 42SP, 56SP are models for vertical installation only.

(*11) There are two ways to mount the slide unit type: mounting the main unit and mounting the guide bracket. Beware that vertical mounting is not possible when brackets are used.

(*12) When brackets are used for mounting, payload will be reduced by 1.5kg.

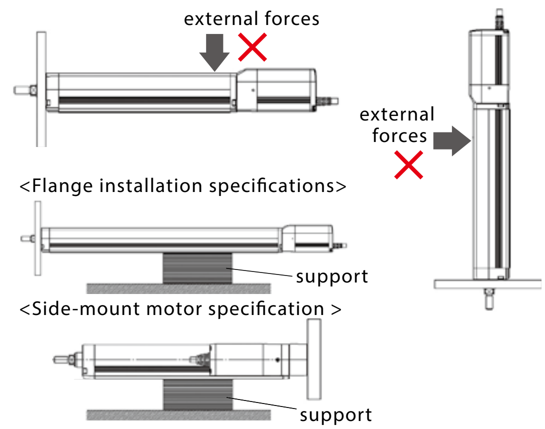
(*13) There are two ways to mount the slide unit type: mounting the main unit and mounting the guide bracket. Please note that vertical mounting is not possible when mounting the bracket.

<Installing the guide bracket>



<Caution when installing a rod type>

When installing a front housing and a flange (option), please make sure no external force acts on the actuator. (malfunctions and parts damages can occur from external force). When there will be external forces or if the actuator is going to be combined with something like a Cartesian robot, please use the mounting holes on the actuator to secure it.
Please install a support block when front installing or back installing an actuator in a horizontal orientation. Depending on the installation condition and operating conditions, it may cause damage to the actuator due to vibration.

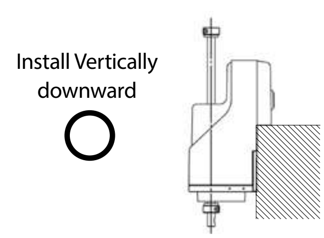


<Cautions on installation of pulse press and servo press>

Customer's tooling is to be installed on the load cell.
Please provide guides to the outside so that radial load and moment load will not be applied to the load cell.
When using the reversing bracket mounting holes, depending on the installation condition and operating conditions, damage or malfunction of parts may occur due to external force, bending moment, vibration. Please secure the base frame main body with a supporting base etc.

<ZR mounting orientation>

The ZR series can only be used for vertical downward installation.

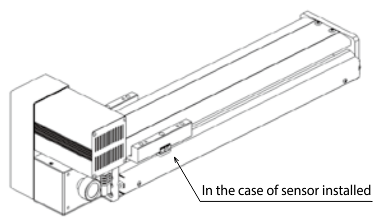


IF Series Motor Installation Orientation

Depending on the installation condition of the actuator, the positions of the motor and sensors can be changed to 6 types as shown below.
This makes it possible to change the motor position according to the installation environment.
Where the motor is installed horizontally or below, the position of the motor will be lower than the slider so there is no work interference.
In addition, when attaching the creep sensor (C) and the origin limit switch (L) as an option, when the motor installing direction is L, they are mounted as standard (on the right side as viewed from the motor side, symbols C and L). R they are mounted to the reverse side (on the left side as viewed from the motor side, symbols CL and LL).

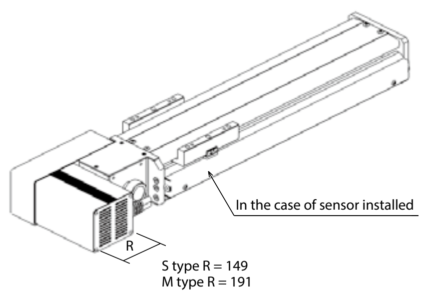
Standard type

■ Type: 1L



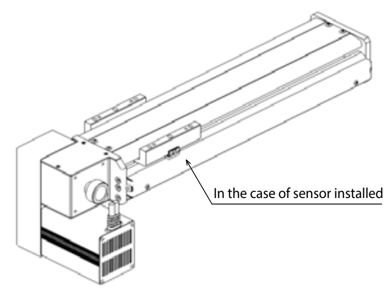
Installing motor horizontally

■ Type: 2L



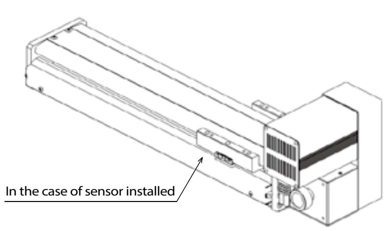
Installing motor below

■ Type: 3L



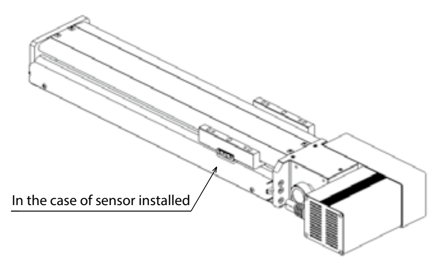
Standard type

■ Type: 1R



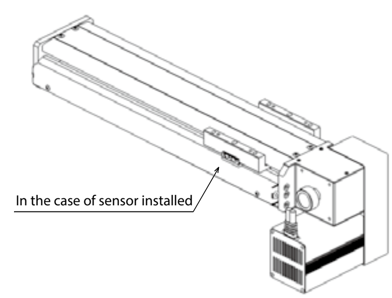
Installing motor horizontally

■ Type: 2R



Installing motor below

■ Type: 3R



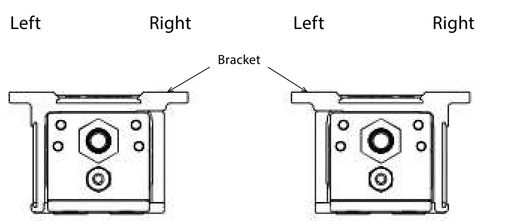
RCP4W-SA Installation Orientation

Illustration when optional ceiling mounting is selected (Model TFL/HFR).

When the optional ceiling installation (Model HFL / HFR) is selected, or when lateral wall installation (Model TFL / TFR) is selected, the direction of the actuator body is horizontal. Please refer to the following for installation orientation.

RCP4W-SA Ceiling installation specification

Installing with the bracket option for ceiling mounting (Model HFL/HFR).

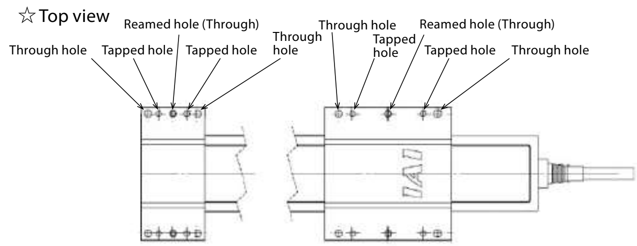


Ceiling mount to the left type (HFL)

Ceiling mount to the right type (HFR)

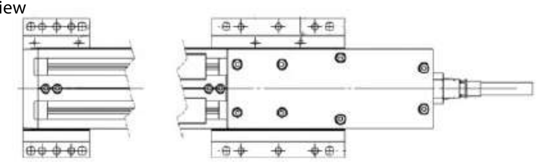
(View from motor side shaft end)

☆Top view



Bracket (front) Bracket (rear)

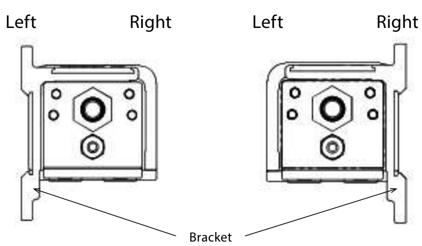
☆Bottom view



Bracket (front) Bracket (rear)

RCP4W-SA Wall installation specification

Installing with the bracket option for wall mounting (Model TFL / TFR).

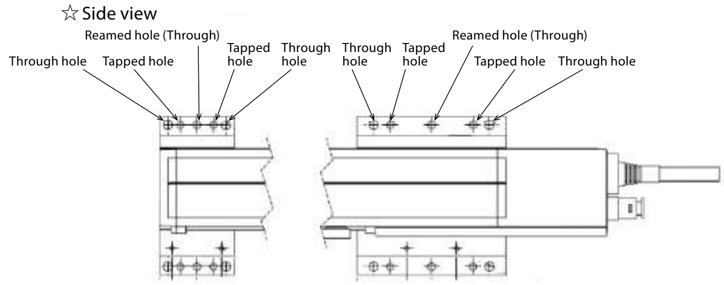


Left wall mounting specification (TFL)

Right wall mounting specification (TFR)

(View from motor side shaft end)

☆Side view

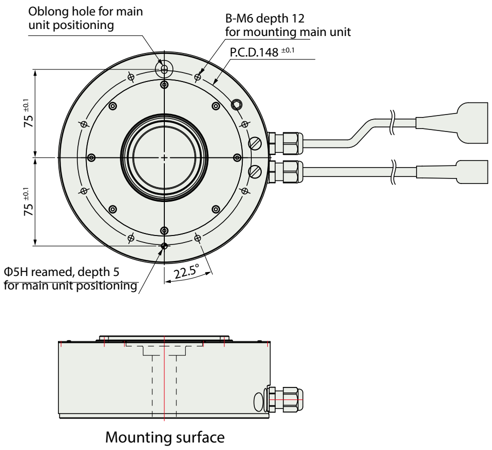


Bracket (front) Bracket (rear)

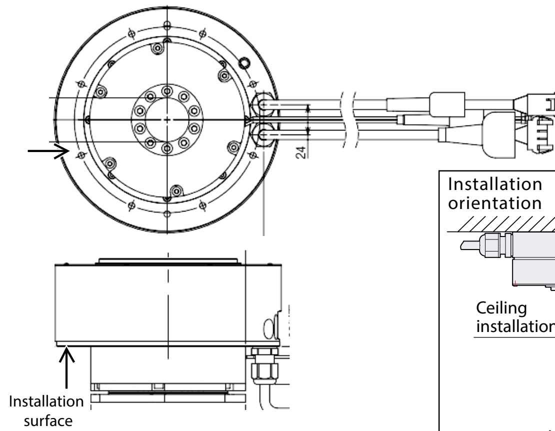
Caution for Installation (DD·DDA·DDW·RCS3-CT8C·CT4)

Direct drive motor

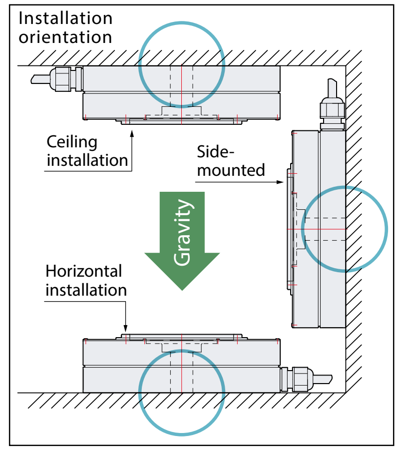
■DD



■DDA (with brake)



* For brake option and cable exit downward direction option, a hole or holes for the room for those items.



Note) Please use this product by mounting it to a surface that has heat dissipation characteristics equivalent to w450 x d450 x t12 aluminum plate. Please contact us if the installation conditions have poor heat dissipation.

■RCS3-CT8C

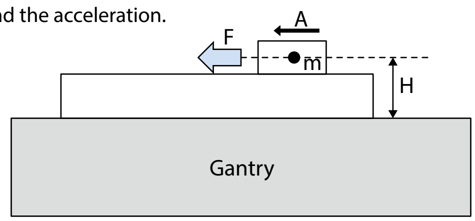
Secure the high-speed type ROBO Cylinder by preparing a sufficiently rigid rack and mount it so that the gantry does not move when operating the ROBO Cylinder.

- The reaction force during ROBO Cylinder operation is determined by the mass of the moving part and the acceleration.

Reaction force: F = mA	m: Mass of moving part	A: Acceleration

- Moment load due to the above reaction force and the height H to the center of gravity position is added to the mount.

Moment load: M = FH = mAH	H: Distance from gantry to movable part center of gravity

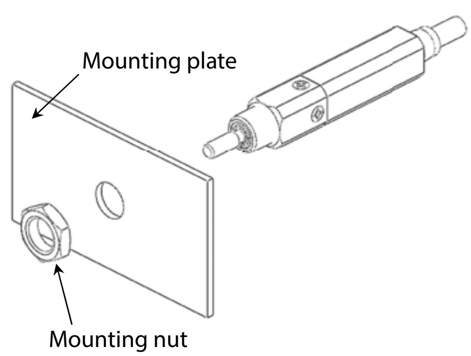


Consider the rigidity against this load moment.

RCD Rod Type Installation Method

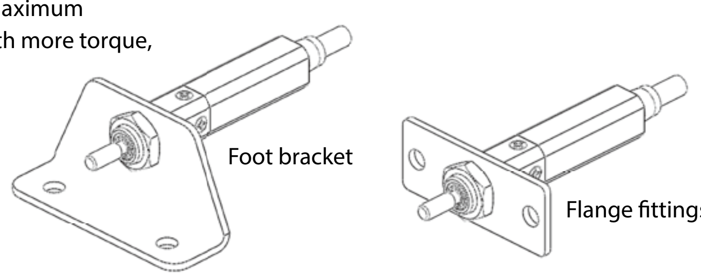
■ RCD series Installation method

- The installation hardware is a structure with sufficient rigidity so that vibration exceeding 0.3 G is not transmitted.
- Please set up a space where maintenance work can be done.
  Fit and fix the main body into the through hole (φ10) of a smooth plate with a thickness of 1 to 3 mm. The installation posture can be either horizontal installation or vertical installation.
- The base of the body of the male thread (m10×1.0) is a tolerance h8, so please use it as an in-row.
- When tightening with the attached mount nut etc., the maximum tightening torque should be 9.0 N · m. If it is tightened with more torque, breakage may occur.



The following general-purpose products can be used for foot brackets and flange fittings.

For foot brackets and flange fittings, please contact the manufacturer directly.



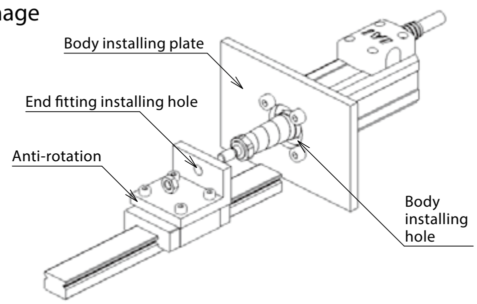
Mini Rod Type Anti-Rotation Installation Method

■ Thin and small rod type anti-rotation

In the following models, there is no anti-rotation of the ball screw inside the main body, so be sure to set the anti-rotation on the outside when using. When installing the anti-rotation, please install according to the following installation conditions. If you operate in a state where the anti-rotation mechanism is not installed, the ball screw idles, the rod does not move back and forth, and the rotation speed of the encoder and the actual movement distance can not be matched and the position may be misaligned.

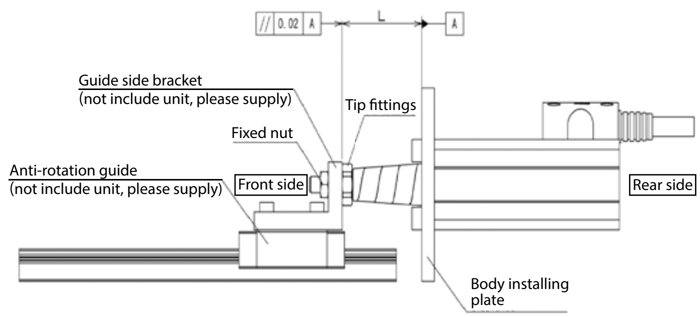
Applicable model **RCA2-RN3NA / RN4NA / RP3NA / RP4NA / RCA2CR / W-RN3NB / RN4NB / RP3NB / RP4NB / RCS2-RN5N / RP5N / RCS2CR / W-RN5NB / RP5NB / EC-RP4**

Installation image

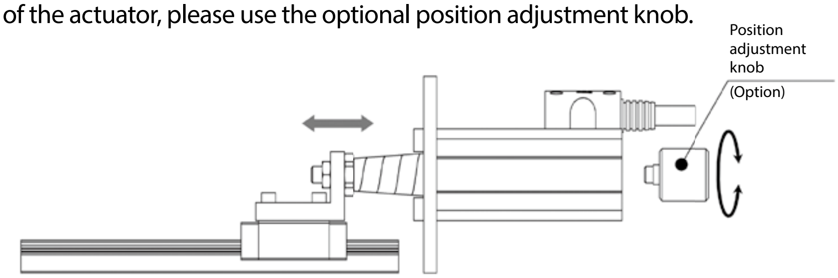


Please do not connect the tip of the actuator rod and the anti-rotation with the floating joint.
Radial load due to eccentricity is applied to the screw shaft, leading to malfunction of the actuator and premature failure.

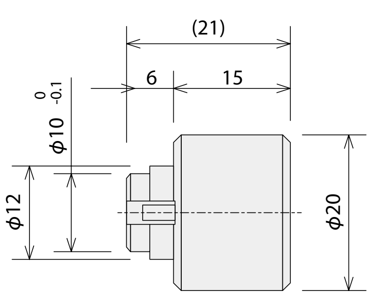
Installation method, condition the body installing hole of the fixed plate and the coaxial level of the tip bracket installing hole of the guide side brackets should be within 0.05 mm. The degree of parallelism should be within 0.02 mm.



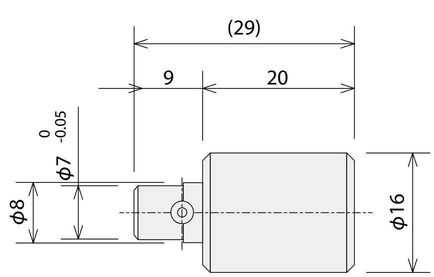
When moving the rod part of the actuator, please use the optional position adjustment knob.



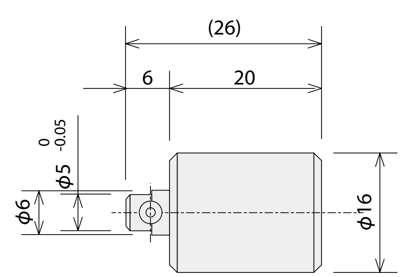
<Position adjustment knob>



For 5 Series
Model number: RCS2-AK-R5



For 4 Series
Model number: RCA2-AK-R4



For 3 Series
Model number: RCA2-AK-R3

Pressing Operation

As with pneumatic cylinders, push force motion is a function to keep holding rods and sliders pressed against workpiece etc. Please make sure the following usage instructions and notes.

[Compatible with push motion]

Motor type	Series	Model	Availability	Notes
Pulse motor	EC/RCP6/ RCP5/RCP4 RCP3/RCP2	Slider type Table type	○	Push motion is possible. (See note 1 below)
		Rod type	◎	It is suitable for pushing operation. (See note 2 below)
	EC/RCP5/RCP2	Belt type	×	Since the push force of the belt is not stable, it can not be pushed.
Servo motor (DC24V)	RCA2/RCA	All model	△	See notes 2 below
	EC	S10/S10X/S13/S13X	×	Push motion is not supported.
Servo motor (AC100/200V)	RCS4	All model	△	See notes 2 below
	RCS3	RA4R/RA6R/RA7R/ RA8R/RA10R/ RA15R/RA20R	◎	It is suitable for pushing operation.
		Other models	△	See notes 2 below
	RCS2	RA13R	◎	It is suitable for pushing operation.
		Other models	△	See notes 2 below

[Notes]

1. When pushing with the slider type and the table type, it is necessary to consider the allowable dynamic moment of the guide.
   For details, refer to the correlation diagram page of push force and current limit value on P.1-271 to 272).

2. RCP6 / RCP5 / RCP4 / RCP3 / RCP2 series are recommended for pushing applications.
   The RCP6 / RCP5 / RCP4 / RCP3 / RCP2 series are excellent in stopping stability at the time of pushing, and when compared with the RCA2 / RCA / RCS2 series of equivalent product cross section, a large push force can be obtained. Please contact our company for pressing on the RCA 2 / RCA / RCS 2 series.

[Adjustment of push force]

· The pushing force (push force) can be adjusted by changing the current limit value of the controller.

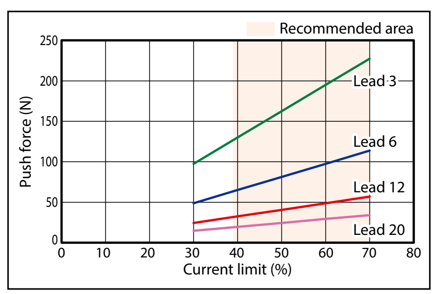
· Check the push force of each model referring to the "Correlation Diagram of Push force and Current Limit Value" for each product and select the model that suits the condition.

[Selection method of lead]

· Select a lead whose desired push force is in the recommended area (colored zone in the graph) of the current limit value.
  In the case of EC-(D)WS10 type, if the push force of 100N is desired, lead 6 is suitable. Lead 3 has a limited adjusting range.

(Note)

EC-(D)WS10



<Correlation diagram of push force and current limit value>

Caution

The correlation diagram of the push force and the current limit value shows the lower limit of the push force at each current limit value.

- Even if the current limit value is the same, the push force could be about 40% higher than the lower limit due to individual differences of motors and the variation of the mechanical efficiency.
- When accurate push force is required, use an actuator equipped with the load cell function that can control force.
  (Refer to 6-9 for pulse press and 6-11 for servo press for the details of the actuators with load cell function)

Force Control Function (Pulse press/Servo press)

The force control function enables highly accurate push control compared to conventional push motion by taking feedback of push force with a dedicated load cell attached to the actuator.

Pulse press

24 v stepper motor

Point 1: Supports tensile load

● Supports up to 60 to 2000N of push force and tensile load.

RCP6-RRA7R	200～2000N
RCP6-RRA6R	60～600N
RCP6-RRA4R	60～300N

Point 2: Easy setting

● Setting of push force by entering % only.

Point 3: Low cost

● A low cost is achieved by employing a stepper motor.

Note

· When operating in the pulse-train mode, the force control function cannot be used.

Servo press

200 v AC servo motor

Point 1: Full lineup

● Supports up to 20 to 50,000N (5 t) of thrust force.

RCS3–RA20R(Note)	5,000~50,000N
RCS3–RA15R(Note)	5,000~30,000N
RCS2–RA13R(Note)	2,000~19,600N ← 1t, 2t type
RCS3–RA10R	600~6,000N
RCS3–RA8R	200~2,000N
RCS3–RA7R	200~1,200N
RCS3–RA6R	60~600N
RCS3–RA4R	20~200N

(Note) Thrust force of the servo press specification.

Point 2: Operable by a dedicated program

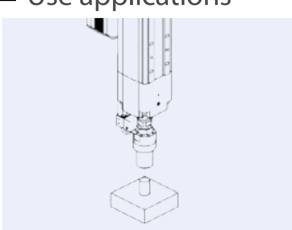
● Operations are possible by an easy input of position, speed, acceleration, load, etc. in 4 steps at the press program input sheet of the PC compatible software.

Step 1: Selection of operating mode
Step 2: Input of the home position
Step 3: Input of position, load and speed
Step 4: Input of judgement condition of press force

Note

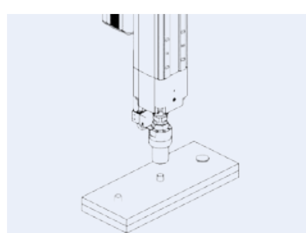
· Dedicated to push force. Force control of the tensile direction cannot be controlled.
· When operating in the pulse-train mode, the force control function cannot be used.
· Time for continuous push motion is limited by the setting load value. See P.1-273 for details.

■ Use applications



Used for press-fitting pins

It is possible to manage accurate pressing power.Even when the pin to be press-fitted is thin and loose, it is possible to confirm the failure judgment by setting the threshold value.



Riveting Work

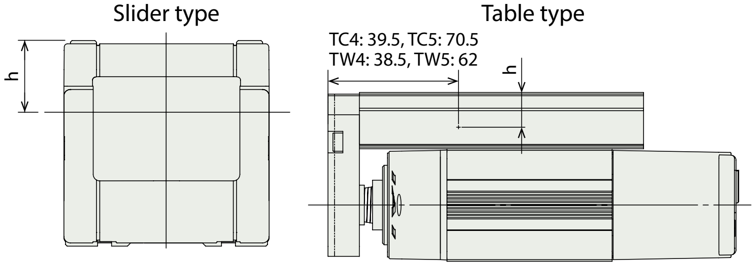
A detailed push force setting is possible for each product, and it is also possible to check whether the riveting completion position has been reache

Cautions on Push Force by Slider Type and Table Type

EC Series | Slider type / Table type * Same as CR

When performing a push force-motion operation using a slider type or table type actuator, be sure to limit the push force current so that the reactive moment caused by the torque does not exceed the dynamic allowable moment (Ma, Mb) listed in the catalog.
Refer to the figures below, which show the working point of the guide moment, for help with calculating the moment. When doing so, take the offset amount of the torque working point into consideration.
Note that applying excessive force that exceeds the dynamic allowable moment may damage the guide and reduce its operation life.
Select a push current that is safely within its limits.

Slider type Table type



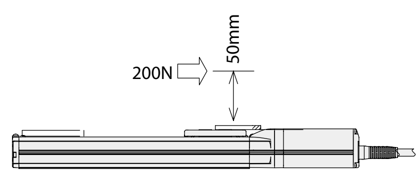
Guide moment working point

h measurement			
Slider type		Table type	
S3/S3☐R	16	TC4	10.5
S4/S4☐R	18	TW4	10.5
S6/S6☐R	22	TC5	12
S7/S7☐R	22	TW5	16
S6☐AH/S6☐AHR	50.5		
S7☐AH/S7☐AHR	58		

* Unit: mm

Calculation example)
When a 200N push force operation is performed with **EC-S7** type at the position shown in the figure to the right, the moment applied to the guide is:

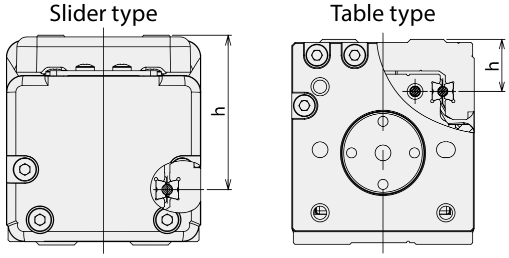
Ma = (22 + 50) × 200 = 14400 (N·mm)
= 14. 4 (N·m)



The dynamic allowable moment for EC-S7 is Ma = 17 (N·m); this is acceptable as 17 > 14.4.
If push force would cause an Mb moment, calculate from the overhang and ensure that it is within range of the dynamic allowable moment.

RCP6 Series | Slider type / Rod type / Table type * Same as CR/W

Slider type Table type



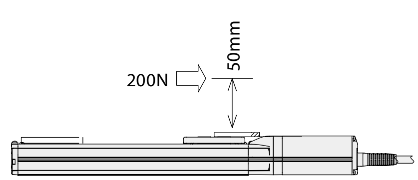
Operating position of guide moment

h measurement			
Slider type		Table type	
SA4	36	TA4	12
SA6	46	TA6	16.5
SA7	48	TA7	19.5
SA8	45.5		
WSA10	26.5		
WSA12	32		
WSA14	36		
WSA16	38.5		

* Unit: mm

Calculation example)
With **RCP6-SA7C** type, when push force 200 N at the position on the right figure
The moment the guide receives is

Ma= (48 + 50) × 200 = 19600 (N · mm)
= 19.6 (N · m).



The allowable dynamic moment of SA7C is Ma = 44 (N · m).
Therefore it is OK because it is 44 > 19.6.
When Mb's moment is generated by push force, it is calculated from the overhang amount
Make sure that it is within the allowable dynamic moment as well.

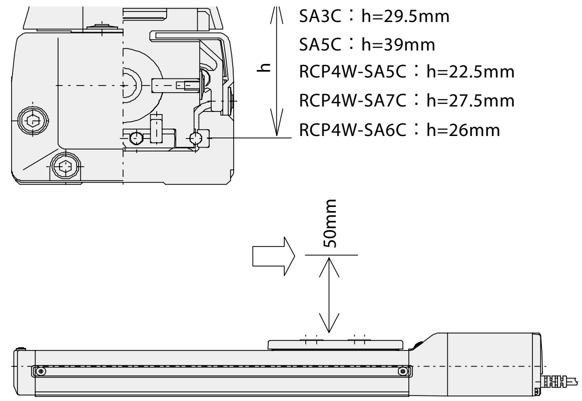
RCP4 Series | Slider type / Rod type * Same as CR

Calculation example)

With the **RCP4-SA5C** type, when push force 50N at the position on the right figure, the moment applied to the guide is

Ma= (39 + 50) × 50 = 4450 (N · mm)
= 4.45 (N · m).

The allowable dynamic moment of SA5C is Ma = 5 (N · m).
Hence it is OK because it is 5>4.45.
When Mb's moment is generated by push force, it is calculated from the overhang amount.
Make sure that it is within the allowable dynamic moment as well.



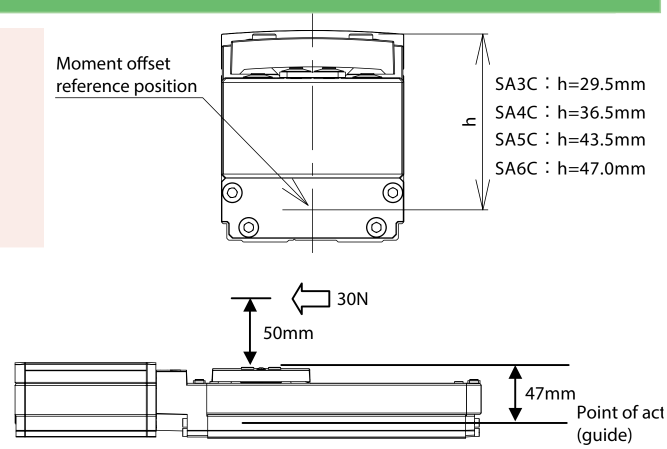
RCP3 Series | Slider type

Calculation example)

With **RCP 3-SA 6 C** (Lead 12) type, when push force 30 N at the position of 50 mm from the upper surface of the slider, the moment the guide receives is

Ma= (14 + 50) × 30 = 2910 (N · mm)
= 2.91 (N · m).

The allowable dynamic moment (Ma) of SA6C is 5 (N · m).
Therefore it is OK because it is greater than the moment load (2.91) applied to the guide actually.



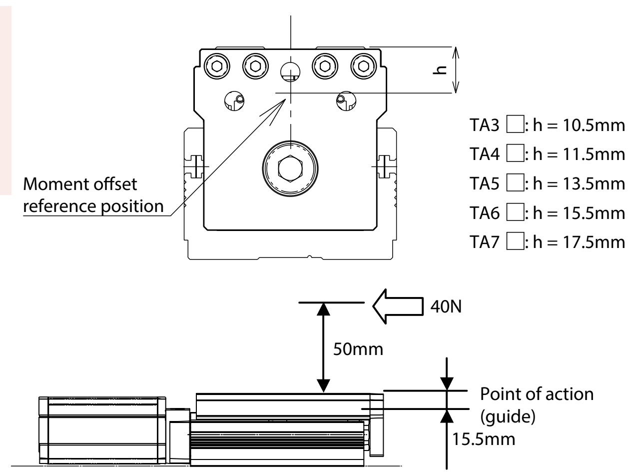
RCP3 Series | Table type

Calculation example)

With **RCP 3-TA 6 C** (Lead 12) type, when push force 40 N at the position on the figure, the moment the guide receives is

Ma= (15.5 + 50) × 40 = 2620 (N · mm)
= 2.62 (N · m).

The allowable dynamic moment (Ma) of TA6C is 8 (N · m).
Therefore it is OK because it is greater than the moment load (2.62) applied to the guide actually.



Cautions on Push Motion by Servo Press

RCS3-RCS2 Series | Servo press specification (with load cell)

When using this machine, it is necessary to clear the following three conditions.

Condition 1. The pressing time is shorter than the fixed time

Condition 2. The continuous operation thrust of 1 cycle is less than the permissible thrust of continuous operation of actuator

Condition 3. One push operation must be performed within one cycle

Selection method

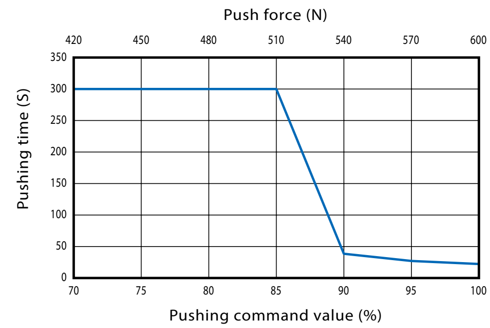
Condition 1. Pushing time

The maximum pushing time for each push command value is determined as shown in the table below. Be sure to use the pressing time below the time shown in the table below.
Please be aware that malfunction may occur in the actuator if you use it without following the table below.
There is no limit on the continuous push time for RA4R.

RCS3

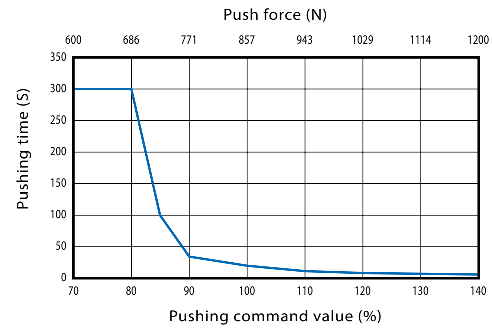
RA6R

Push command value (%)	Maximum pressing time (S)
70 or less	Capable of continuous pushing
85	300
90	38
95	27
100	21



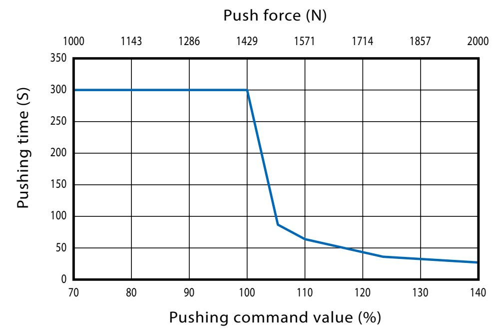
RA7R

Push command value (%)	Maximum pressing time (S)
70 or less	Capable of continuous pushing
80	300
85	94
90	33
95	24
100	18
105	15
110	12
115	11
120	9
125	8
130	7
135	6
140	5



RA8R

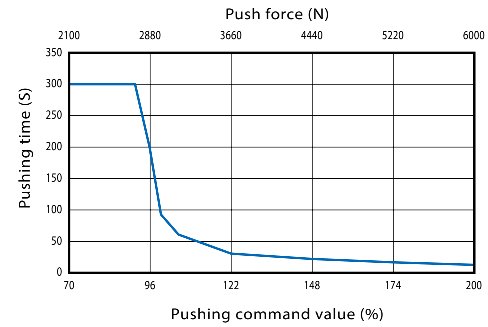
Push command value (%)	Maximum pressing time (S)
70 or less	Capable of continuous pushing
100	300
105	92
110	67
115	54
120	44
125	38
130	33
135	29
140	25



RCS3·RCS2 Series | Rod type with load cell

RA10R

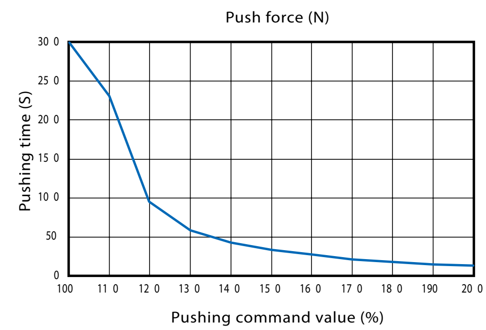
Push command value (%)	Maximum pressing time (S)
70 or less	Capable of continuous pushing
90	300
95	210
100	95
105	70
110	56
115	46
120	39
125	34
130	30
135	26
140	24
145	21
150	19
155	17
160	16
165	14
170	13
175	12
180	11
185	10
190	9
195	9
200	8



RCS2

RA13R

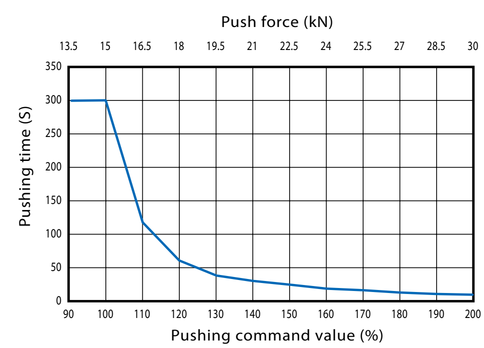
Push command value (%)	Maximum pressing time (S)
70 or less	(Capable of continuous pushing)
71-100	300
110	230
120	95
130	58
140	43
150	33
160	27
170	21
180	18
190	15
200	13



RCS3

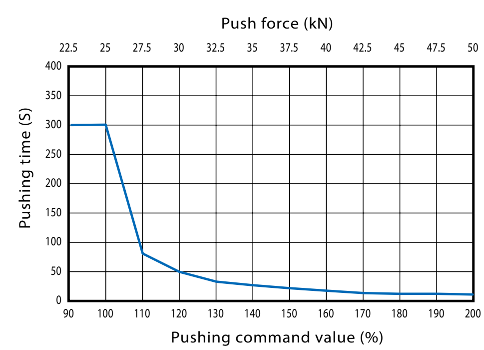
RA15R

Push command value (%)	Maximum pressing time (S)
90 or less	Capable of continuous pushing
91-100	300
110	118
120	58
130	40
140	30
150	25
160	20
170	16
180	13
190	10
200	9



RA20R

Push command value (%)	Maximum pressing time (S)
90 or less	Capable of continuous pushing
91-100	300
110	80
120	50
130	36
140	28
150	22
160	18
170	15
180	13
190	11
200	10

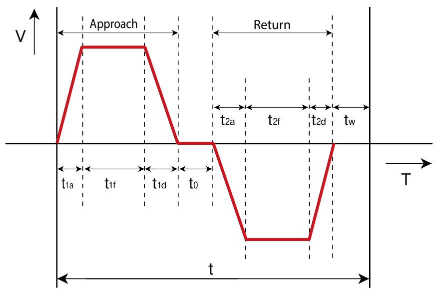


Cautions on Push Motion by Servo Press

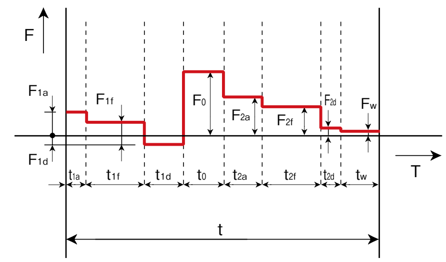
RCS3-RCS2 Series | Servo press specification (with load cell)

Condition 2. Continuous operation thrust

It is confirmed that the continuous operation of the one cycle with load and duty is less than the continuous operation allowable thrust of the actuator. The push operation should be performed once in one cycle.



Regarding the driving pattern on the left,
When rewritten with the vertical axis as thrust,



t	: Operating time of one cycle (s)	t_{2a}	: Acceleration time 2
t_{1a}	: Acceleration time 1	t_{2f}	: Constant speed movement time 2
t_{1f}	: Constant speed movement time 1	t_{2d}	: Deceleration time 2
t_{1d}	: Deceleration time 1	t_w	: Standby time
t_0	: Push operation time * within the range of condition 1		

F_{1a}	: Thrust required for acceleration 1	F_{2a}	: Thrust required for acceleration 2
F_{1f}	: Thrust required for constant speed movement 1	F_{2f}	: Thrust required for constant speed movement 2
F_{1d}	: Thrust required for deceleration 1	F_{2d}	: Thrust required for deceleration 2
F_0	: Thrust required for pressing operation	F_w	: Thrust required for standby

Calculate the continuous operation thrust Ft of one cycle from the following calculation formula.

$$F_t = \sqrt{\frac{F_{1a}^2 \times t_{1a} + F_{1f}^2 \times t_{1f} + F_{1d}^2 \times t_{1d} + F_0^2 \times t_0 + F_{2a}^2 \times t_{2a} + F_{2f}^2 \times t_{2f} + F_{2d}^2 \times t_{2d} + F_w^2 \times t_w}{t}}$$

- Since F1a / F2a / F1d / F2d varies depending on the direction of motion, calculate by the following formula.

In case of horizontal use (common for acceleration / deceleration)	$F_{1a} = F_{1d} = F_{2a} = F_{2d} = (M+m) \times d + F_s$
Horizontal use For constant speed movement	$F_{1f} = F_{2f} = f + F_s$
Horizontal use For standby state	$F_w = 0$
Horizontal use Case of acceleration during descent	$F_{1a} = (M+m) \times 9.8 - (M+m) \times d + F_s$
Vertical use Case of constant speed movement during descent	$F_{1f} = (M+m) \times 9.8 + \alpha(^{*1}) + F_s$
Vertical use Case of deceleration during descent	$F_{1d} = (M+m) \times 9.8 + (M+m) \times d + F_s$
Vertical use Case of acceleration during ascent	$F_{2a} = (M+m) \times 9.8 + (M+m) \times d + F_s$
Vertical use Case of constant-speed movement during descent	$F_{2f} = (M+m) \times 9.8 + \alpha(^{*1}) + F_s$
Vertical use Case of deceleration during descent	$F_{2d} = (M+m) \times 9.8 - (M+m) \cdot d + F_s$
Vertical use Case of standby state	$F_w = (M+m) \times 9.8$

M: Weight of moving part (kg)
m: Load weight (kg)
d: Command acceleration / deceleration (m/s²)
α: Thrust considering running resistance of the external guide
f: Running resistance (N) generated when an external guide or the like is attached
Fs: For RA15R, 20R only Please calculate the thrust for each speed from the table below

* 1 When installing an external guide etc., it is necessary to consider running resistance f.

Actuator	Mass of moving part
RA6R	2.5kg
RA7R	3.5kg
RA8R	4kg
RA10R	5kg
RA13R	9kg
RA15R	10kg
RA20R	18kg

RCS3-RA15R		RCS3-RA20R	
Speed [mm/s]	Fs [N]	Speed [mm/s]	Fs [N]
0～180	0	0～40	0
181～190	625	41～50	1875
191～200	1250	51～60	3750
201～210	1875	61～70	5625
211～220	2500	71～80	7500
221～230	3125	81～90	9375
231～240	3750	91～100	11250
		101～110	13125
		111～120	15000
		121～130	16875
		131～140	18750
		141～150	20625
		151～160	22500
		161～170	24375
		171～180	26250
		181～220	27500

RCS3-RCS2 Series | Servo press specification (with load cell)

- t□a is the acceleration time, but the calculation method differs depending on the ① trapezoidal pattern ② triangular pattern of the motion pattern. The difference between the trapezoidal pattern and the triangular pattern can be judged by operating the moving distance at the set speed, depending on whether the arrival speed is higher or lower than the set speed.

Reaching speed (Vmax) = $\sqrt{\text{moving distance (m)} \times \text{set acceleration (m/s}^2\text{)}}$

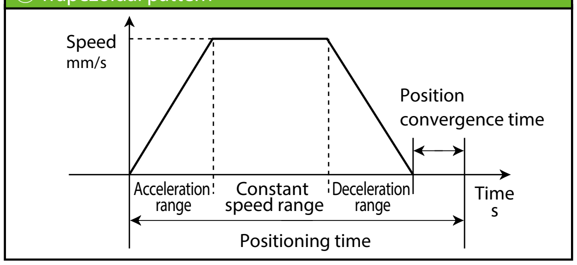
Set speed < Arrival speed ① Trapezoidal pattern

Setting speed > Arrival speed ② Triangular pattern

① In case of trapezoidal pattern

t□a = Vs/a Vs: set speed (m/s) a: command acceleration (m/s²)

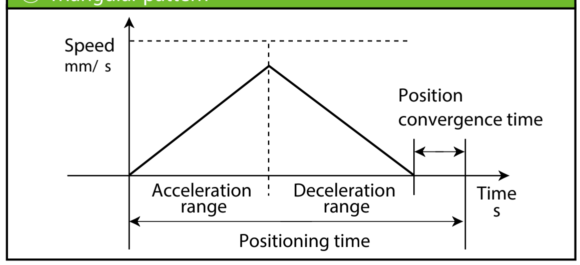
① Trapezoidal pattern



② In case of triangular pattern

t□a = Vt/a Vt: arrival speed (m/s) a: command acceleration (m/s²)

② Triangular pattern



- t□f is the constant-speed movement time. Calculate by calculating the constant speed moving distance.

t□f = L_c/V L_c : Constant speed moving distance (m) V: Command speed (m/s)

* Constant speed movement distance = movement distance - acceleration distance - deceleration distance
acceleration distance (deceleration distance) = $V^2/2a$

- t□d is the deceleration time, but it is the same as the acceleration time if the acceleration and deceleration are the same.

t□d = V/a V: Set speed (trapezoidal pattern) or reaching speed (triangular pattern) (m/s) a: Command deceleration (m/s²)

[RCS 3 - RA 15 R / RA 20 R only]

- Calculate average speed. The average speed is given by the following equation.

$$v_t = \frac{0.5 \cdot v_1 \cdot t_{1a} + v_1 \cdot t_{1f} + 0.5 \cdot v_1 \cdot t_{1d} + 0.5 \cdot v_2 \cdot t_{2a} + v_2 \cdot t_{2f} + 0.5 \cdot v_2 \cdot t_{2d}}{t}$$

v_1 : Constant velocity speed at approach
v_2 : Constant velocity at return (during trapezoidal pattern)
Arrival speed (in triangular pattern)

Then, calculate the final continuous operation thrust from the calculated continuous operation thrust Ft and average speed vt.

$$F = F_t + v_t \cdot K$$

The coefficient K is selected from the table below.

Model	Coefficient K
RA15R	150
RA20R	412.5

Please confirm that the calculated continuous operation thrust Ft (F in the case of RA15R, 20R, calculated by the above formula) is smaller than the continuous operation allowable thrust.
The permissible thrust of continuous operation of this product is as follows.

Model	Allowable continuous thrust force [N]
RA6R-LC	420
RA7R-LC	600
RA8R-LC	1000
RA10R-LC	2100
RA13R-LC	1t 5100
	2t 10200
RA15R-LC	13500
RA20R-LC	22500

I* 2 Use RA13R at duty 50% or less.

If conditions can not be satisfied, take measures such as shortening the pressing time or prolonging the waiting time.

Cautions on Push Force Motion by Rod Type

RCS3-RCS2 Series | Servo press specification (without load cell)

RCS2

RA13R This is the same condition as the rod type with load cell for servo press.
See P1-273 to P1-276.

RCS3

It is required to meet the following two conditions bellow when using this model.

Condition 1. Push force time must be less than or equal to the specified time.

Condition 2. Operation duty is less than usable duty depending on the operating conditions (Payload, speed).

Condition 3. The push forceoperation should be performed once in one cycle.

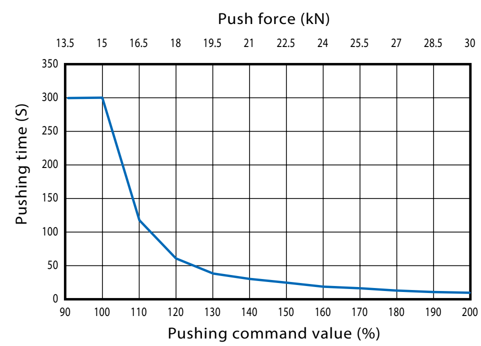
■ Selection method

Condition 1. Push force time

The maximum push force time for each push command value is determined as shown in the table below. Be sure to use the pressing time below the time shown in the table below.
Please pay attention that malfunction may occur in the actuator if you use it without following the table below.

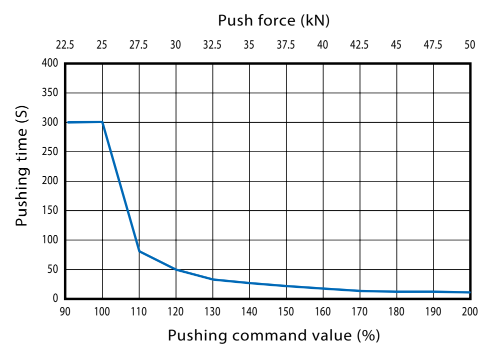
RA15R

Push command value (%)	Maximum pressing time (S)
90 or less	Capable of continuous pushing
91-100	300
110	118
120	58
130	40
140	30
150	25
160	20
170	16
180	13
190	10
200	9



RA20R

Push command value (%)	Maximum pressing time (S)
90 or less	Capable of continuous pushing
91-100	300
110	80
120	50
130	36
140	28
150	22
160	18
170	15
180	13
190	11
200	10



RCS3-RCS2 Series Rod type (without load cell)

Condition 2. Duty

Duty refers to the operating rate of the actuator (the time during which the actuator is operating during one cycle).
The standard of the usable duty varies depending on the operating conditions (conveying mass, acceleration /deceleration etc.).
From the combination of the maximum speed and the payload within one cycle, check the following graphs for the usable duty, and operate below the usable duty.

<Example>
If the speed and payload change in reciprocating motion, check with a large value.

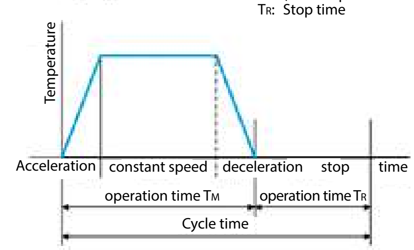
	Forward	Backward
Speed	Small value	Large value
Payload quantity	Large value	Small value

Please check from the following graph with this combination of values.

[Duty ratio]
The duty ratio is the operating rate in% of the time the actuator is operating in one cycle.

$$D = \frac{T_M}{T_M + T_R} \times 100\ (\%)$$

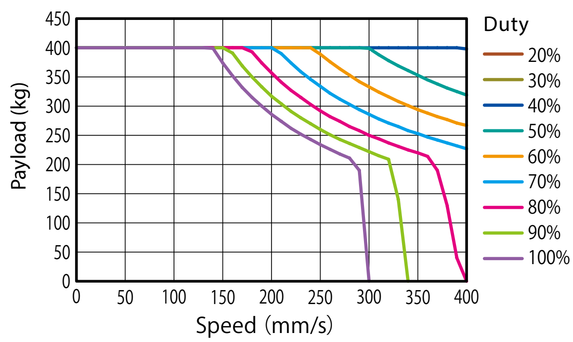
D: Duty
TM: operating time (include push force time)
TR: Stop time



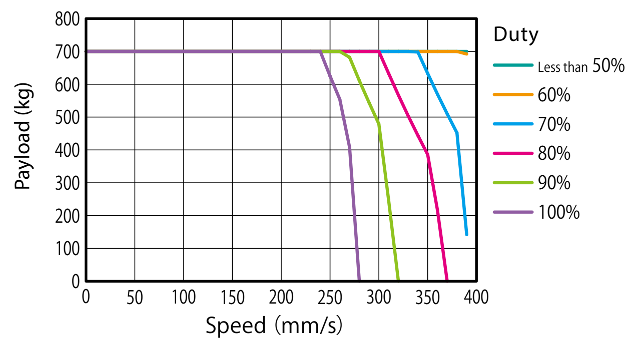
RCS3

RA15R

[Vertical installation]



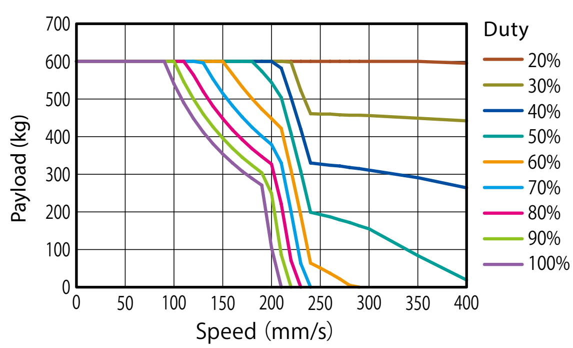
[Horizontal installation]



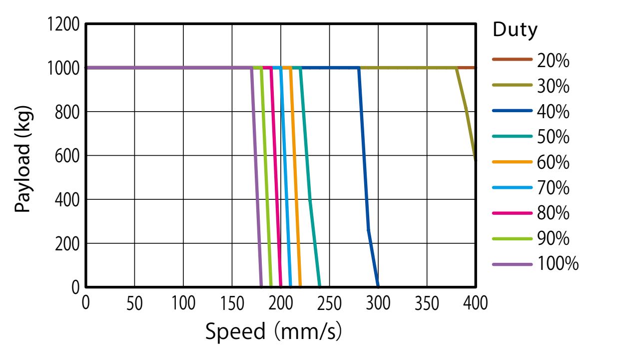
* The graph above shows the case where two external regenerative resistors are installed.
The number of regenerative resistance units (RESU - 35T) can be reduced by payload, speed, and duty.
For details, please contact our sales representative.

RA20R

[Vertical installation]



[Horizontal installation]



* The graph above shows the case where two external regenerative resistors are installed.
The number of regenerative resistance units (RESU - 35T) can be reduced by payload, speed, and duty.
For details, please contact our sales representative.

Information on Moment Selection (RCS3·RCS2)

RCS3-RCS2 Series Rod type (without load cell)

RCS2

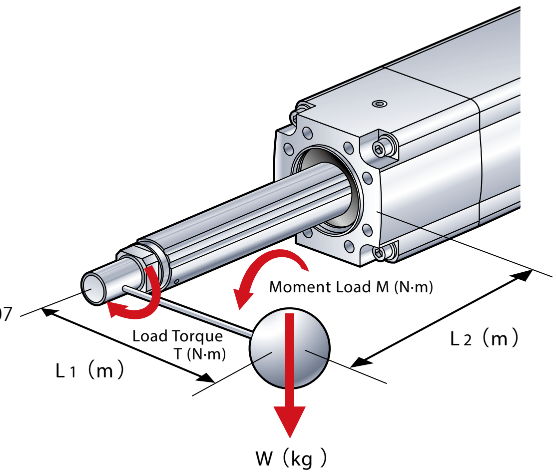
RA13R This can apply a load on the rod within the range of conditions calculated below.

RCS 2 - RA 13 R (without load cell) can apply a load on the rod within the range of conditions calculated below.

M+T ≦ 120（N・m）
Moment Load M = Wg × L2
Load Torque T = Wg × L1

* g = gravitational acceleration 9.8
* L1 = Distance from rod center to work center of gravity
* L2 = Distance from actuator mounting surface to work center of gravity + 0.07

If the above conditions are not satis ed, please pay attention so that no load is applied to the rod by providing guides to the outside.



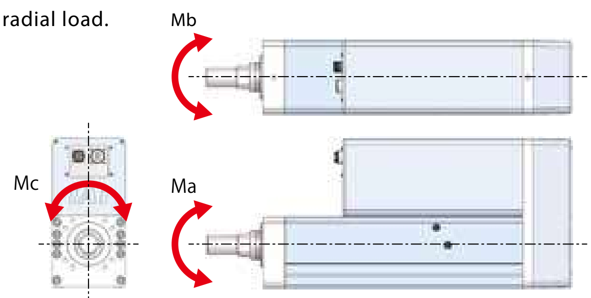
RCS3

RCS3-RA15R/RA20R The load can be applied to the rod within the following two conditions.

Condition 1. The radial load applied is less than the allowable maximum radial load.

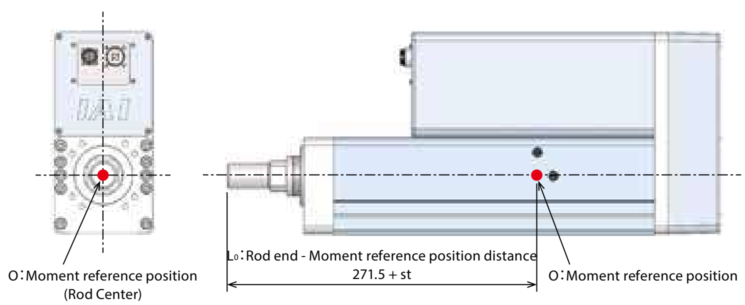
Condition 2. The moment applied should meet the following formula.

M ≧ Ma + Mb + K・Mc
M: Allowable moment (see table below)
Ma, Mb, Mc: Load moment (see the right figure)
K: Equivalent coefficient
RCS3-RA15R：0.36
RCS3-RA20R：0.37



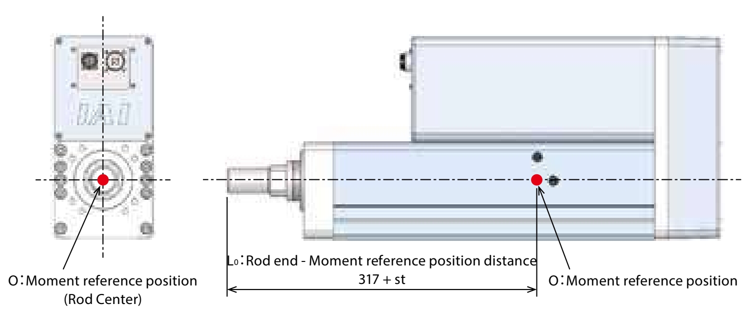
■RCS3-RA15R

Stroke (mm)	100	200	300	400	500
Maximum allowable Radial load (N)	392				
Allowable moment (Nm)	140	135	130	125	120



■RCS3-RA20R

Stroke (mm)	100	200	300	400	500
Maximum allowable Radial load (N)	540				
Allowable moment (Nm)	230	220	210	200	190



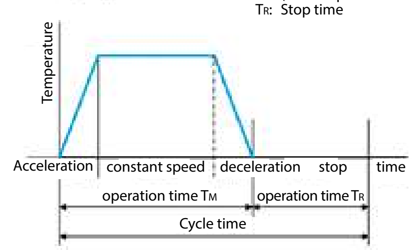
About Duty Ratio

Duty ratio refers to the operating rate of the actuator (the time during which the actuator is operating for one cycle).
Note that the calculation method of the duty ratio is different between the stepper motor type and the AC servo motor type actuator.

[Duty ratio]
The duty ratio is the operating rate in% of the time the actuator is operating in one cycle.

$$D = \frac{T_M}{T_M + T_R} \times 100\ (\%)$$

D: Duty
T_M: operating time (include push force time)
T_R: Stop time

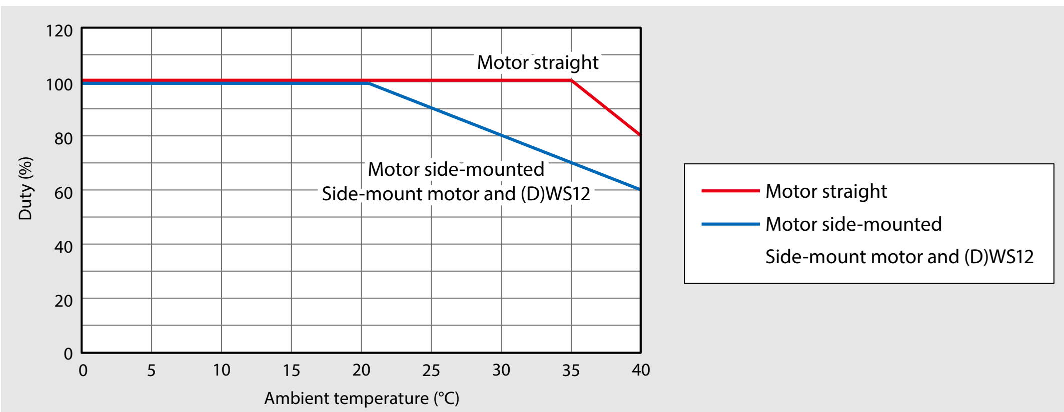


<Pulse motor>
The stepper motor can be operated at the duty ratio of 100%.
For models that require duty ratio restrictions, see the following.

In the case of EC

The duty ratio of the (D)S3(□CR), (D)S4(□CR), (D)RR3, (D)RR4, RP, GS, GD, TC and TW is 100% at an ambient temperature of 0-40°C.

■ Relationship between ambient temperature and duty ratio



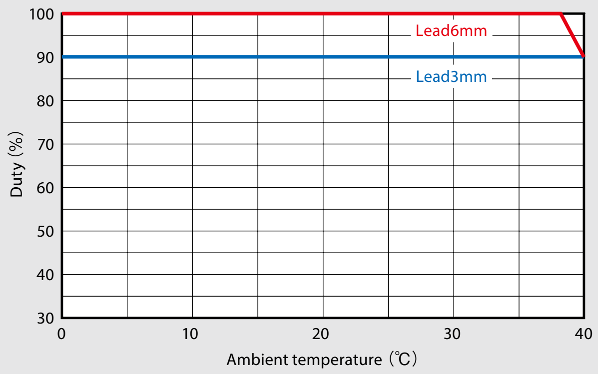
In the case of RCP 6 S (CR)

Duty ratio by type

RCP6S series	Duty ratio
□35 pulse motor type SA4 / RRA4 / RA4 / TA4 / WSA10 / WRA10 (Motor straight / Motor turn back common)	100%
□42 pulse motor type SA6 / RRA6 / RA6 / TA6 / WSA12 / WRA12 (Motor straight / Motor turn back common)	See graph on P1-281
□56 pulse motor type SA7 / RRA7 / RA7 / TA7 / WSA14 / WRA14 (Motor straight / Motor turn back common)	See graph on P1-281
□56 High Thrust Pulse Motor Type SA8 / WSA 16 (Motor straight / Motor turn back common)	100%
□60 High Thrust Pulse Motor Type RRA 8 / RA 8 / WRA 16 (Motor straight / Motor turn back common)	70%

About Duty Ratio

■ Relationship between ambient temperature and duty ratio of 42 pulse motor type.

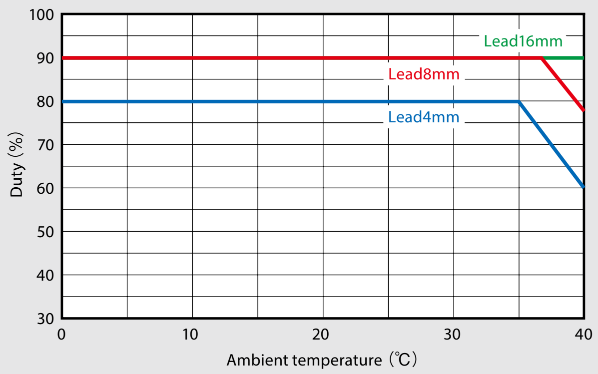


□42 pulse motor type
SA6/RRA6/RA6/TA6/WSA12/WRA12
(Common in motor straight / motor side-mounted)

Lead	3mm	6mm	12mm/20mm
Limit on duty ratio	90% or less	38°C or less 100% 40°C 90% or less	100%

(Note) There is no 20mm for RCP6W.

■ Relationship between ambient temperature and duty ratio of 56 pulse motor type (except for high-thrust motor).



□56 pulse motor type
SA7/RRA7/RA7/TA7/WSA14/WRA14
(Common in motor straight / motor side-mounted)

Lead	4mm	8mm	16mm	24mm
Limit on duty ratio	35°C or less 80% 40°C 60% or less	37°C or less 90% 40°C 78% or less	90% or less	100%

(Note) There is no 24mm for RCP6W.

<AC servomotor>

Since the guideline of the usable duty ratio varies depending on the operating conditions (payload, acceleration/deceleration etc.), calculate the load factor, LF, and the acceleration/deceleration time ratio, tod, from the following calculation formula and obtain it from the graph.

❶ Calculate the load factor LF from the following formula.

The load factor LF calculation formula varies depending on the model. Please check the target model and calculate the load factor.

1 In case of IF/RCA/RCA2/RCS2 series

Ⓐ Load factor: $LF_{①} = \dfrac{M \times \alpha}{M_1 \times \alpha_1}$ (%)

· Payload capacity at rated acceleration : M1
· Rated acceleration / deceleration : $\alpha 1$
· Actual carrying mass : M ($M \leqq M1$)
· Command acceleration / deceleration : α ($\alpha \leqq \alpha 1$)

(Note) Please refer to model / spec table of each model for payload capacity and rated acceleration / deceleration at rated acceleration / deceleration.

When operating under the following operating conditions, the load factor is as follows.

<Example 1>
Actual conveying mass : 5 kg
Command acceleration / deceleration : 0.3 G
Load capacity at rated acceleration / deceleration : 5 kg
Rated acceleration / deceleration : 0.3 G
Load factor: LF ① = 100%

<Example 2>
Actual conveying mass : 2.5 kg
Command acceleration / deceleration : 0.3 G
Load capacity at rated acceleration / deceleration : 5 kg
Rated acceleration / deceleration : 0.3 G
Load factor: LF ① = 50%

<Example 3>
Actual conveying mass : 5 kg
Command acceleration / deceleration : 0.15 G
Load capacity at rated acceleration / deceleration : 5 kg
Rated acceleration / deceleration : 0.3 G
Load factor: LF ① = 50%

2 In case of IS(P)B/SSPA/IS(P)A/IS(P)DB/NSA/NS/IS(P)DBCR/SSPDACR/IS(P)DACR/RCS4/RCS3/TTA series

Acceleration / deceleration above the rating is set for the above compatible models.
Depending on command acceleration / deceleration, the calculation formula to be used is different.

(1) When the specified acceleration/deceleration is less than the rated values, use the above formula Ⓐ.
(2) When the command acceleration / deceleration is not less than the rated acceleration / deceleration, please use calculation formula Ⓑ.

Ⓑ Load factor: $LF_{②} = \dfrac{M \times \alpha}{M_2 \times \alpha} = \dfrac{M}{M_2}$ (%)

· Actual conveying mass : M
· Command command acceleration / deceleration : α
· Payload quantity of command acceleration / deceleration : M 2 ($M \leqq M2$)

(Note) For payload capacity corresponding to acceleration / deceleration and acceleration / deceleration of each model, please refer to the acceleration weighted payload quantity table of each model.

When operating under the following operating conditions, the load factor is as follows.
As an example, we will use the acceleration weighted payload table of "RCS 3 - SA 8 C 150 W Lead 30".

Model	Type	Motor outpu	Lead [mm]	Payload quantity by acceleration [kg]			
				0.3G	0.5G	0.7G	1G
RCS3	SA8C	150W	30	12	10	6	2

(Note) When horizontal use, Low speed acceleration / deceleration 0.3G

<Example 1>
Actual conveying mass : 2 kg
Command acceleration / deceleration : 1.0 G
Payload quantity of command acceleration / deceleration : 2 kg
Load factor: LF ② = 100%

<Example 2>
Actual conveying mass : 5 kg
Command acceleration / deceleration : 0.5 G
Payload quantity of command acceleration / deceleration : 10 kg
Load factor: LF ② = 50%

<Example 2>
Actual conveying mass : 5 kg
Command acceleration / deceleration : 0.5 G
Payload quantity of command acceleration / deceleration : 10 kg
Load factor: LF ② = 50%

About Duty Ratio

3 RCA, RCS 2 For high acceleration / deceleration option use model

Calculate the load factor LF ③ from the calculation formula Ⓒ. Even in case of high acceleration / deceleration specification, the rated acceleration is the same value as the standard specification.

$$\text{Ⓒ Load factor: } LF_{③} = \frac{M \times \alpha_2}{M_1 \times \alpha_1} \%$$

- Actual conveying mass : M
- Command acceleration / deceleration : $\alpha 2$
- Payload quantity at rated acceleration / deceleration : M1
- Rated acceleration / deceleration : $\alpha 1$ (0.3G)

<Example 1>

Actual conveying mass	: 2 kg
Command acceleration / deceleration	: 0.6 G
Load capacity at rated acceleration / deceleration	: 2 kg
Rated acceleration / deceleration	: 0.3 G
Load factor: LF ③	= 200%

<Example 2>

Actual conveying mass	: 1 kg
Command acceleration / deceleration	: 0.9 G
Load capacity at rated acceleration / deceleration	: 2 kg
Rated acceleration / deceleration	: 0.3 G
Load factor: LF ③	= 150%

Maximum acceleration / deceleration by model: α max
($M \leqq M_1$, $\alpha_1 < \alpha_2 \leqq \alpha$ max)

α max (maximum acceleration / deceleration by model) list

Model	Lead	α max
RCA/RCS2-SA4C	10	1
	5	1
RCA/RCS2-SA5C	12	0.8
	6	0.8
RCA/RCS2-SA6C	12	1
	6	1
RCS2-SA7C	16	1
	8	0.8
RCA-RA3C	10	1
	5	1
RCA-RA4C 30W	12	1
	6	1
RCS2-RA5C 100W	16	1
	8	1

❷ Calculate the acceleration / deceleration time ratio tod from the following calculation formula.

* Calculation is not needed for the NSA series. Skip ② and ③. Go to ④.

$$\text{Acceleration / deceleration time ratio: } t_{od} = \frac{\text{Acceleration time} + \text{deceleration time}}{\text{Operating time}} \%$$

$$\text{Acceleration time} = \frac{\text{Speed (mm / s)}}{\text{Acceleration (mm/s}^2\text{)}} \text{(sec)} \quad \text{Deceleration time} = \frac{\text{Speed (mm/s)}}{\text{Deceleration (mm/s}^2\text{)}} \text{(sec)}$$

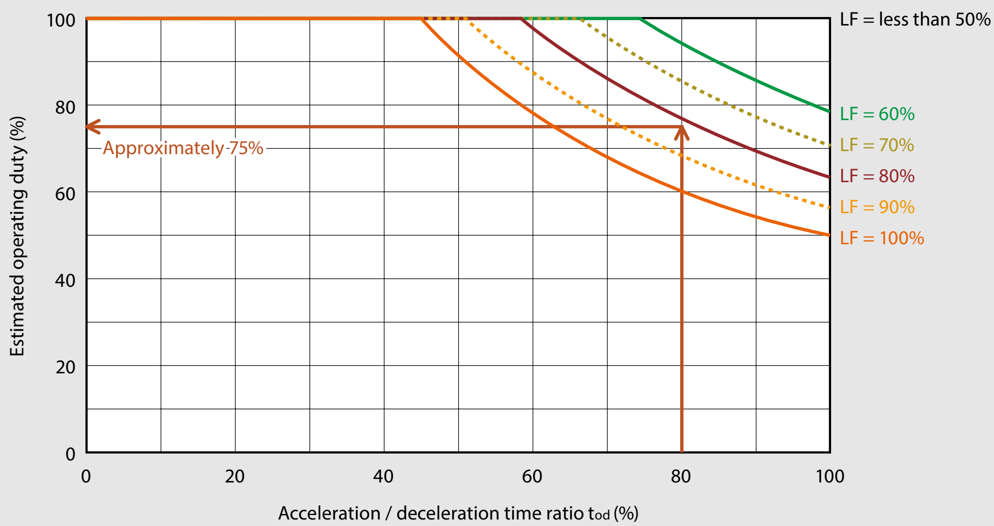
Acceleration (mm/s²) = Acceleration (G) × 9,800mm/s²   Deceleration (mm/s²) = Deceleration (G) × 9,800mm/s²

❸ Read the guideline of duty ratio from the calculated "load factor" and "acceleration/ deceleration time ratio."

For RCA and RCS2 high acceleration / deceleration option use models, use "Duty guide 2 (for high acceleration / deceleration specification)").

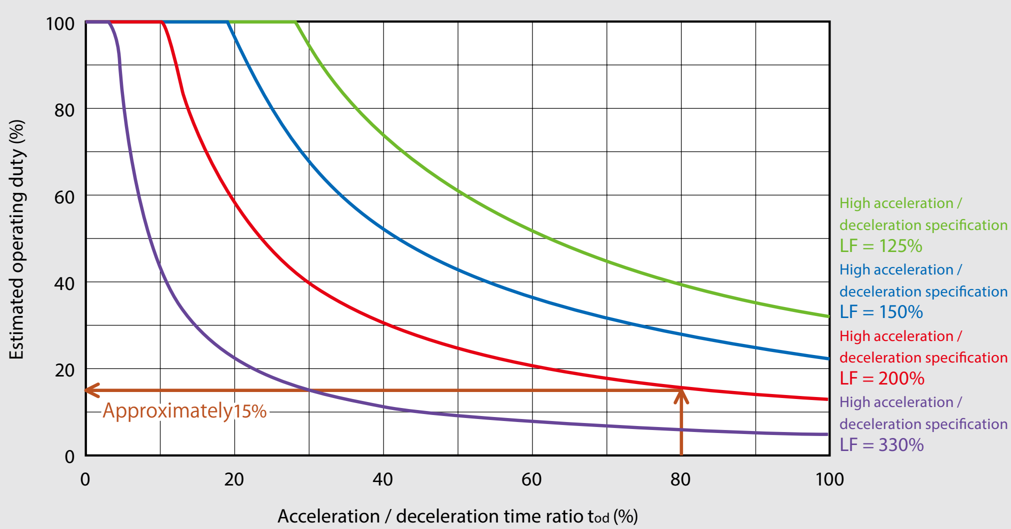
Duty ratio measure guide 1 (for standard use)

Example: When the load factor is 80% and the acceleration / deceleration time ratio is 80%, the guideline for the duty ratio is approximately 75%.



Duty ratio guide 2 (for high acceleration / deceleration specification)

Example: When the load factor is 200% and the acceleration / deceleration time ratio is 80%, the guideline for the duty ratio is approximately 15%.



❹ [NSA series] Confirm the guide duty ratio from the calculated "load factor."

The guide duty ratio of the NSA series is determined according to the load factor, LF, as specified in the table below.

Load factor LF	100%	90%	80%	70%	60%	50% or less
Duty ratio	50%	56%	63%	70%	78%	100%

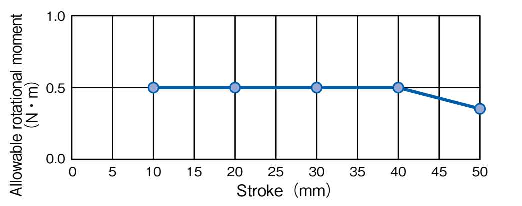
Note: M size lead 30 is operated at duty ratio of 50% regardless of the conditions such as load factor.

Guide-Equipped Type RCA2/RCP2/RCA/RCS2

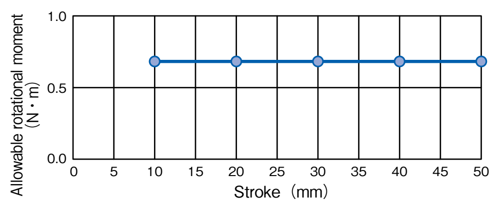
Allowable rotating torque

The allowable torque of each model is as shown below.
When giving rotational torque, please use within the range of the following values. In addition, single guide type can not receive rotational torque.

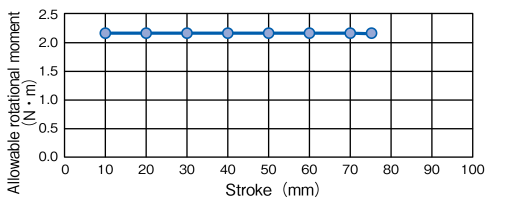
RCA2-GD3NA Type



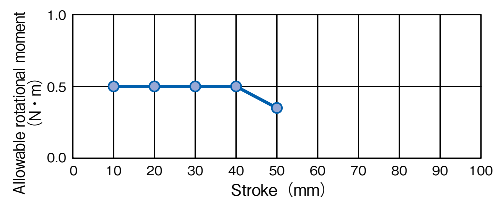
RCA2-GD4NA Type



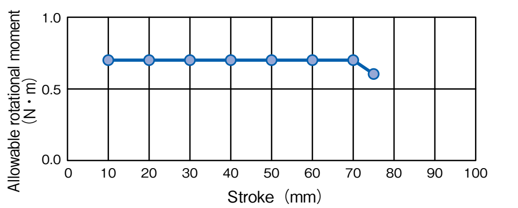
RCS2-GD5N Type



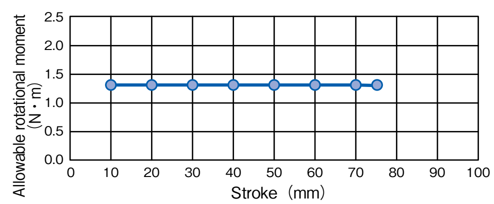
RCA2-SD3NA Type



RCA2-SD4NA Type

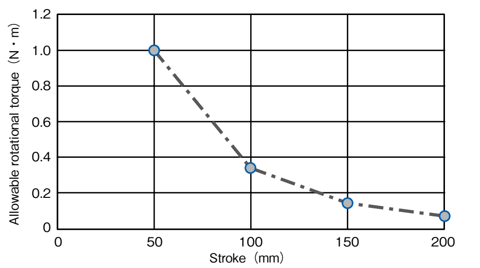


RCS2-SD5N Type



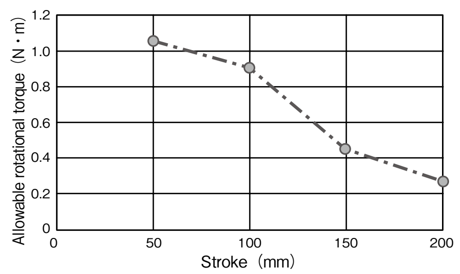
RCA / RCS2-RGD3□ Type

■ Double guide



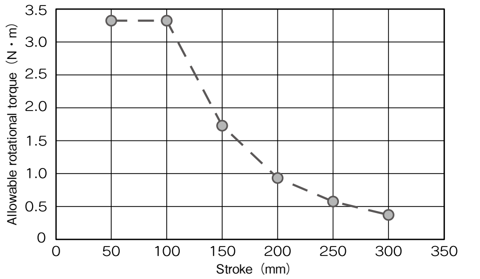
RCS2-RGD4□ Type

■ Double guide



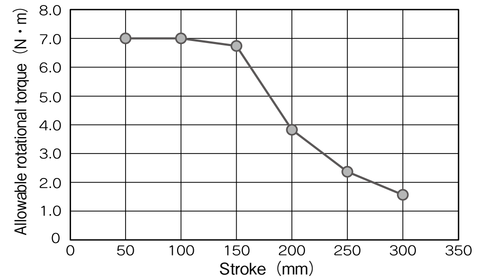
RCS2-RGD5C Type (Double guide specification)

■ Double guide

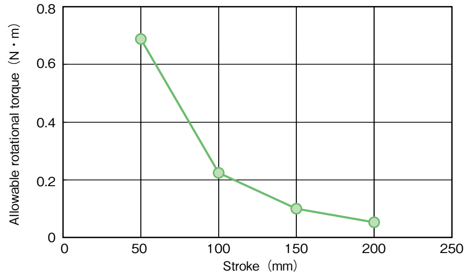


RCS2-SRGD7BD Type

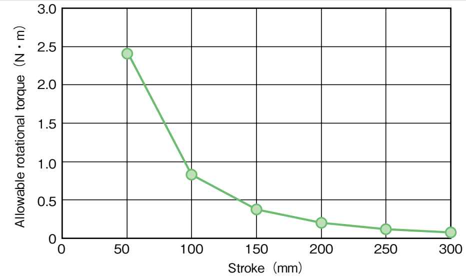
■ Double guide



RCP2-RGD3C Type

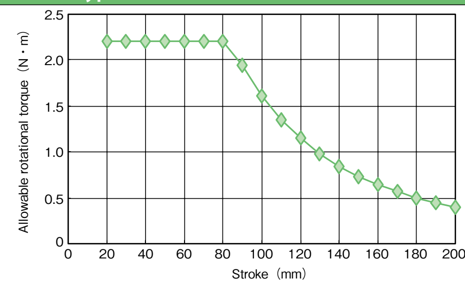


RCP2-RGD4C Type



RCP2-RGD6C Type

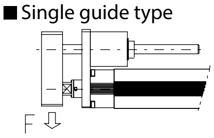
RCP2-SRGD4R Type



Relationship between tip allowable load and running life

The longer the load at the guide tip becomes, the lower its life.
Please select the model considering considering the balance between the load and the life span.

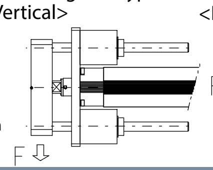
■ Single guide type



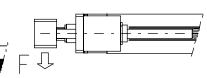
* The single-guide specification can only be used with vertical loads.

■ Double guide type

<Vertical>

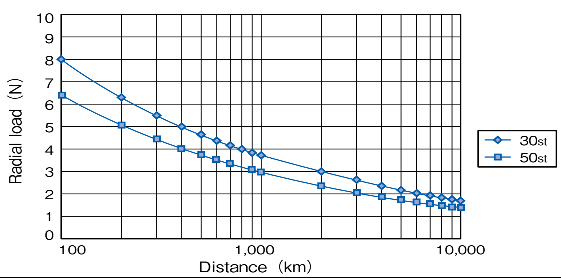


<Horizontal>

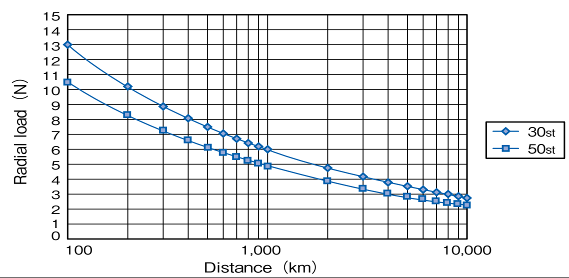


Single guide

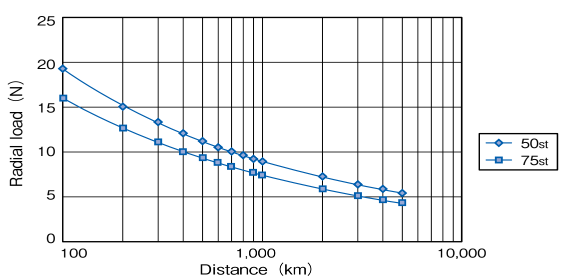
RCA2-GS3NA Type



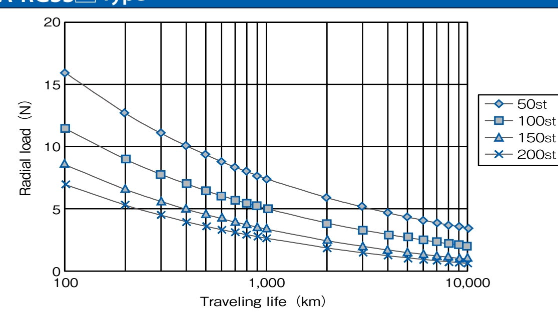
RCA2-GS4NA Type



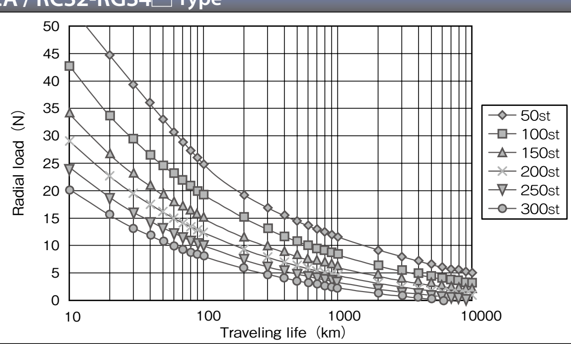
RCS2-GS5N Type



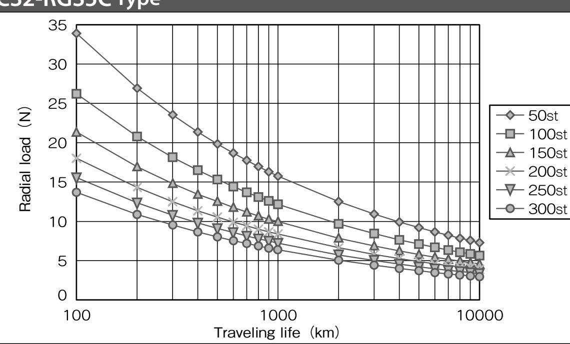
RCA-RGS3□ Type



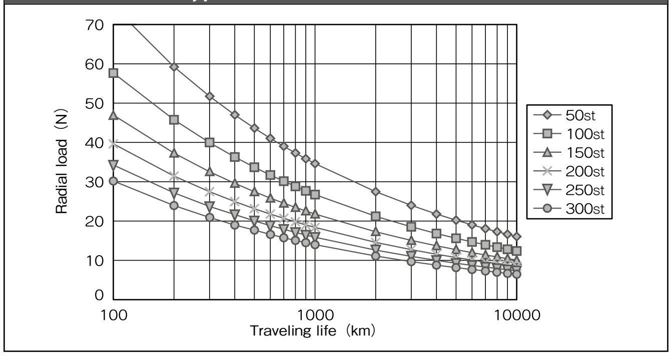
RCA / RCS2-RGS4□ Type



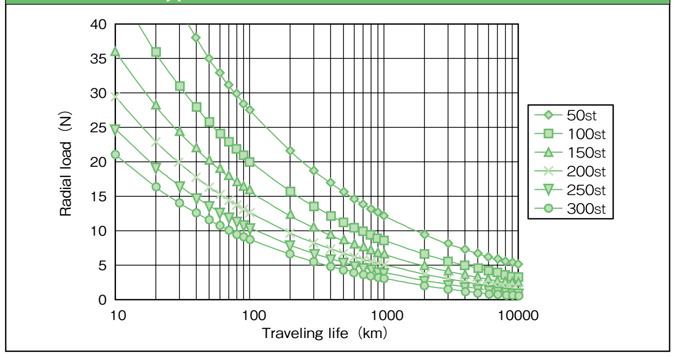
RCS2-RGS5C Type



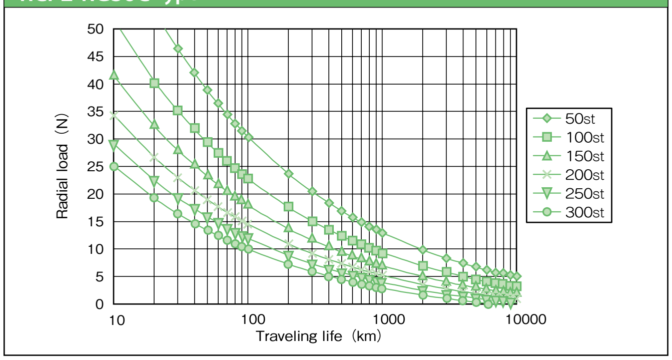
RCS2-SRGS7BD Type



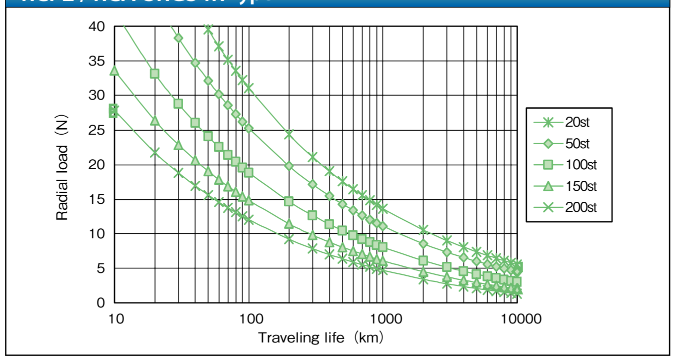
RCP2-RGS4C Type



RCP2-RGS6C Type

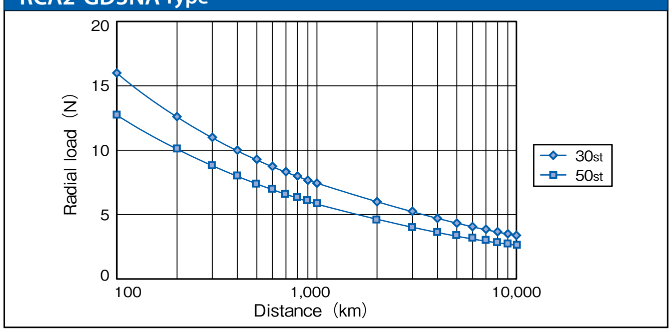


RCP2 / RCA-SRGS4R Type

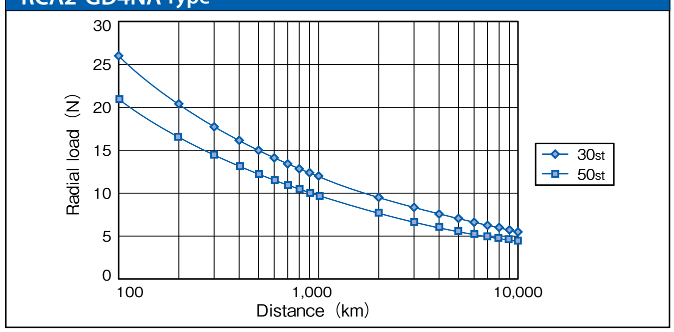


Double guide

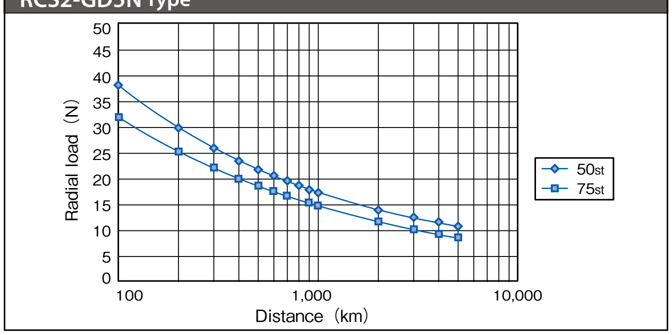
RCA2-GD3NA Type



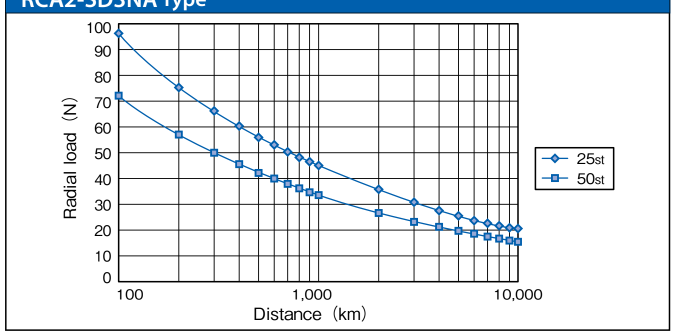
RCA2-GD4NA Type



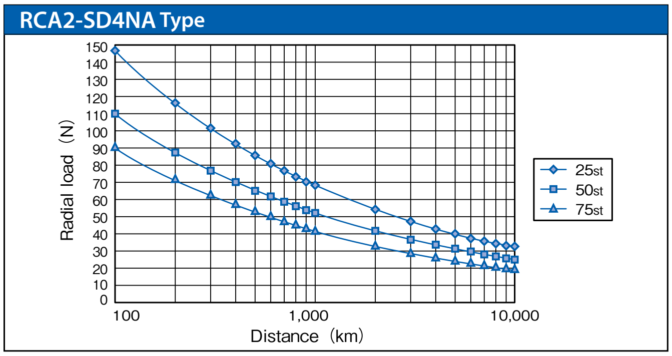
RCS2-GD5N Type



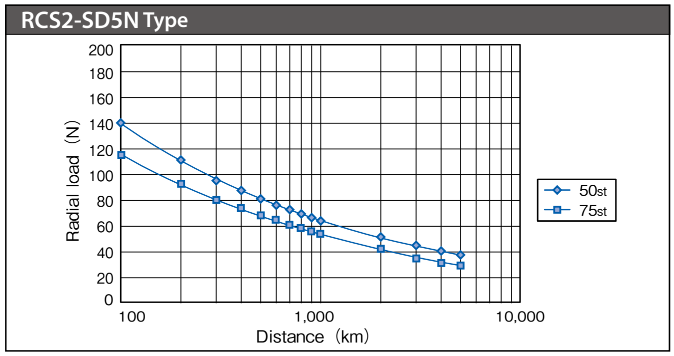
RCA2-SD3NA Type



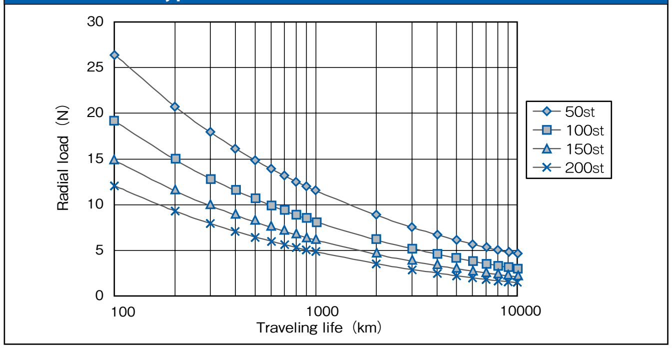
RCA2-SD4NA Type



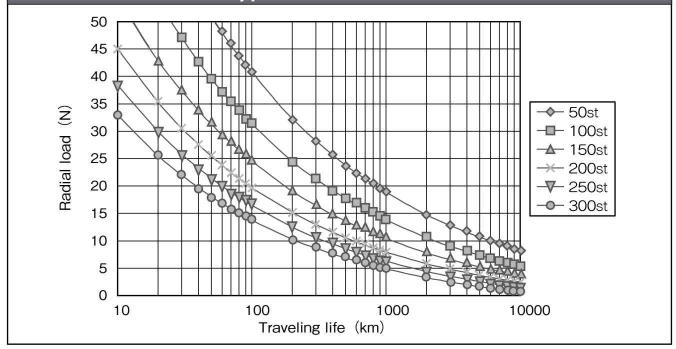
RCS2-SD5N Type



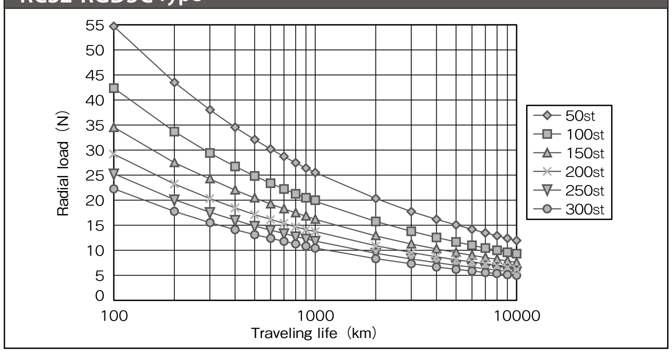
RCA-RGD3□ Type



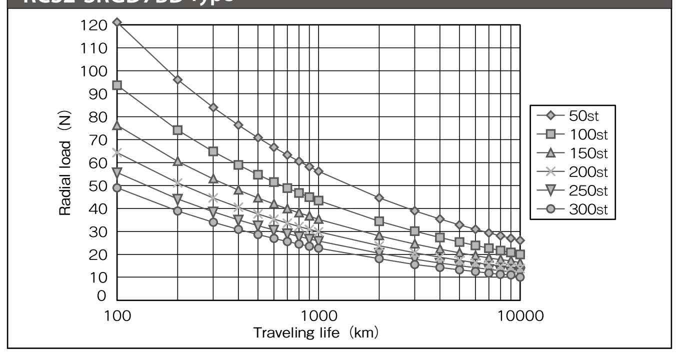
RCA / RCS2-RGD4□ Type



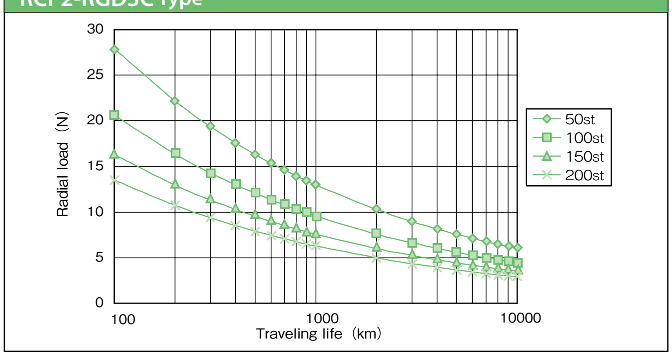
RCS2-RGD5C Type



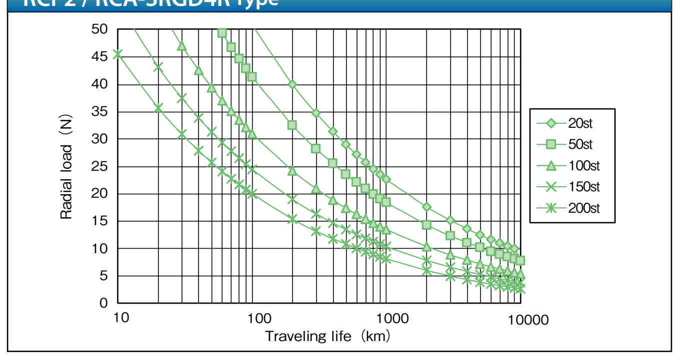
RCS2-SRGD7BD Type



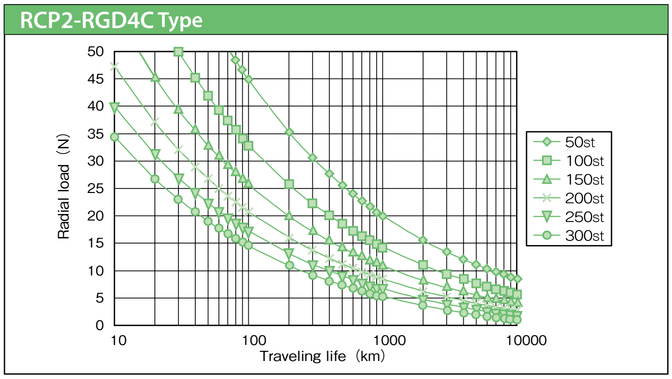
RCP2-RGD3C Type



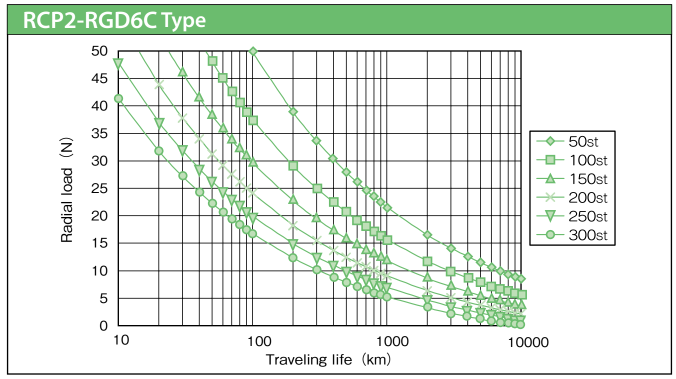
RCP2 / RCA-SRGD4R Type



RCP2-RGD4C Type



RCP2-RGD6C Type

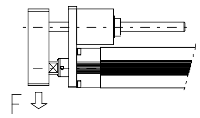


Radial load and tip deflection

It is a correlation diagram between the load applied to the guide tip and the amount of deflection at that time.

Caution
The load on the graph does not show the allowable load. Lifetime greatly decreases as the load increases. Please refer to "Relationship between tip allowable load and running life"

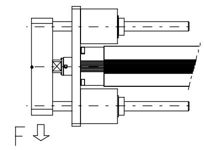
■**Single-guide type**



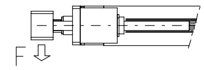
* The single-guide specification can only be used with vertical loads.

■**Double-guide type**

<Vertical>

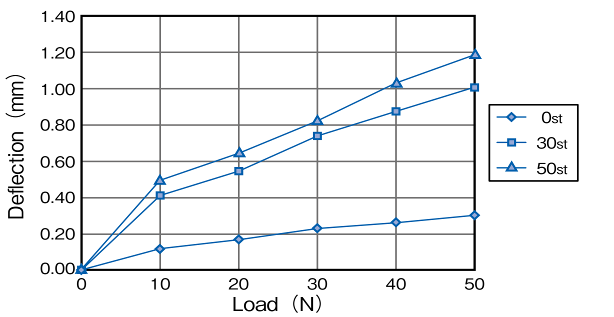


<Horizontal>

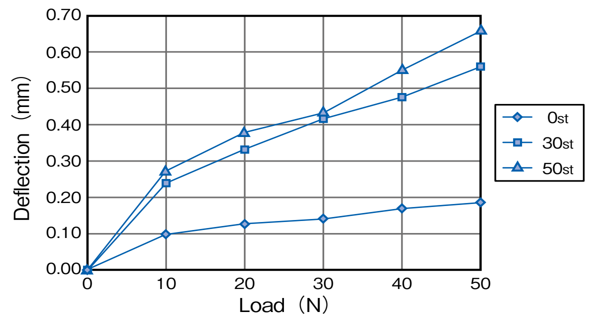


Single guide

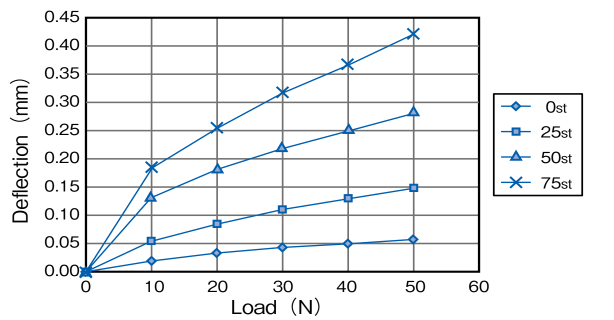
RCA2-GS3NA Type



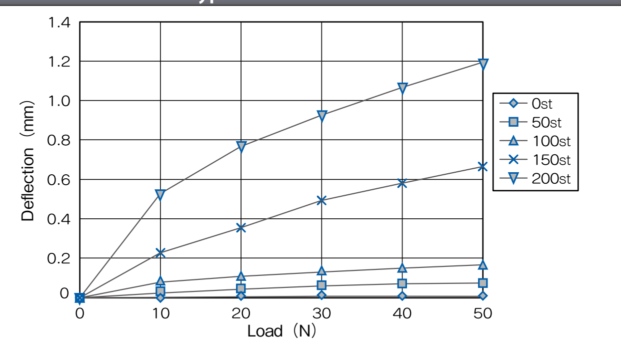
RCA2-GS4NA Type



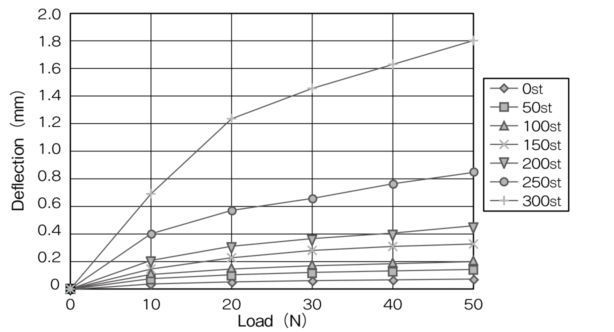
RCS2-GS5N Type



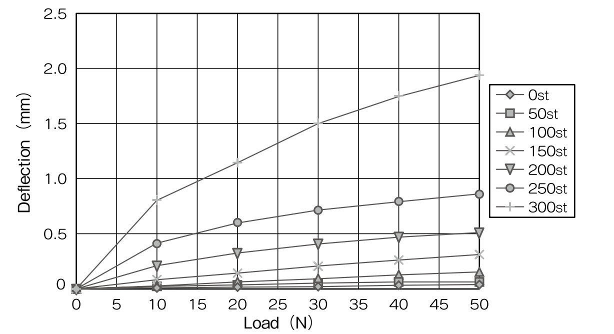
RCA / RCS2-RGS3□ Type



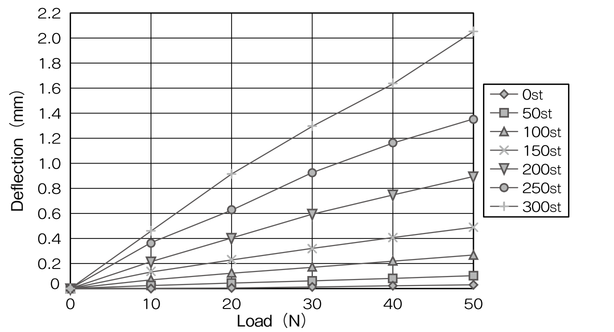
RCS2-RGS4□ Type



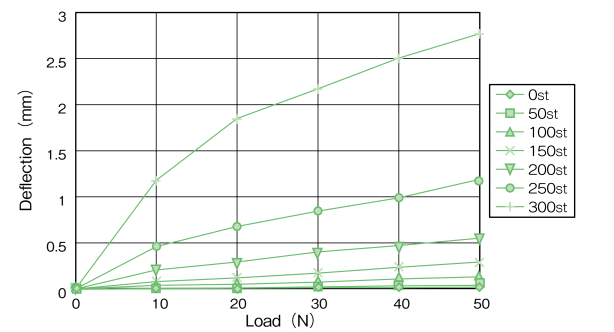
RCS2-RGS5C Type



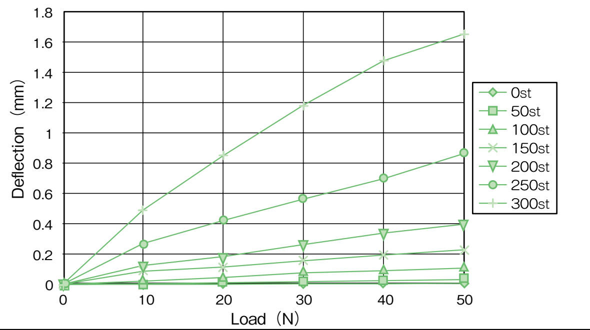
RCS2-SRGS7BD Type



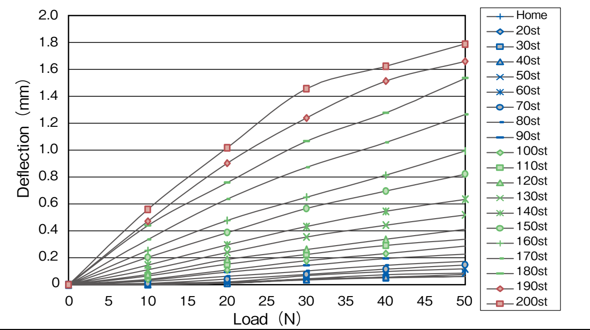
RCP2-RGS4C Type



RCP2-RGS6C Type



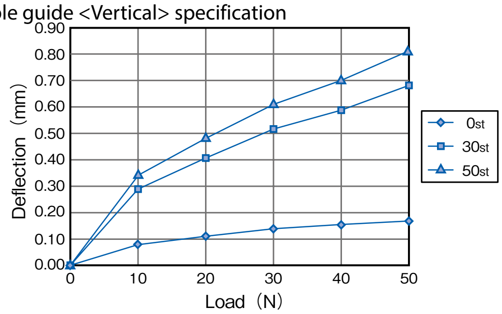
RCP2-SRGS4R Type



Double guide

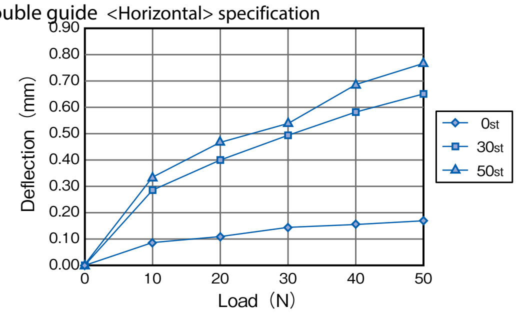
RCA2-GD3NA Type

■ Double guide <Vertical> specification



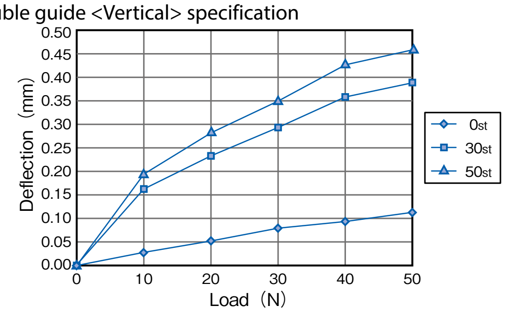
RCA2-GD3NA Type

■ Double guide <Horizontal> specification



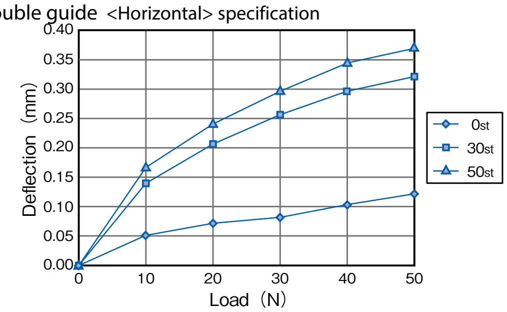
RCA2-GD4NA Type

■ Double guide <Vertical> specification



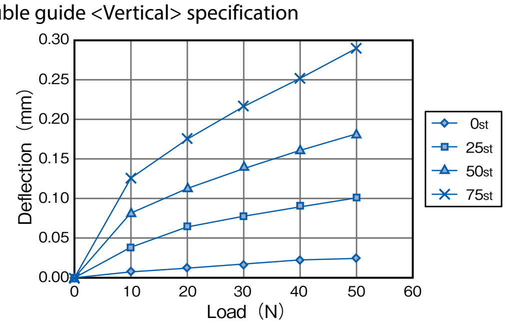
RCA2-GD4NA Type

■ Double guide <Horizontal> specification



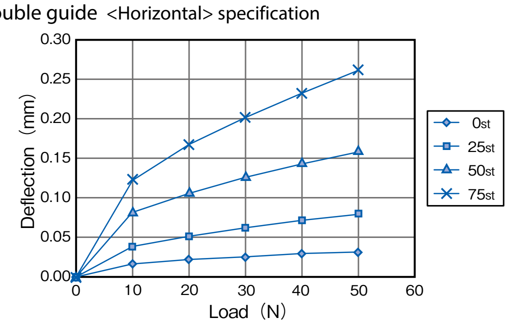
RCS2-GD5N Type

■ Double guide <Vertical> specification



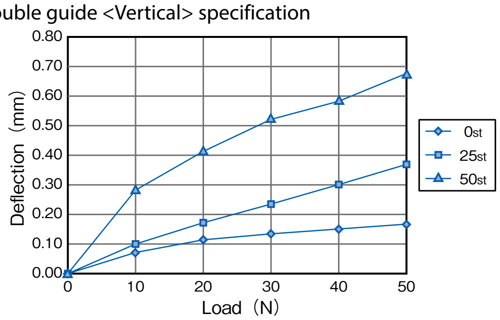
RCS2-GD5N Type

■ Double guide <Horizontal> specification



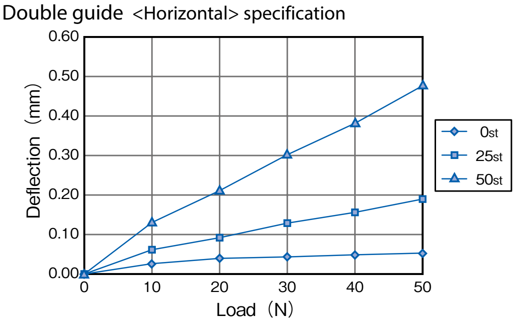
RCA2-SD3NA Type

■ Double guide <Vertical> specification



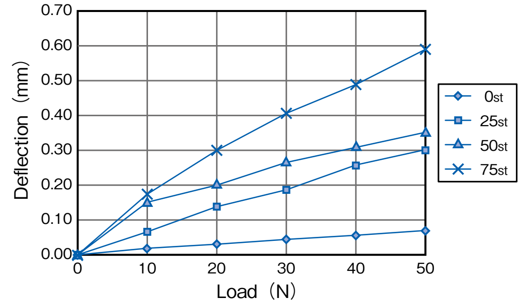
RCA2-SD3NA Type

■ Double guide <Horizontal> specification



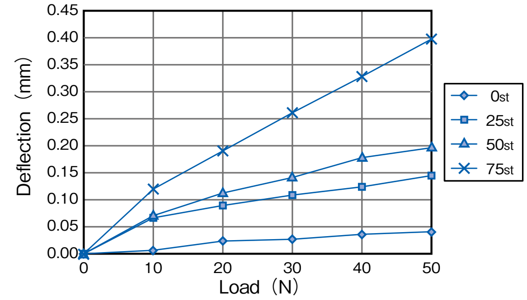
RCA2-SD4NA Type

■Double guide <Vertical> specification



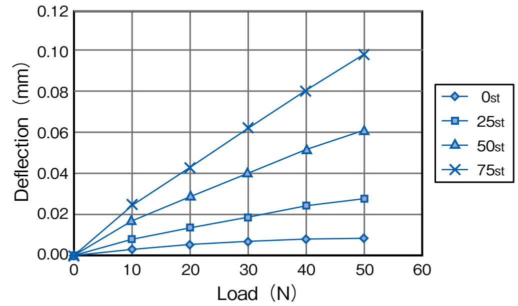
RCA2-SD4NA Type

■Double guide <Horizontal> specification



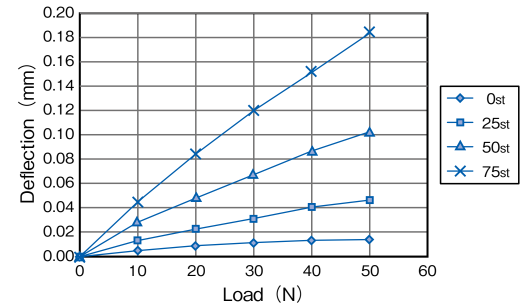
RCS2-SD5N Type

■Double guide <Vertical> specification



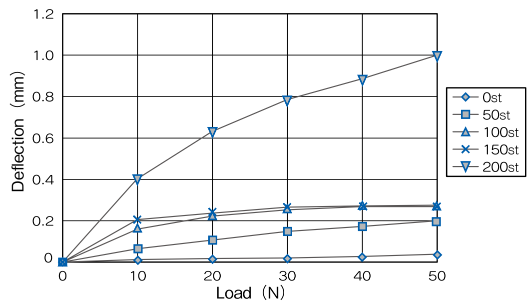
RCS2-SD5N Type

■Double guide <Horizontal> specification



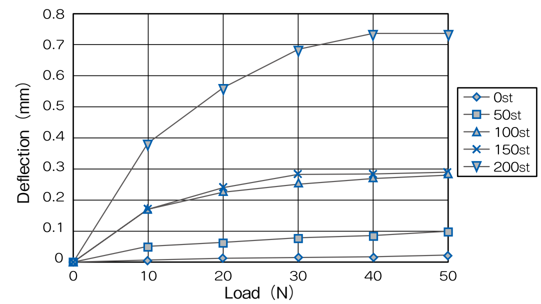
RCA / RCS-RGD3□ Type

■Double guide <Vertical> specification



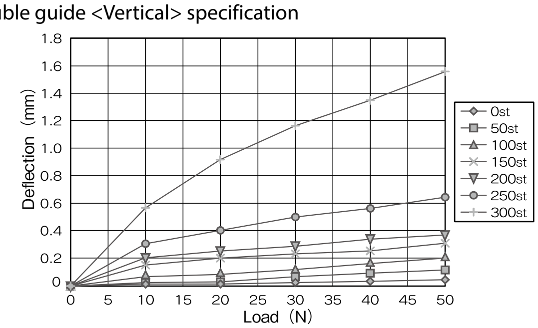
RCA / RCS-RGD3□ Type

■Double guide <Horizontal> specification



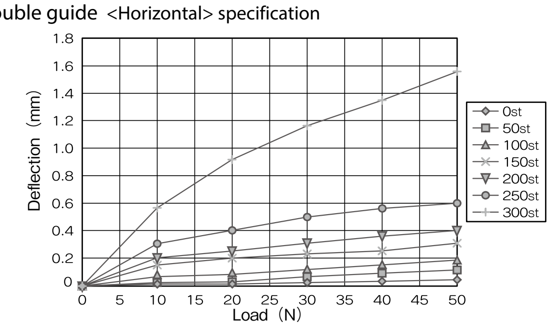
RCS2-RGD4□ Type

■Double guide <Vertical> specification



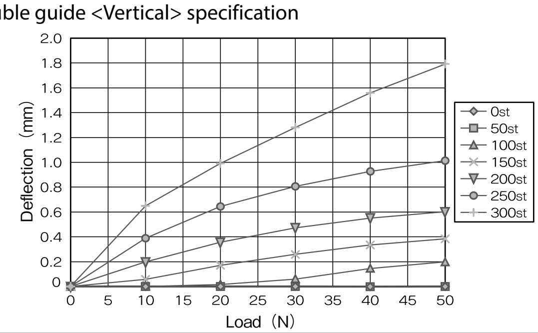
RCS2-RGD4□ Type

■Double guide <Horizontal> specification



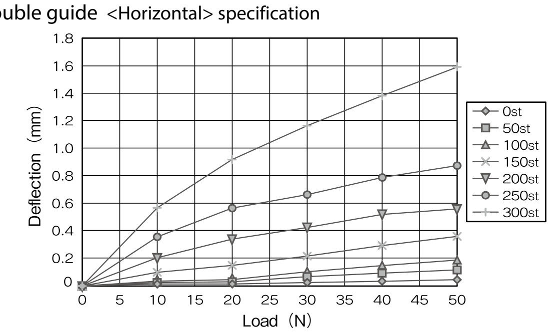
RCS2-RGD5C Type

■Double guide <Vertical> specification



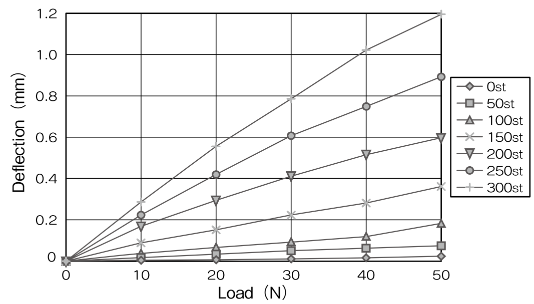
RCS2-RGD5C Type

■Double guide <Horizontal> specification



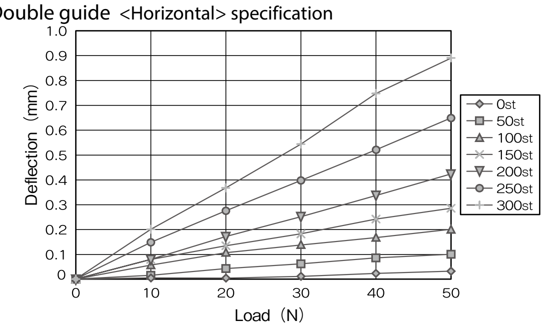
RCS2-SRGD7BD Type

■ Double guide <Vertical> specification



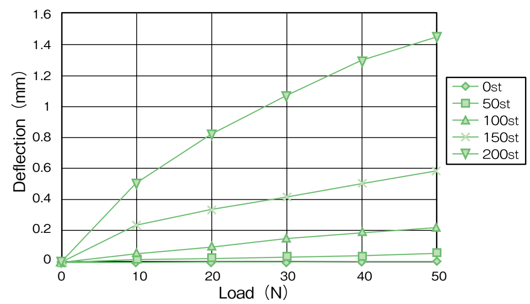
RCS2-SRGD7BD Type

■ Double guide <Horizontal> specification



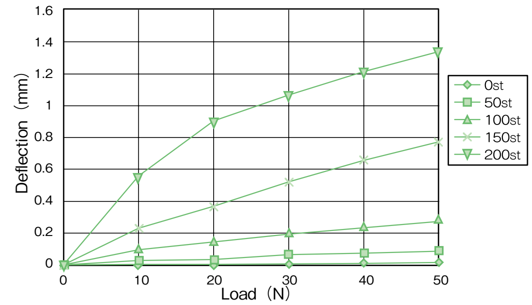
RCP2-RGD3C Type

■ Double guide <Vertical> specification



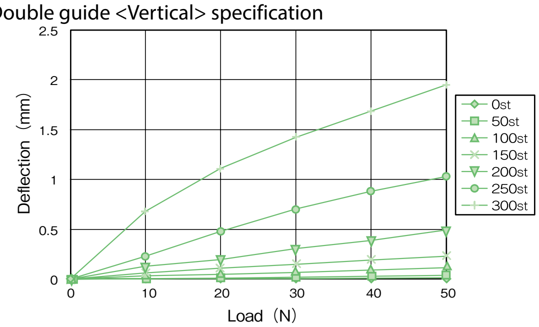
RCP2-RGD3C Type

■ Double guide <Horizontal> specification



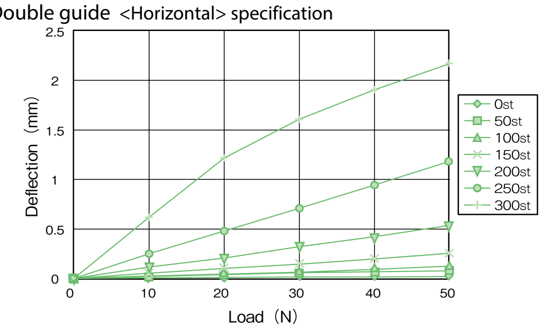
RCP2-RGD4C Type

■ Double guide <Vertical> specification



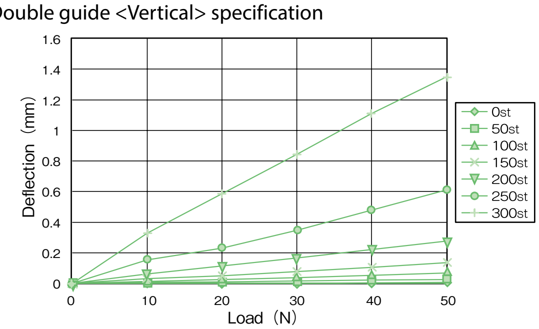
RCP2-RGD4C Type

■ Double guide <Horizontal> specification



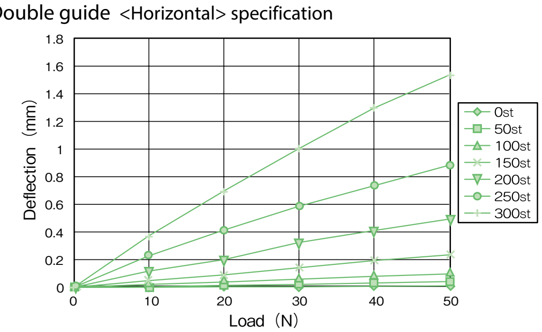
RCP2-RGD6C Type

■ Double guide <Vertical> specification



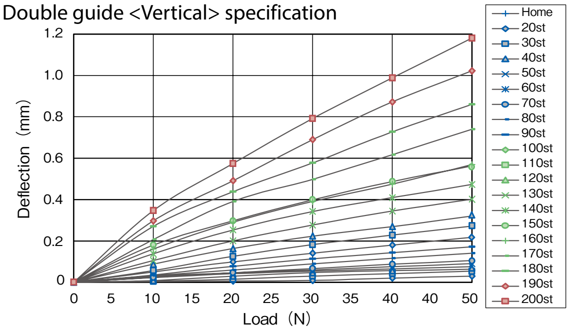
RCP2-RGD6C Type

■ Double guide <Horizontal> specification



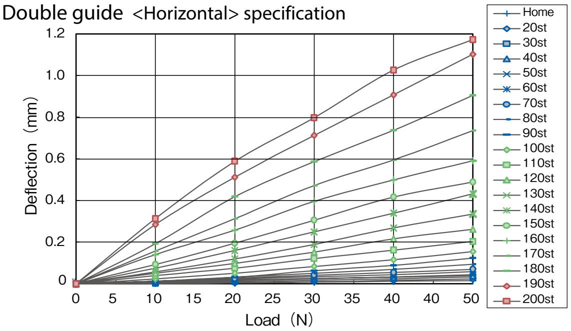
RCP2-SRGD4R Type

■ Double guide <Vertical> specification



RCP2-SRGD4R Type

■ Double guide <Horizontal> specification

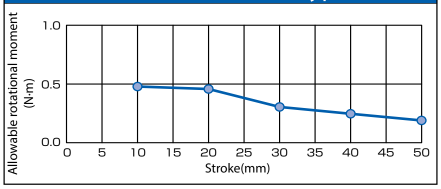


Guide-Equipped Type Technical Reference (CR/W)

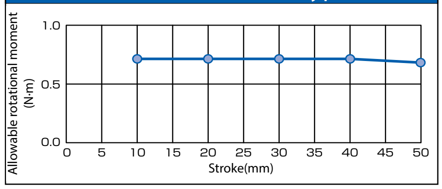
Allowable rotating torque

The allowable torque of each model is as shown below.
When giving rotational torque, please use within the range of the following values. In addition, single guide type can not receive rotational torque.

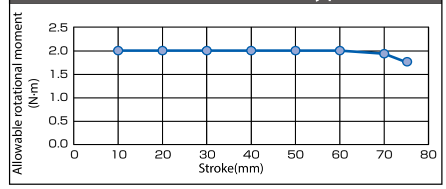
RCA2CR/W-GD3NB Type



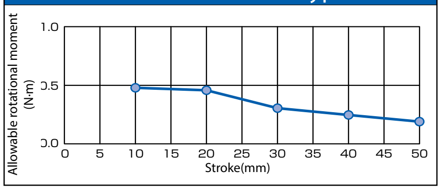
RCA2CR/W-GD4NB Type



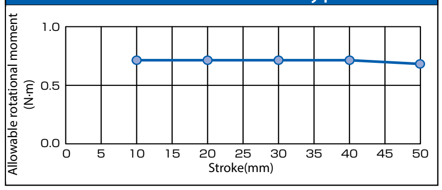
RCA2CR/W-GD5NB Type



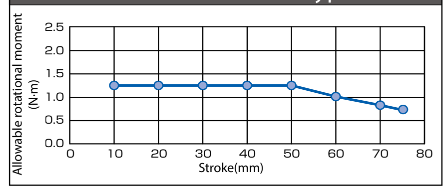
RCA2CR/W-GD3NB Type



RCA2CR/W-GD4NB Type



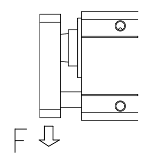
RCA2CR/W-GD5NB Type



Relationship between tip allowable load and running life

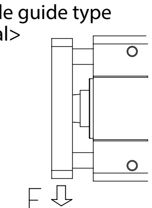
The longer the load at the guide tip becomes, the lower its life.
Please select the model considering considering the balance between the load and the life span.

■ Single guide type

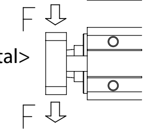


* The single-guide specification can only be used with vertical loads.

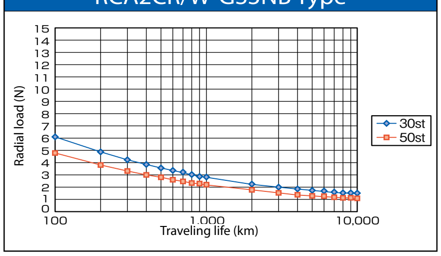
■ Double guide type
<Vertical>



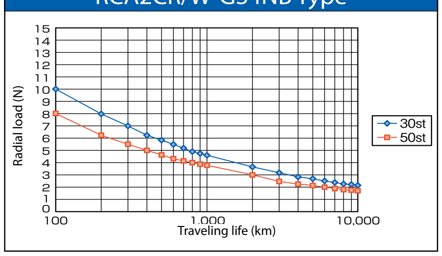
<Horizontal>



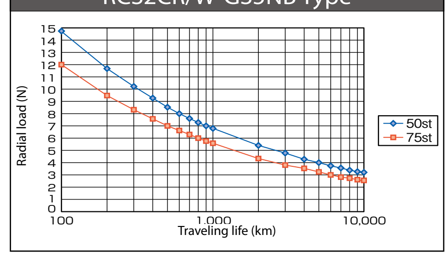
RCA2CR/W-GS3NB Type



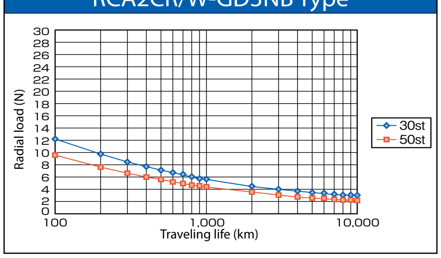
RCA2CR/W-GS4NB Type



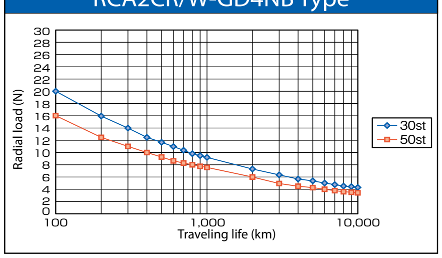
RCS2CR/W-GS5NB Type



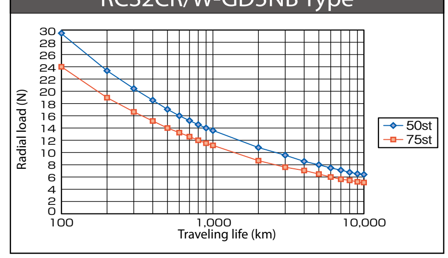
RCA2CR/W-GD3NB Type



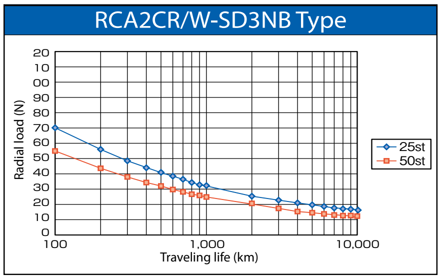
RCA2CR/W-GD4NB Type



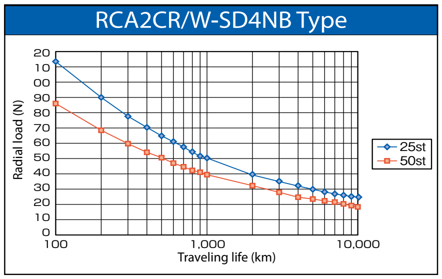
RCS2CR/W-GD5NB Type



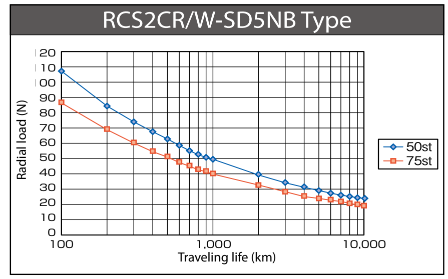
RCA2CR/W-SD3NB Type



RCA2CR/W-SD4NB Type



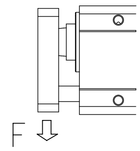
RCS2CR/W-SD5NB Type



Radial load and tip deflection

It is a correlation diagram between the load applied to the guide tip and the amount of deflection at that time.

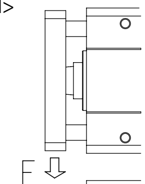
■ Single guide type



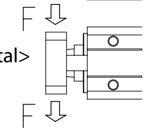
* The single-guide specification can only be used with vertical loads.

■ Double guide type

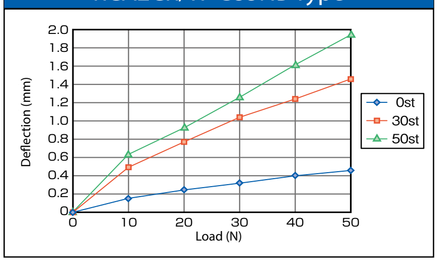
<Vertical>



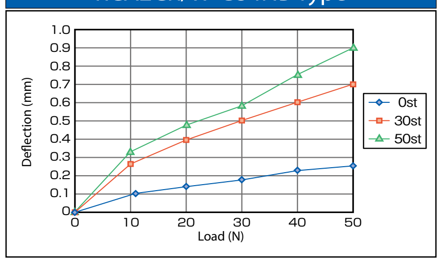
<Horizontal>



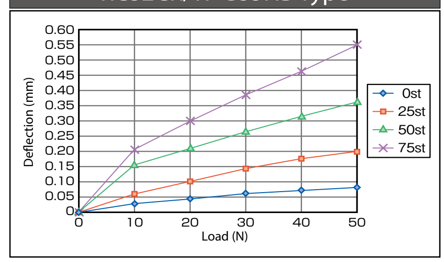
RCA2CR/W-GS3NB Type



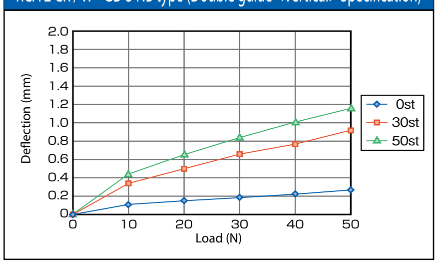
RCA2CR/W-GS4NB Type



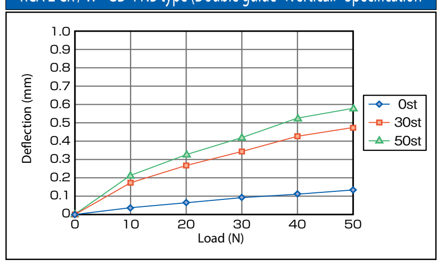
RCS2CR/W-GS5NB Type



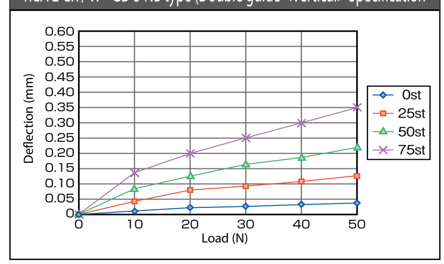
RCA 2 CR / W - GD 3 NB type (Double guide <Vertical> Specification)



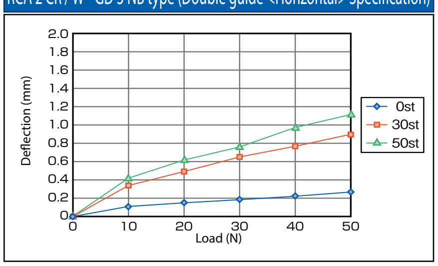
RCA 2 CR / W - GD 4 NB type (Double guide <Vertical> Specification



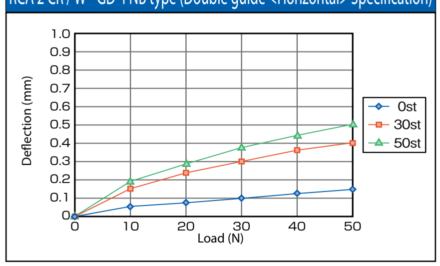
RCA 2 CR / W - GD 5 NB type (Double guide <Vertical> Specification



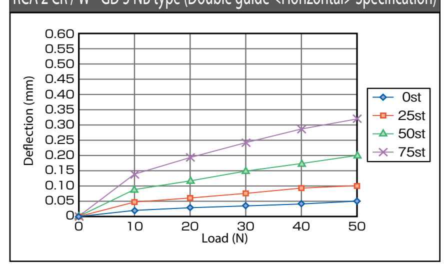
RCA 2 CR / W - GD 3 NB type (Double guide <Horizontal> Specification)



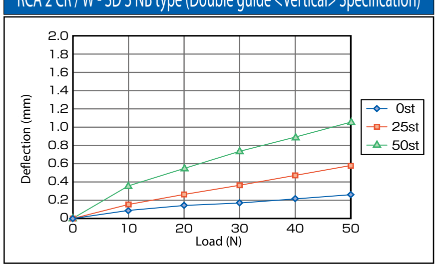
RCA 2 CR / W - GD 4 NB type (Double guide <Horizontal> Specification)



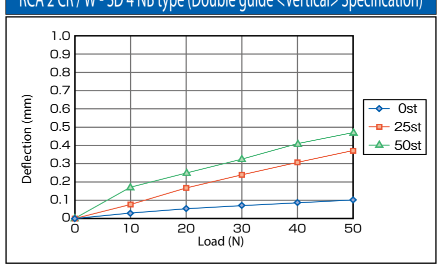
RCA 2 CR / W - GD 5 NB type (Double guide <Horizontal> Specification)



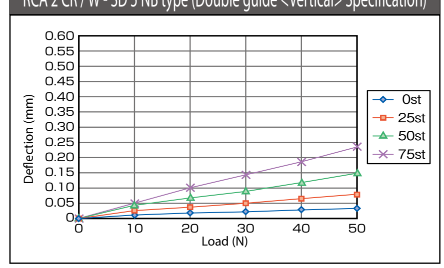
RCA 2 CR / W - SD 3 NB type (Double guide <Vertical> Specification)



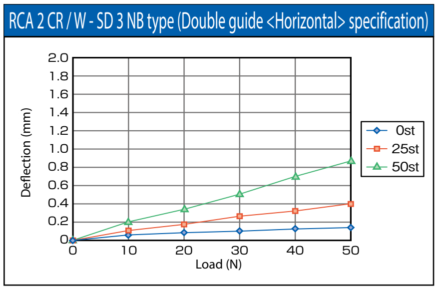
RCA 2 CR / W - SD 4 NB type (Double guide <Vertical> Specification)



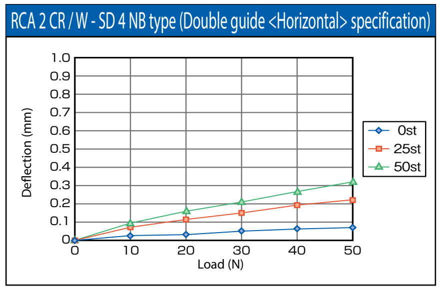
RCA 2 CR / W - SD 5 NB type (Double guide <Vertical> Specification)



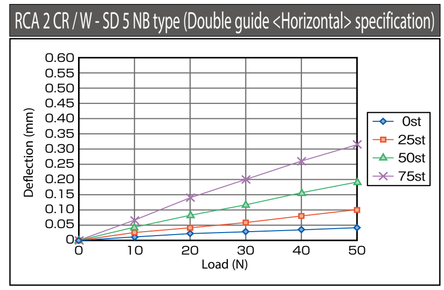
RCA 2 CR / W - SD 3 NB type (Double guide <Horizontal> specification)



RCA 2 CR / W - SD 4 NB type (Double guide <Horizontal> specification)



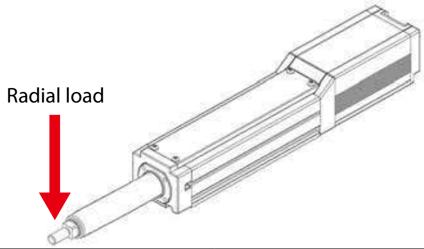
RCA 2 CR / W - SD 5 NB type (Double guide <Horizontal> specification)



Radial Cylinder Allowable Load Mass Selection Data (EC)

Radial cylinders have a linear guide built into the body so that radial and moment loads can be applied to the rod.
The allowable radial and moment loads must meet the following three conditions.

1. The radial load acting on the rod must not exceed the allowable value.

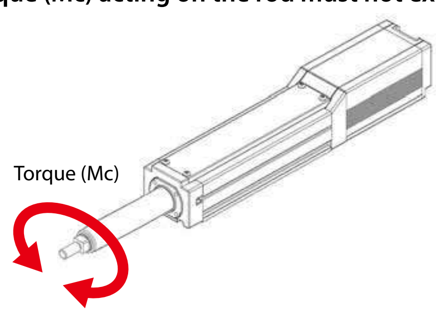


Type	Rod tip static allowable radial load	Rod tip dynamic allowable radial load (*1)
RR3/DRR3/RR3□R/DRR3□R RR4/DRR4/RR4□R/DRR4□R	40N	20N
RR6/DRR6/RR6□R/DRR6□R/ RR6□W	90N	45N
RR7/DRR7/RR7□R/DRR7□R/ RR7□W	120N	60N

Type	Rod tip static allowable radial load	Rod tip dynamic allowable radial load (*1)							
		Stroke (mm)							
RR6□AH/DRR6□AH/RR6□AHR/ DRR6□AHR	190N	50 ~ 250	300	350	400	450	500		
		130N	40N	35N	25N	20N	15N		
RR7□AH/DRR7□AH/RR7□AHR/ DRR7□AHR		600 ~ 750		800 ~ 900		950 ~ 1000			
		15N		10N		5N			
RR7□AH/DRR7□AH/RR7□AHR/ DRR7□AHR	250N	50 ~ 250	300	350	400	450	500 ~ 550	600 ~ 650	700
		170N	50N	45N	40N	35N	30N	25N	20N
RR7□AH/DRR7□AH/RR7□AHR/ DRR7□AHR		750		800 ~ 850		900 ~ 1000			
		20N		15N		10N			

(*1) Value at a standard rated operation life of 5,000km.

2. The torque (Mc) acting on the rod must not exceed the allowable value.



Type	Rod tip static allowable torque	Rod tip dynamic allowable torque (*2)
RR3/DRR3/RR3□R/DRR3□R RR4/DRR4/RR4□R/DRR4□R	3.5N·m	3.5N·m
RR6/DRR6/RR6□R/DRR6□R/RR6□W	5.5N·m	5.5N·m
RR7/DRR7/RR7□R/DRR7□R/RR7□W	10.5N·m	10.5N·m
RR6(X)□AH/DRR6(X)□AH/RR6□AHR/DRR6□AHR	9N·m	5.5N·m
RR7(X)□AH/DRR7(X)□AH/RR7□AHR/DRR7□AHR	17.6N·m	10.5N·m

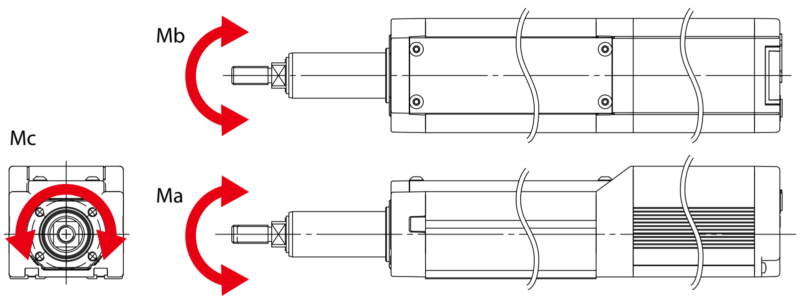
(*2) Value at a standard rated operation life of 5,000km.

3. The uniform load acting on the rod must not exceed the allowable value.
The uniform load is obtained by the following formula.
Uniform load = Ma · Ka + Mb · Kb + Mc · Kc

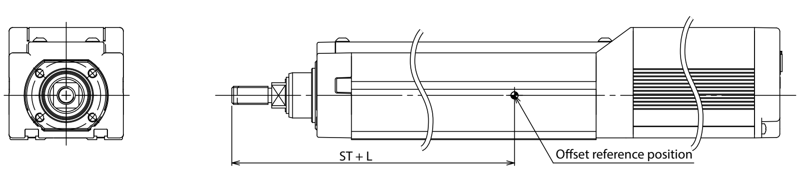
Type	Static allowable uniform load	Dynamic allowable uniform load (*3)	Load uniform coefficient Ka	Load uniform coefficient Kb	Load uniform coefficient Kc
RR3/DRR3/RR3□R/DRR3□R	1440N	580N	209/m	147/m	131/m
RR4/DRR4/RR4□R/DRR4□R	1720N	660N	181/m	127/m	93/m
RR6/DRR6/RR6□R/DRR6□R/RR6□W	4400N	1050N	124/m	87/m	62/m
RR7/DRR7/RR7□R/DRR7□R/RR7□W	5680N	1260N	98/m	69/m	50/m
RR6(X)□AH/DRR6(X)□AH/RR6□AHR/DRR6□AHR	6700N	2400N	104/m	87/m	62/m
RR7(X)□AH/DRR7(X)□AH/RR7□AHR/DRR7□AHR	11400N	3000N	90/m	76/m	50/m

(*3) Value at a standard rated operation life of 5,000km.

Ma, Mb, Mc: Moment load

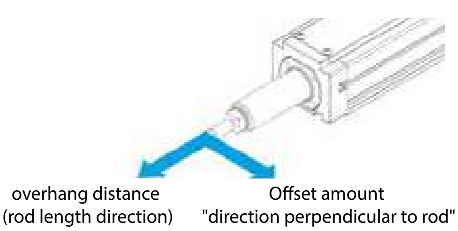


Moment offset reference position



Type	L
RR3/DRR3/RR3□R/DRR3□R	73mm
RR4/DRR4/RR4□R/DRR4□R	102mm
RR6/DRR6/RR6□R/DRR6□R	111mm
RR7/DRR7/RR7□R/DRR7□R	144.5mm
RR6□W	131.3mm
RR7□W	161.5mm
RR6□AH/DRR6□AH/ RR6□AHR/DRR6□AHR	126mm
RR6(X)□AH/DRR6(X)□AH	153.5mm
RR7□AH/DRR7□AH/ RR7□AHR/DRR7□AHR	153.5mm
RR7(X)□AH/DRR7(X)□AH	153.5mm

(Caution) Ensure that the radial load applied to a rod does not exceed the allowable offset amount and allowable overhang distance.



Type	Allowable offset amount	Allowable overhang distance
RR3/DRR3/RR3□R/DRR3□R RR4/DRR4/RR4□R/DRR4□R	100mm	100mm
RR6/DRR6/RR6□R/DRR6□R/RR6□W	100mm	100mm
RR7/DRR7/RR7□R/DRR7□R/RR7□W	100mm	100mm
RR6(X)□AH/DRR6(X)□AH/RR6□AHR/DRR6□AHR	100mm	100mm
RR7(X)□AH/DRR7(X)□AH/RR7□AHR/DRR7□AHR	150mm	150mm

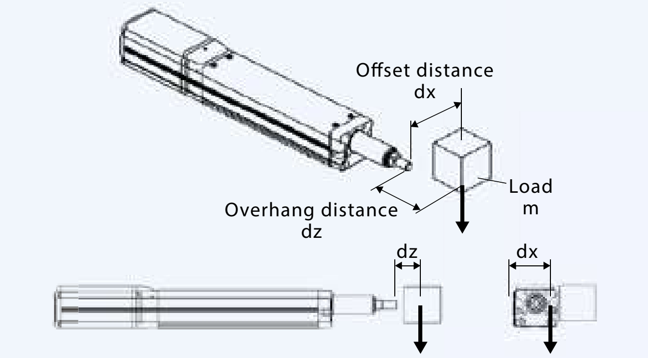
· Even if the radial load and torque load are within allowable values, the operating conditions should be moderated if some abnormal vibration or noise is observed.
· The center mass location of the attached object should not exceed 1/2 the offset amount or overhang distance.

Radial Cylinder Allowable Load Mass Selection Data (RC)

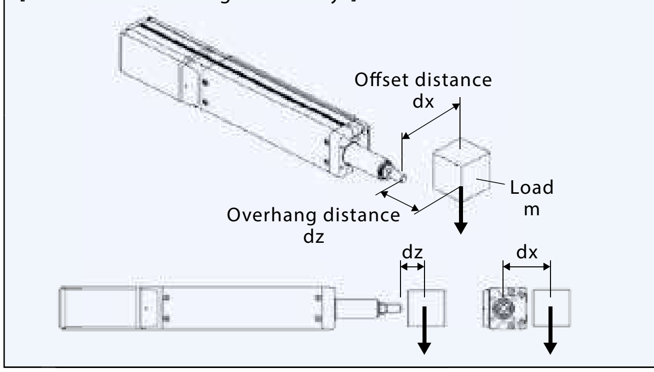
Since the radial cylinder has a built-in guide, it can apply a constant load to the rod even without an external guide.
Please refer to the graph below for allowable load mass.
In addition, when the conditions necessary for operation exceed the allowable load, please use the external guide.

■ RCP6-RRA series Horizontal mounting Allowable load mass

[Horizontal mounting flat]

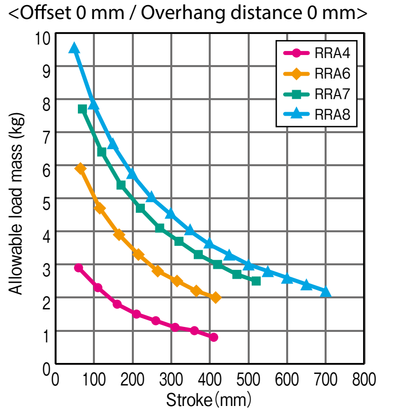


[Horizontal mounting in sideways]

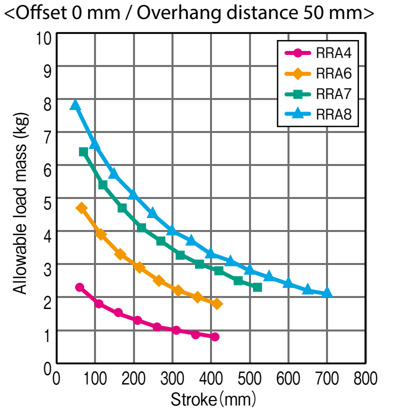


■ RCP6-RRA4/RRA6/RRA7/RRA8

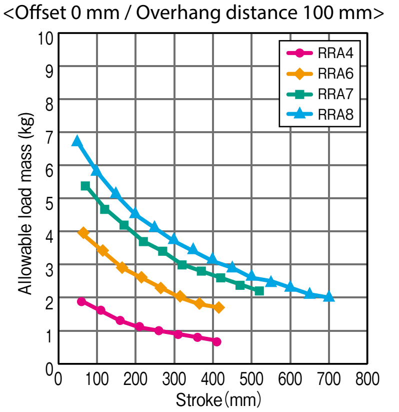
<Offset 0 mm / Overhang distance 0 mm>



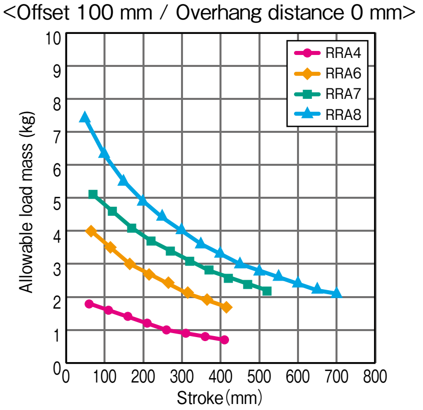
<Offset 0 mm / Overhang distance 50 mm>



<Offset 0 mm / Overhang distance 100 mm>



<Offset 100 mm / Overhang distance 0 mm>



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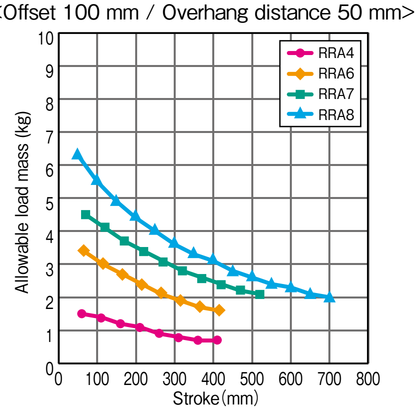
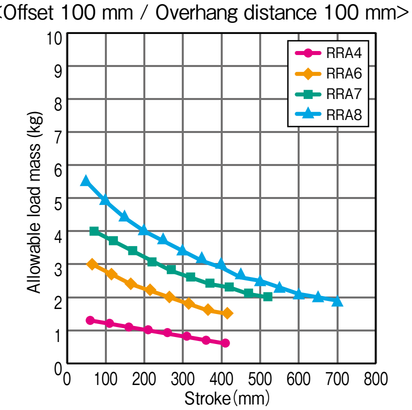


<Offset 100 mm / Overhang distance 100 mm>

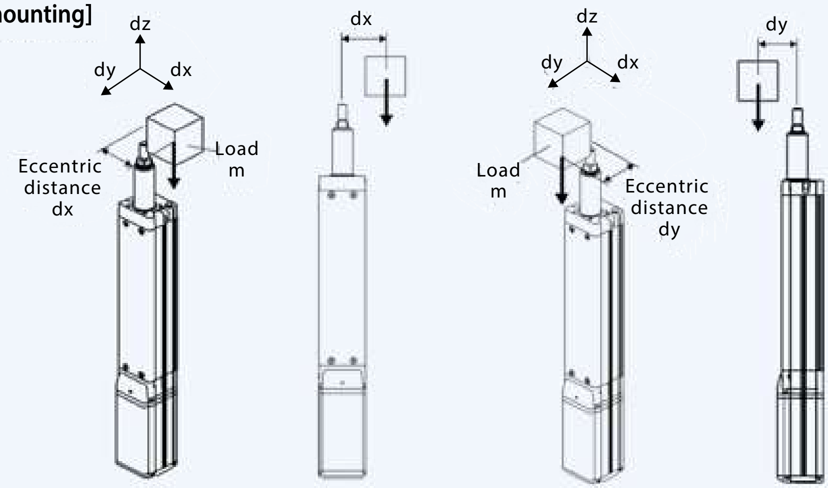


Conditions for calculation of allowable load
Considering the moment due to acceleration and deceleration, the load mass with guided travel life of 5000 km. (Acceleration 1 G, speed 500 mm/s)

■ RCP6(S) -RRA series Vertical mounting Allowable load mass

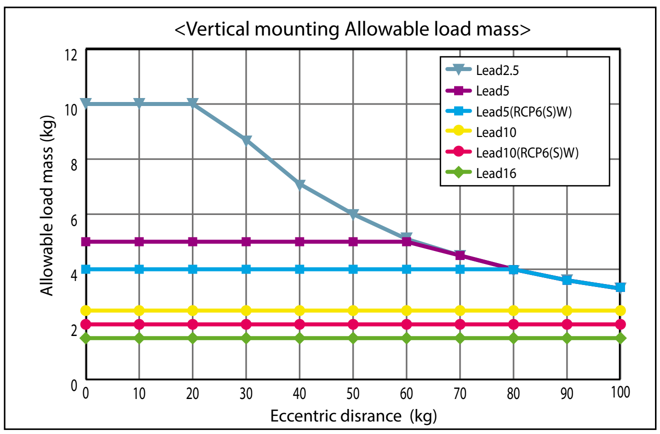
* RCP6(S)W may vary depending on the lead.

[Vertical mounting]

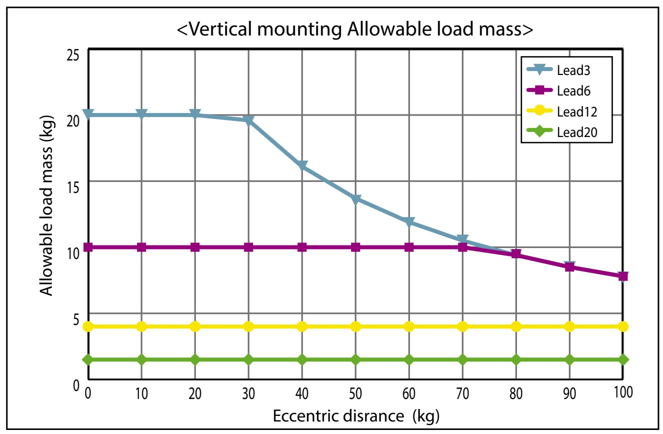


Conditions for calculation of allowable load
Considering the moment due to acceleration and deceleration, the load mass with guided travel life of 5000 km.
(Acceleration 0.5 G, speed 500 mm / s)

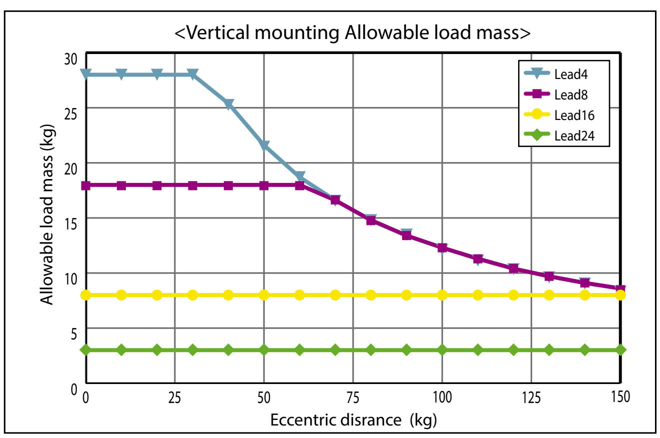
■ RCP6(S)-RRA4



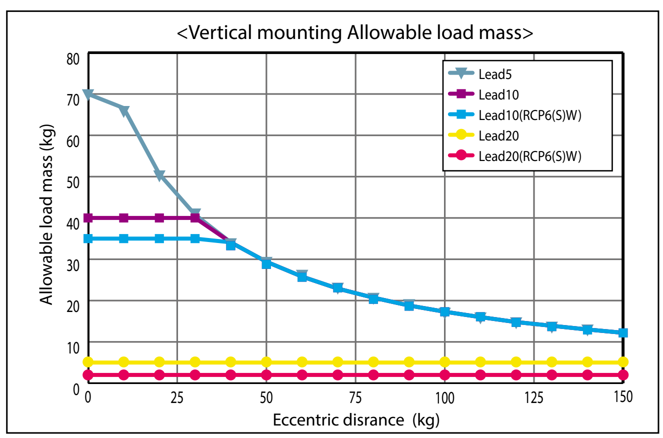
■ RCP6(S)-RRA6



■ RCP6(S)-RRA7



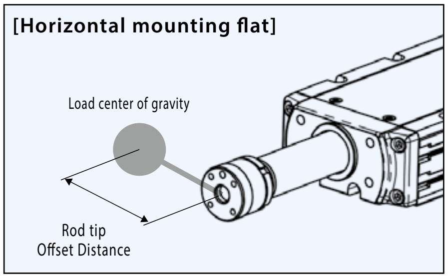
■ RCP6(S)-RRA8

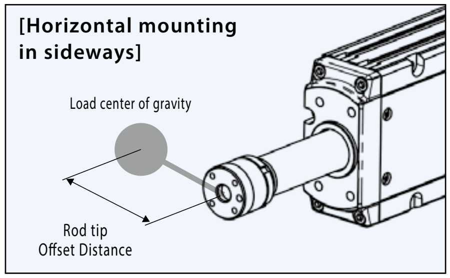


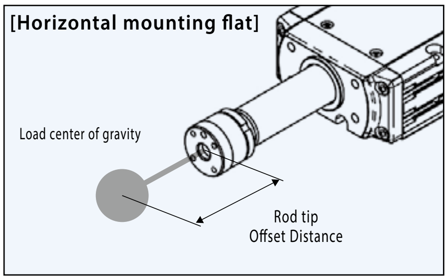
Radial Cylinder Allowable Load Mass Selection Data (RC)

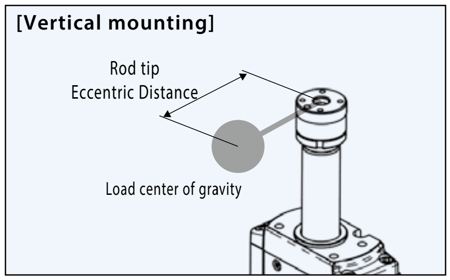
■ RCS6(S)-WRA series Allowable load mass

* RCP6(S)W may vary depending on the lead.

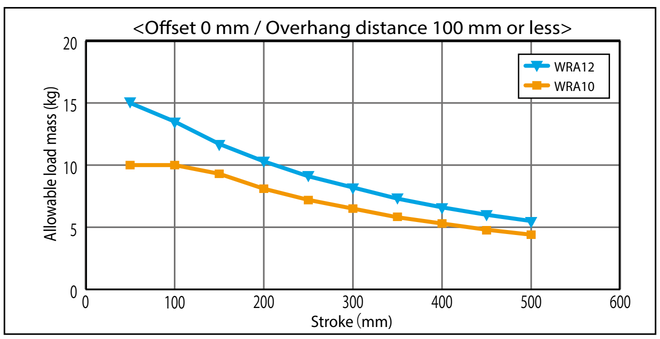


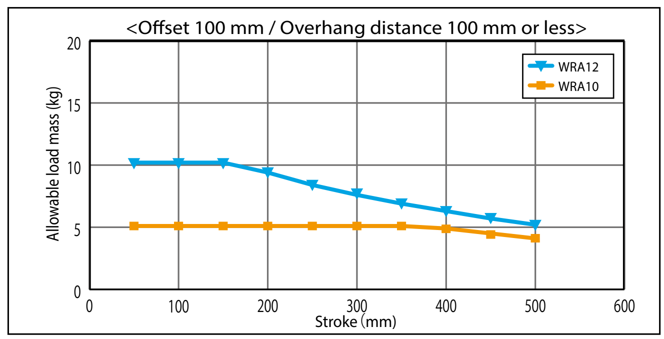




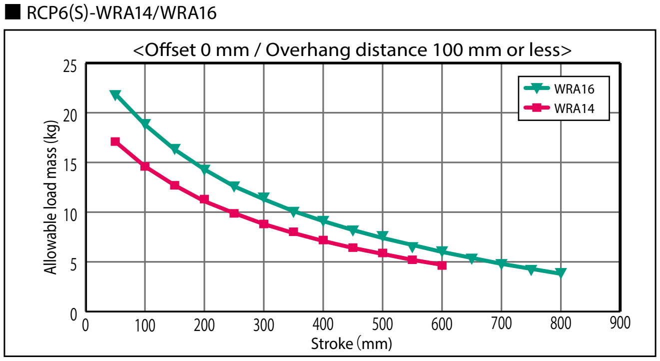


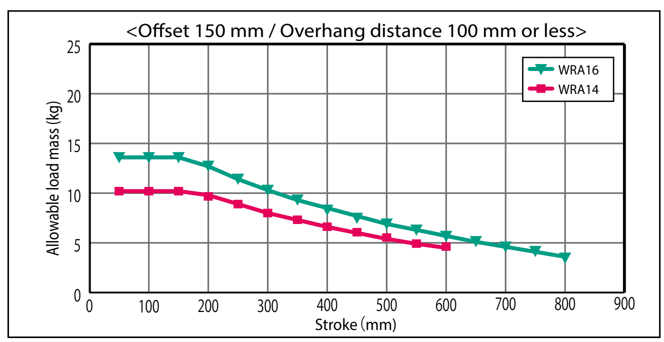
■ RCP6(S)-WRA10/WRA12





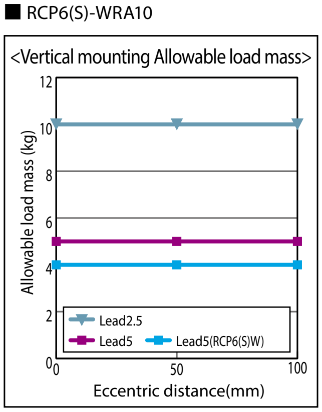
■ RCP6(S)-WRA14/WRA16



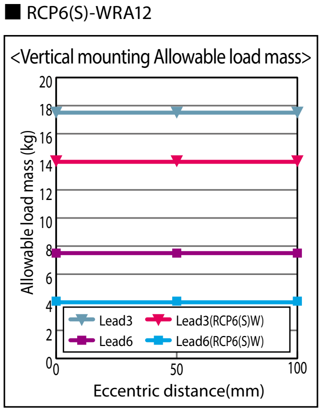


Conditions for calculation of allowable load: Considering the moment due to acceleration, the load mass with guided travel life of 5000 km. (Acceleration 1 G, speed 500 m / s * WRA 16 type acceleration: 0.2 G, speed 500 m / s).

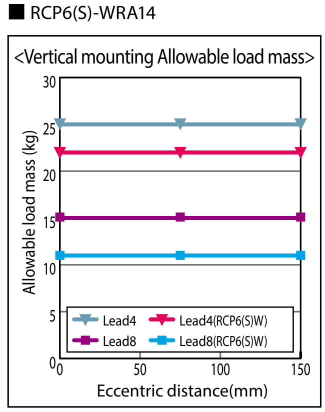
■ RCP6(S)-WRA10



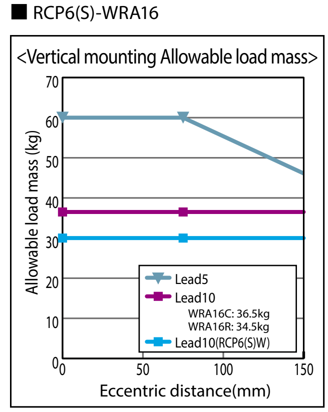
■ RCP6(S)-WRA12



■ RCP6(S)-WRA14

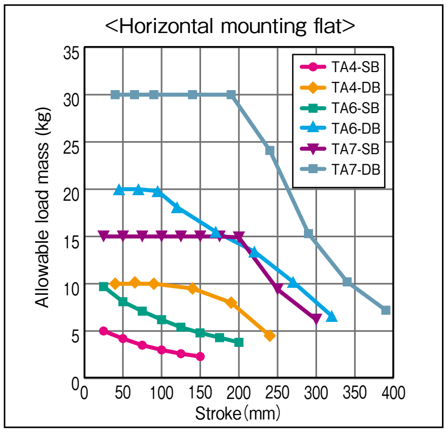


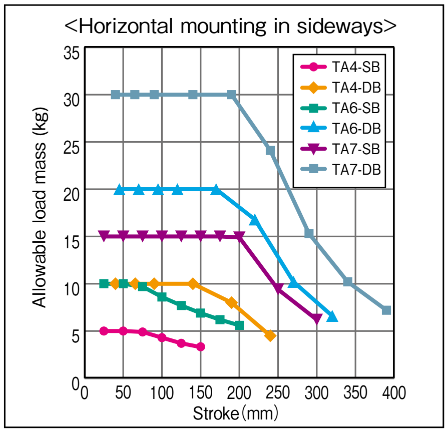
■ RCP6(S)-WRA16

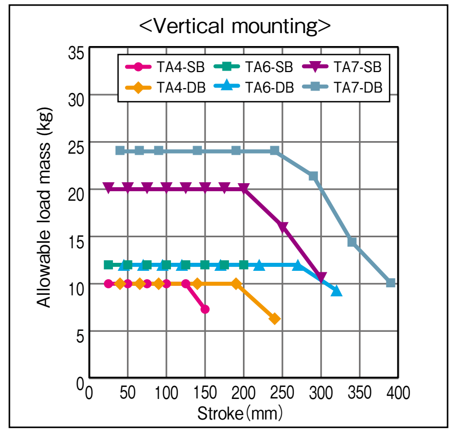


■ (Table type) RCP 6(S)-TA series Allowable load mass

Allowable load mass of the table type decreases as the stroke becomes longer due to the mechanical restriction.

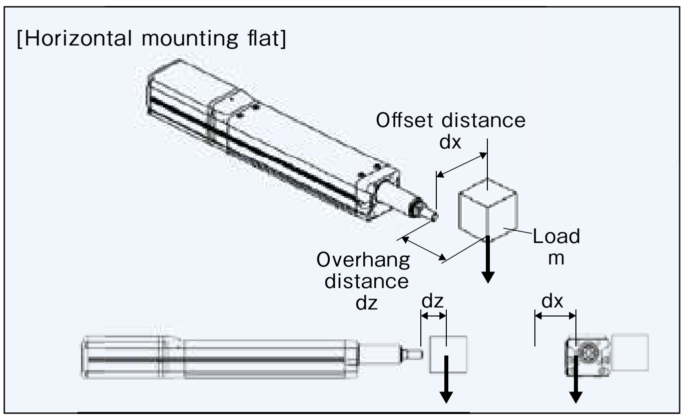


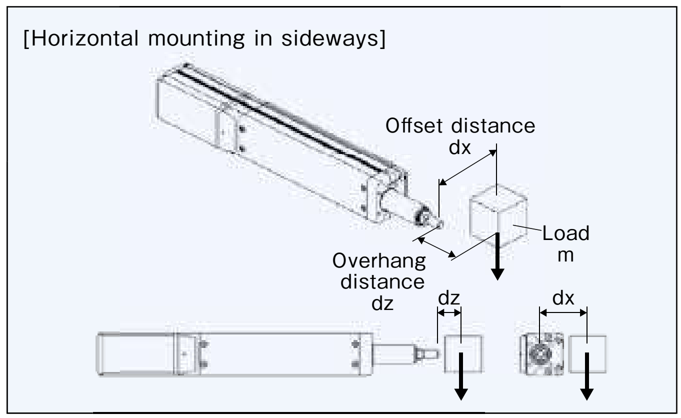




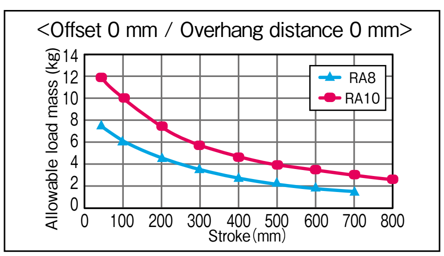
Conditions for calculation of allowable load: Considering the moment due to acceleration, the load mass with guided travel life of 5000 km. (Acceleration 0.5 G, speed 500 m / s * WRA 16 type acceleration: 0.2 G, speed 500 m / s).

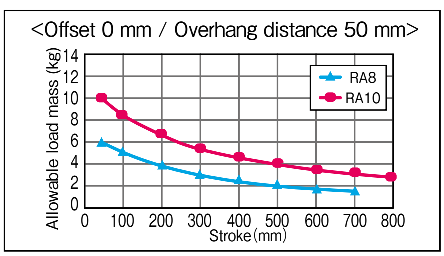
■ RCP5/RCP4 horizontal mounting Allowable load mass

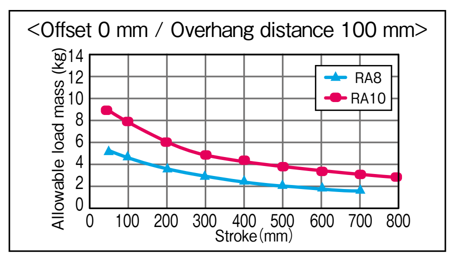


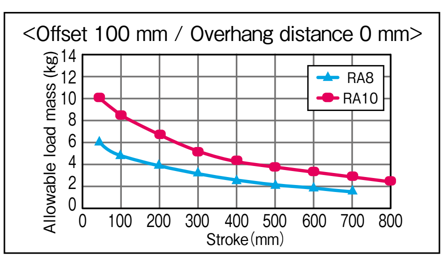


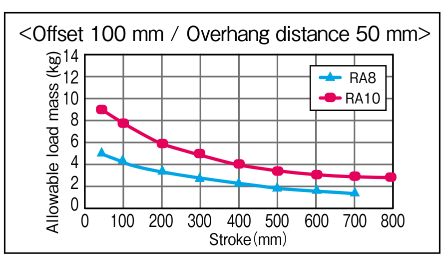
■ RCP5-RA8/RA10

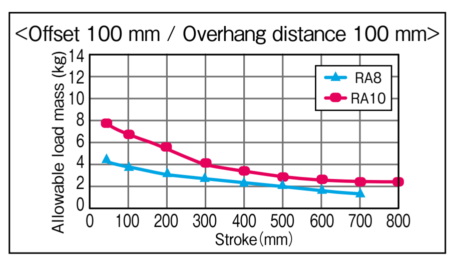






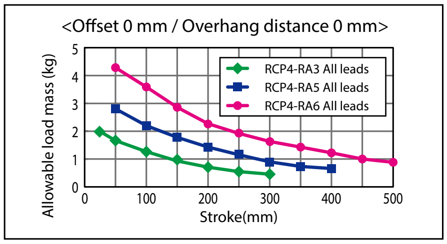


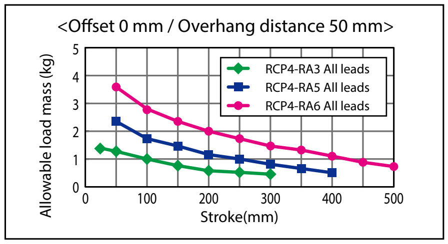


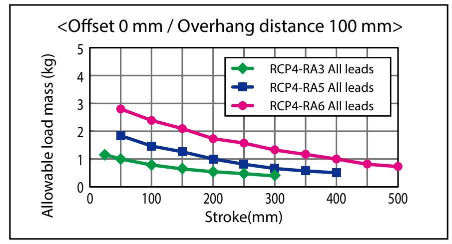


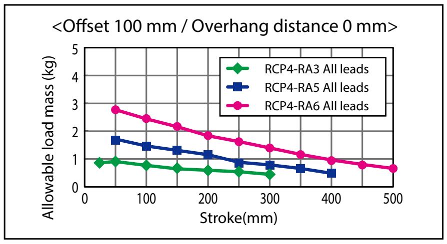
Radial Cylinder Allowable Load Mass Selection Data (RC)

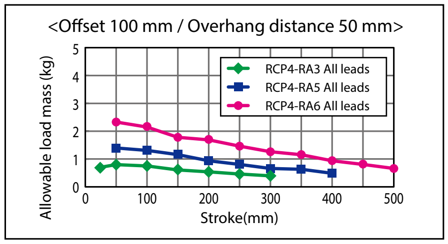
■ RCP4-RA3/RA5/RA6

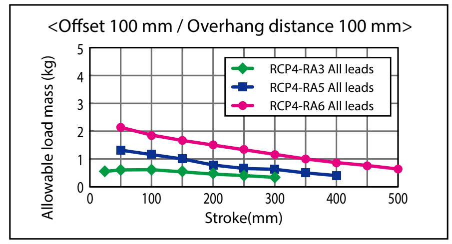








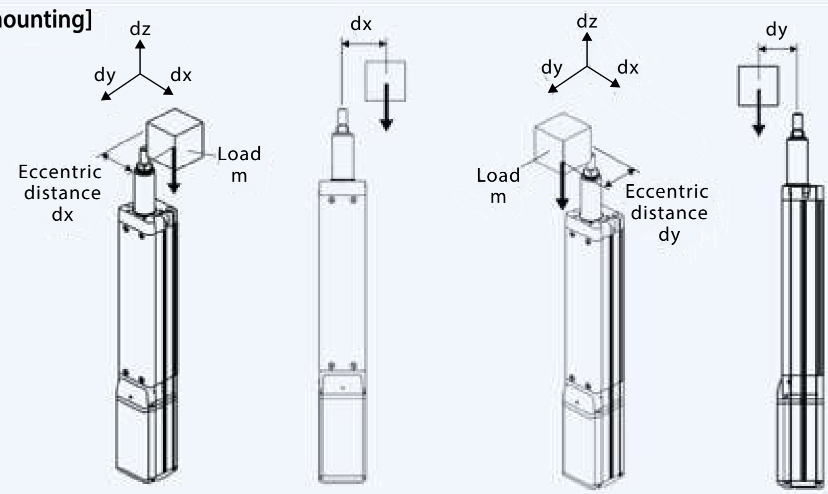




Conditions for calculation of allowable load
Considering the moment due to acceleration, the load mass with guided travel life of 5000 km. (Acceleration 1 G, speed 500 m / s)

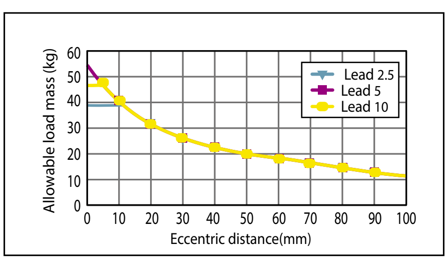
■ RCP5/RCP4 series Vertical mounting Allowable load mass

[Vertical mounting]

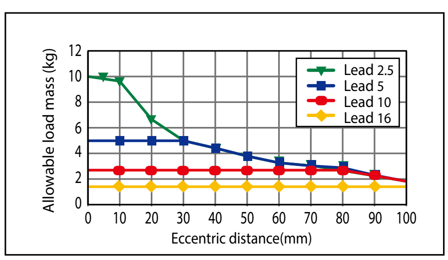


Conditions for calculation of allowable load
Considering the moment due to acceleration and deceleration, the load mass with guided travel life of 5000 km.
(Acceleration 0.5 G, speed 500 mm / s)

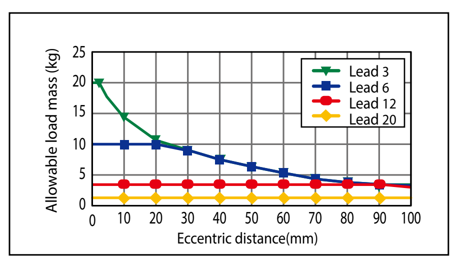
■ RCP5-RA10



■ RCP4-RA3

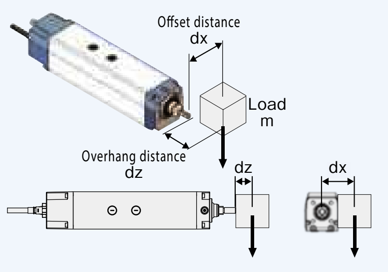


■ RCP4-RA5

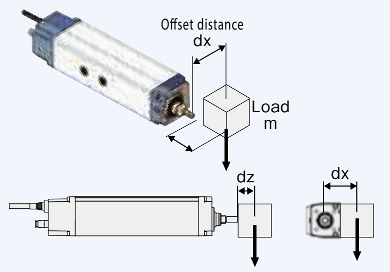


RCP5W-RA10C series Horizontal mounting Allowable load mass

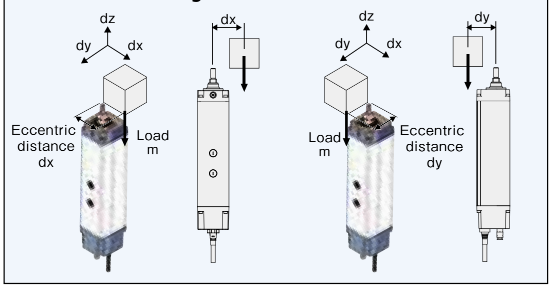
[Horizontal mounting flat]



[Horizontal mounting in sideways]

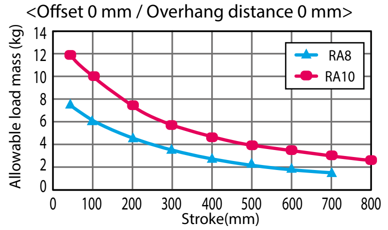


[Vertical mounting]

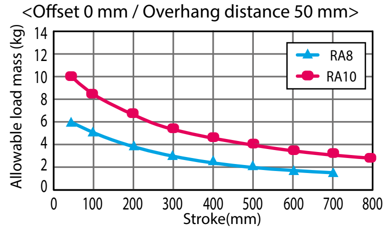


RCP5W-RA10C

<Offset 0 mm / Overhang distance 0 mm>



<Offset 0 mm / Overhang distance 50 mm>



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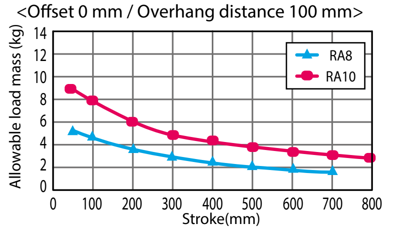

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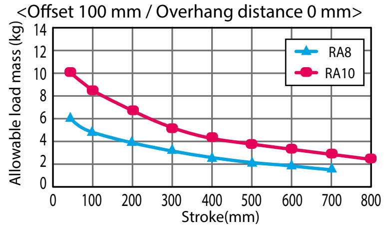

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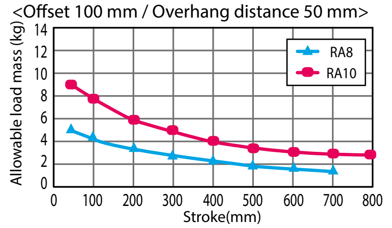
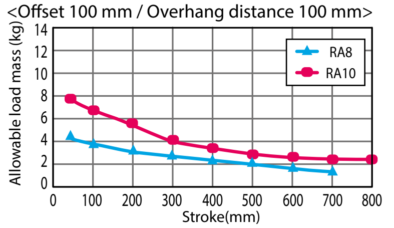
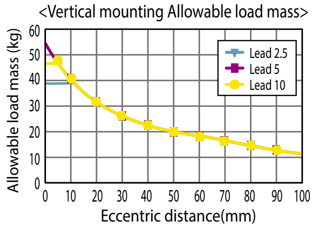


<Offset 100 mm / Overhang distance 100 mm>



RCP5W-RA10C

<Vertical mounting Allowable load mass>

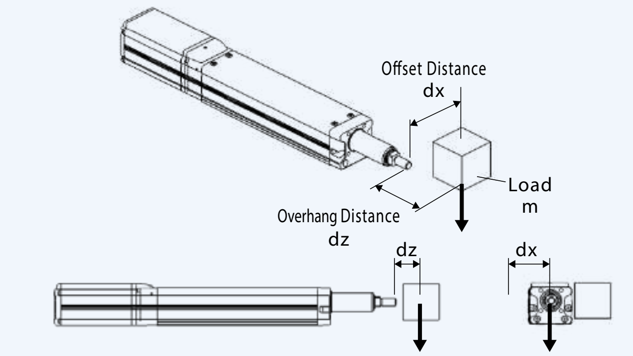


Conditions for calculation of allowable load: Considering the moment due to acceleration,
the load mass with guided travel life of 5000 km. (RA10C: Acceleration 0.04 G, speed 250 m / s).

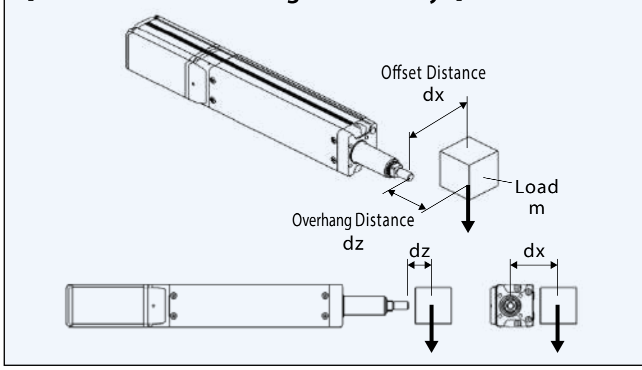
Radial Cylinder Allowable Load Mass Selection Data (RC)

■ RCS4-RRA series Horizontal mounting Allowable load mass

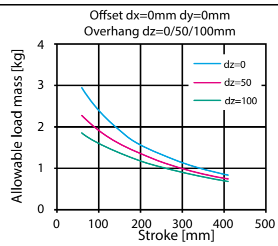
[Horizontal mounting flat]

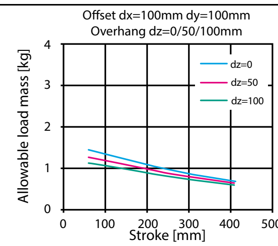


[Horizontal mounting in sideways]

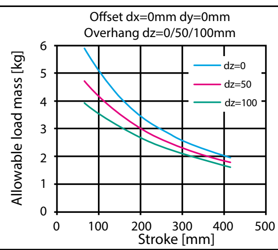


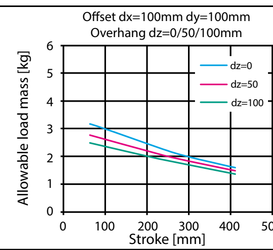
■ RCS4-RRA4



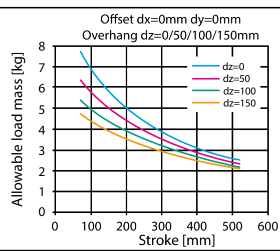


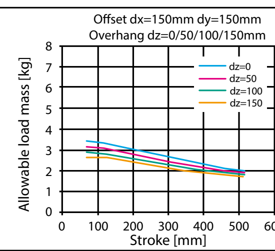
■ RCS4-RRA6



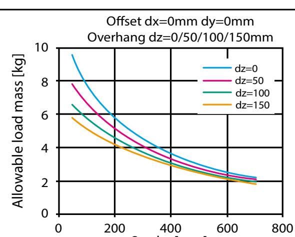


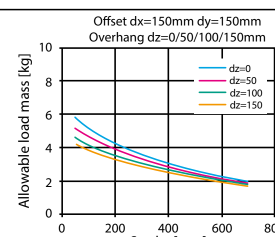
■ RCS4-RRA7



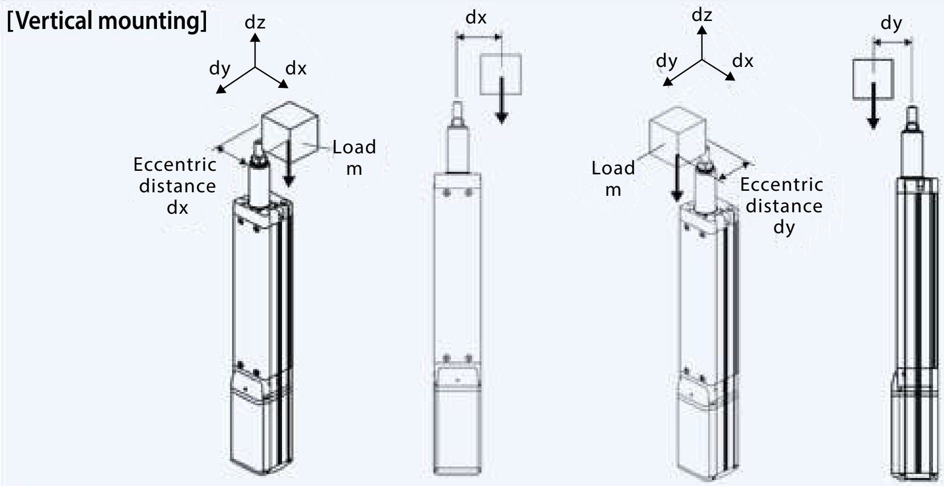


■ RCS4-RRA8



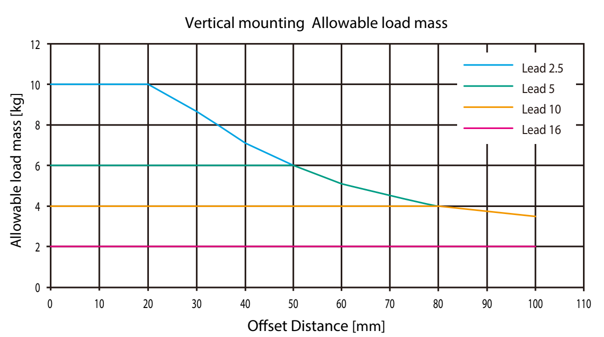


RCS4-RRA series Vertical mounting Allowable load mass

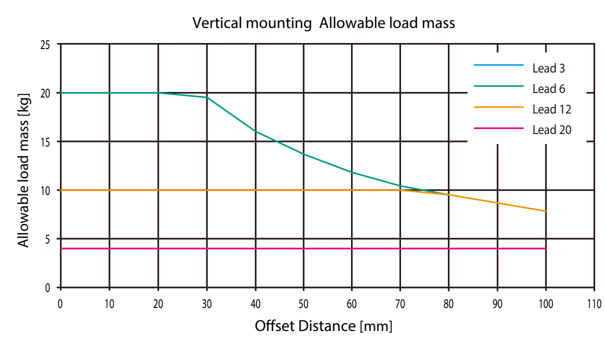


Conditions for calculation of allowable load
Considering the moment due to acceleration and deceleration, the load mass with guided travel life of 5000 km.
(Acceleration 0.5 G, speed 500 mm / s)

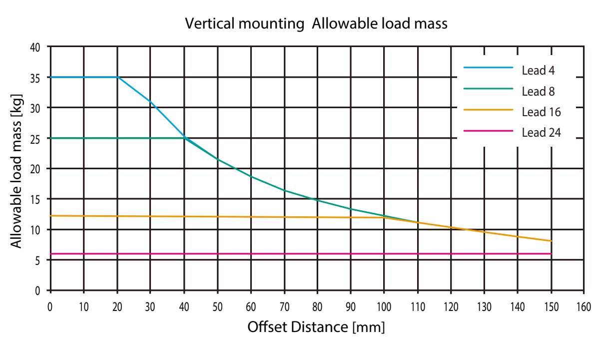
RCS4-RRA4



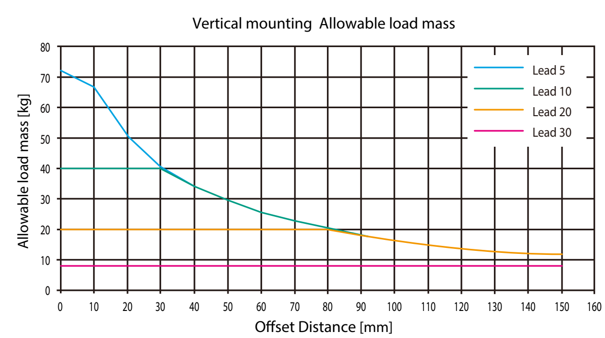
RCS4-RRA6



RCS4-RRA7

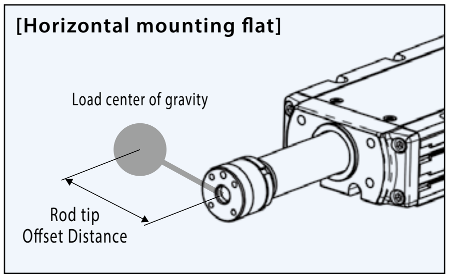


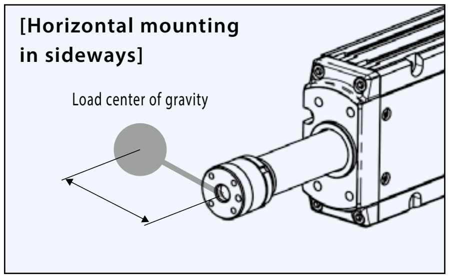
RCS4-RRA8

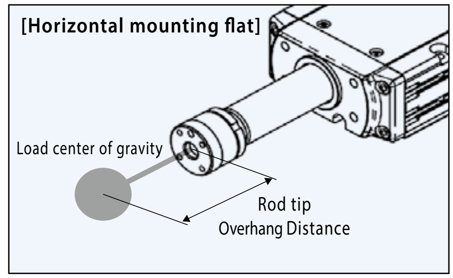


Radial Cylinder Allowable Load Mass Selection Data (RC)

■ RCS4-WRA series Horizontal mounting Allowable load mass

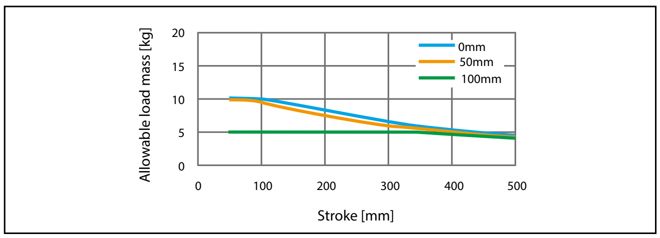




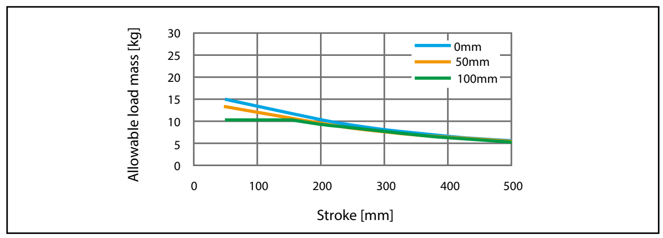


Offset=0mm/50mm/100mm
Overhang=100mm or less

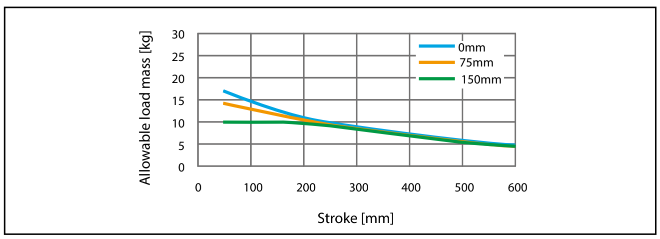
■ RCS4-WRA10



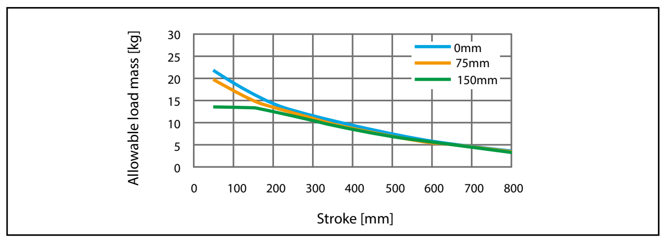
■ RCS4-WRA12



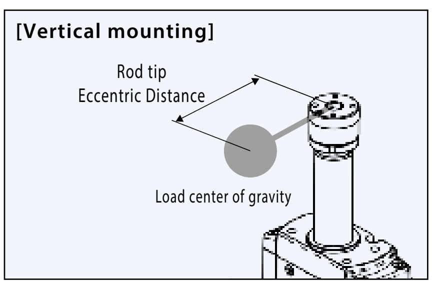
■ RCS4-WRA14



■ RCS4-WRA16

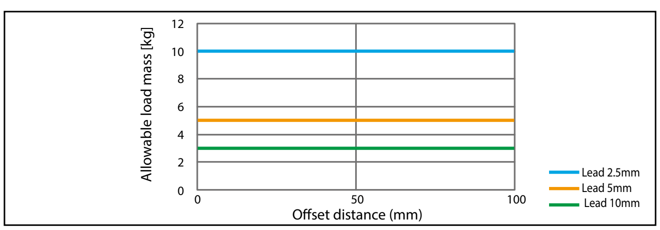


■ RCS4-WRA series Vertical mounting Allowable load mass

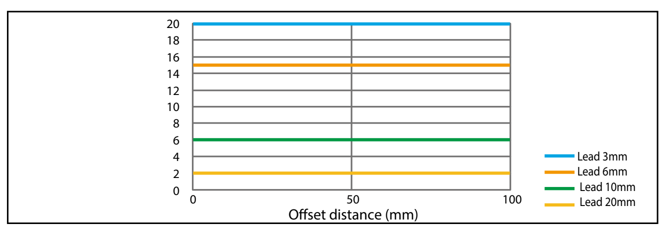


Offset=0mm/50mm/100mm
Overhang=100mm or less

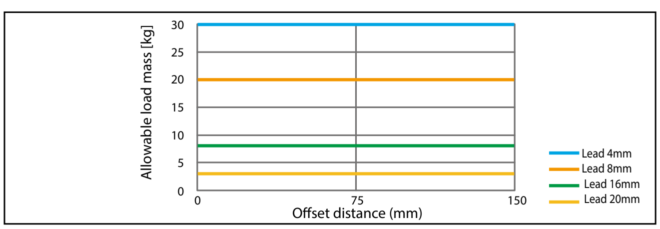
■ RCS4-WRA10



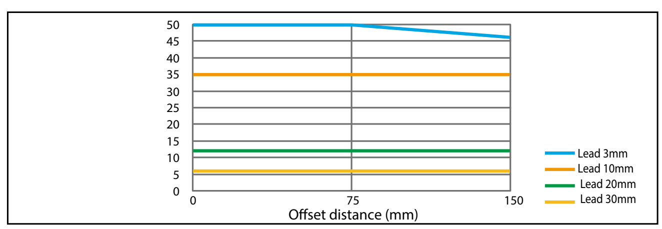
■ RCS4-WRA12



■ RCS4-WRA14



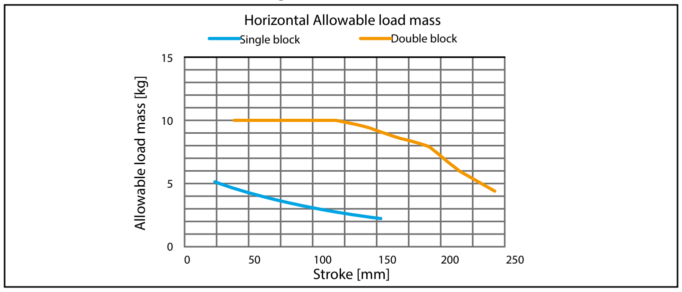
■ RCS4-WRA16



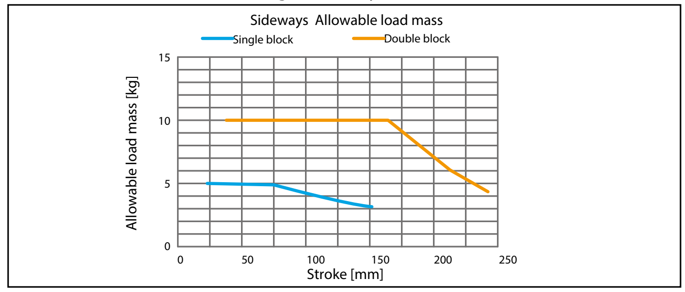
■ (Table type) RCS4 - TA series Horizontal mounting Allowable load mass

The allowable load mass of the table type decreases as the stroke becomes longer due to the mechanical limitation.

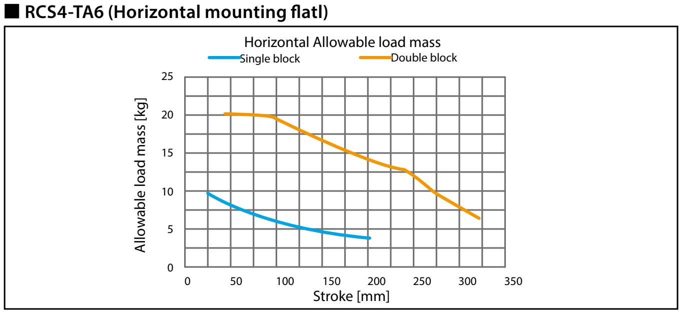
■ RCS4-TA4 (Horizontal mounting flat)



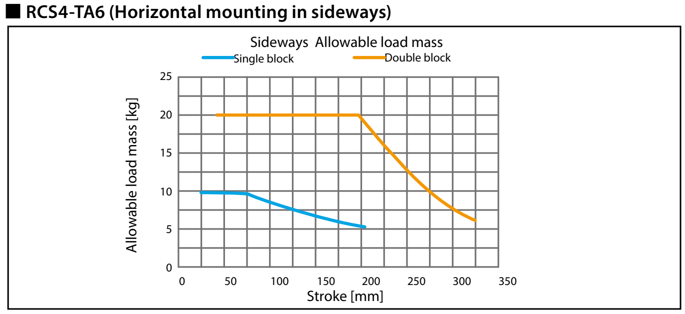
■ RCS4-TA4 (Horizontal mounting in sideways)



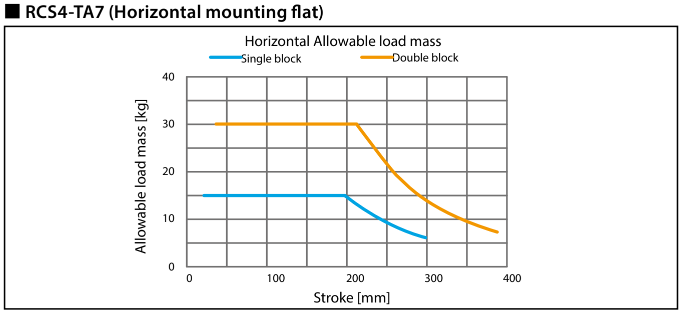
■ RCS4-TA6 (Horizontal mounting flatl)



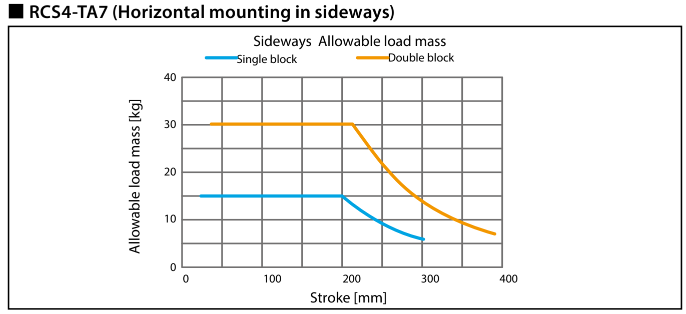
■ RCS4-TA6 (Horizontal mounting in sideways)



■ RCS4-TA7 (Horizontal mounting flat)



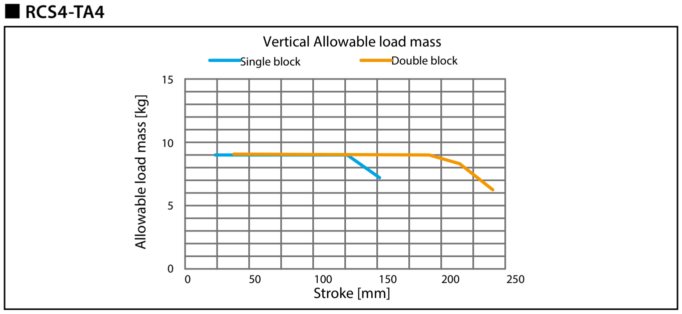
■ RCS4-TA7 (Horizontal mounting in sideways)



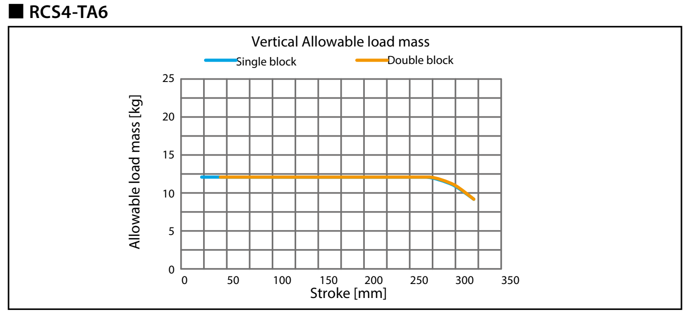
■ (Table type) RCS4 - TA series Horizontal mounting Allowable load mass

The allowable load mass of the table type decreases as the stroke becomes longer due to the mechanical limitation.

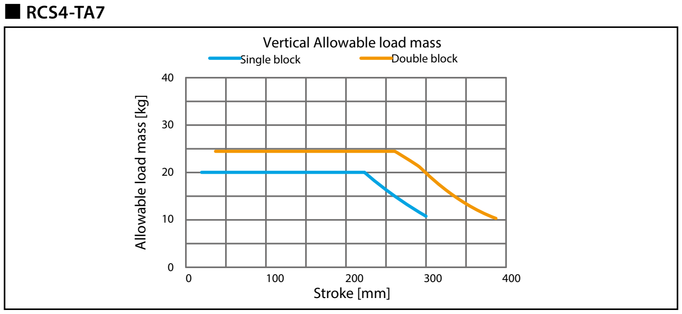
■ RCS4-TA4



■ RCS4-TA6



■ RCS4-TA7



Gripper Selection Method

Slide type

Step 1
Check necessary gripping force and transportable work part weight

Step 2
Check distance to gripping point

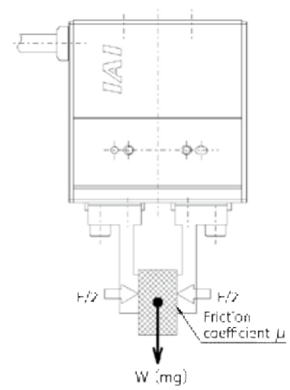
Step 3
Check external force applied to the finger attachment

Step 1 Check necessary gripping force and transportable work part weight

When gripping with frictional force, calculate the necessary gripping force as shown below.

① Normal transportation

F	:	Gripping force [N] …… Sum of push forces
μ	:	Coefficient of static friction between the finger attachment and the work part
m	:	Work part weight [kg]
g	:	Gravitational acceleration [= 9.8m/s²]



● A condition in which a work part does not drop when the work part is

$$F\mu > W \qquad F > \frac{mg}{\mu}$$

● Necessary gripping force as the recommended safety factor of 2 in normal transportation:

$$F > \frac{mg}{\mu} \times 2 \text{ (safety factor)}$$

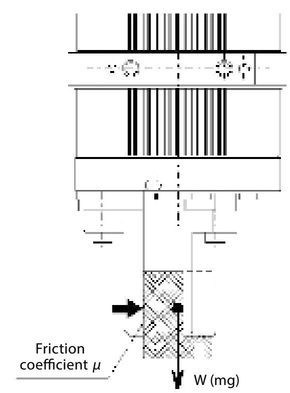
● When the friction coefficient μ is between 0.1 and 0.2:

$$F > \frac{mg}{0.1 \sim 0.2} \times 2 = (10 \sim 20) \times mg$$

Normal work part transportation

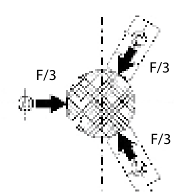
Necessary gripping force	▶ **10 to 20 times** the work part weight **or more**
Transportable work part weight	▶ **One-tenth to one-twentieth or less** of gripping force

* As the Coefficient of static friction increases, the work part weight also increases. Select a model which can achieve the gripping force of 10 to 20 times or more.
* Please refer to page 1-310 for an estimate of the shape and mass of the load.



② When remarkable acceleration, deceleration and/or impact occur

at work part transportation Stronger inertial force is applied to a work part by gravity.
In this case, consider the sufficient safety rate when selecting a model.



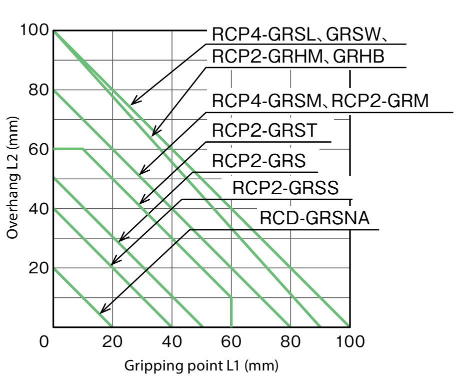
When remarkable acceleration, deceleration and/or impact occur

Necessary gripping force	▶ **30 to 50 times** the work part weight or **more**
Transportable work part weight	▶ **One-thirtieth to one-fiftieth or less** of gripping force

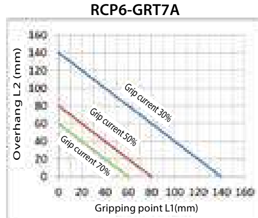
Step 2 Distance between finger attachment (claw) to gripping point

Keep the distance (L, H) from the finger (claw) mounting surface to the gripping point within the following range.
If such distance does not fall within such range, excessive moment applies to the finger sliding parts and internal mechanism and the service life may be affected.

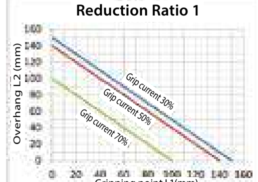
◆ For 2-finger gripper



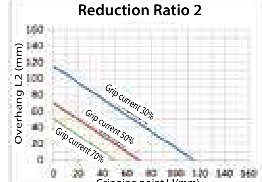
RCP6-GRT7A

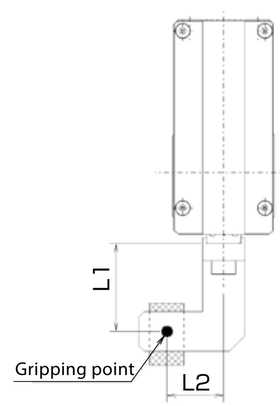


RCP6-GRT7B
Reduction Ratio 1

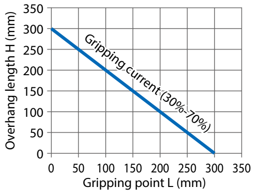


RCP6-GRT7B
Reduction Ratio 2

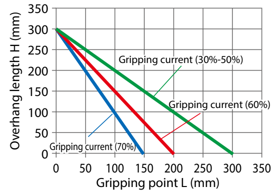




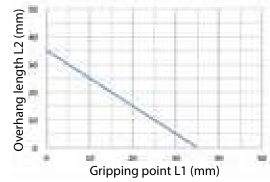
RCP6(S)-GRST6 (Lead 8)



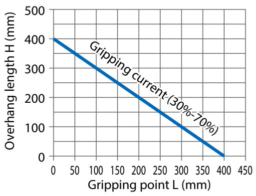
RCP6(S)-GRST6 (Lead 2)



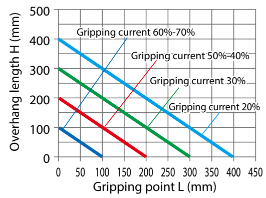
GRS-SEG/SIG
RCP6-RTCKSPE/RTCKSPI/RTCKSRE/RTCKSRI



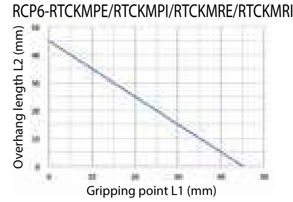
RCP6(S)-GRST7 (Lead 8)



RCP6(S)-GRST7 (Lead 2)

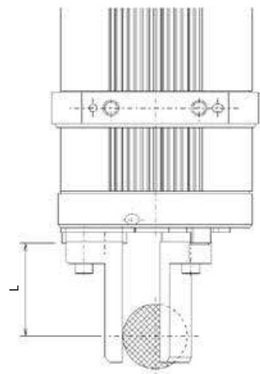


GRS-MEG/MIG
RCP6-RTCKMPE/RTCKMPI/RTCKMRE/RTCKMRI



◆ For 3-finger gripper

RCP2-GR3SS	⇒	L50mm under
RCP2-GR3SM	⇒	L80mm under

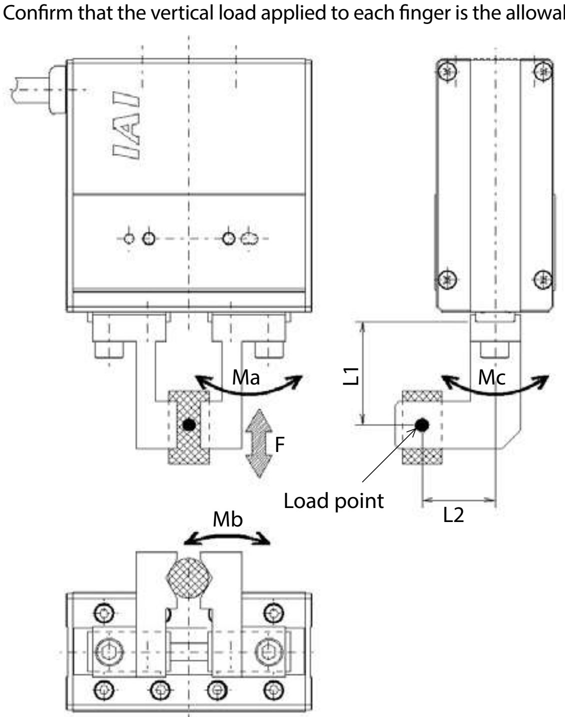


Keep the finger attachment as small and light as possible, even if the distance to the gripping point falls within the limited range.
There are cases in which performance will be decreased or the guides will be adversely affected by inertial forces or bending moment if the finger is too long or too heavy.

Step 3 Checking external force applied to finger

① Allowable vertical load

Confirm that the vertical load applied to each finger is the allowable load or less.



* The above load point indicates the load position on the fingers.
The position varies depending on the type of load.
· Load due to grasping force: Grasping point
· Gravity load: Center of gravity position
· Inertial force during movement, centrifugal force during turning: Center of gravity position
The load moment is the total value calculated for each type of load.

* Finger weight and work part weight are also a part of the external force. Centrifugal force when the gripper rotated gripping a work part and inertial force due to acceleration or deceleration when moving are also the external force applied to the finger.

Gripper Selection Method

② Allowable load moment

Calculate Ma and Mc using L1 and Mb using L2.
Confirm that the moment applied to each finger is less than the maximum allowable load moment.

- Allowable external force when the moment load is applied to each claw is

$$\text{Allowable load F(N)} > \frac{\text{M (max. allowable moment (N•m))}}{\text{L(mm)}\times 10^{-3}}$$

Calculate both the allowable loads F (N), L1 and L2.
Confirm that the external force applied to the finger is equal to or less than the calculated allowable vertical loads F (N), (L1 or L2, whichever is smaller).

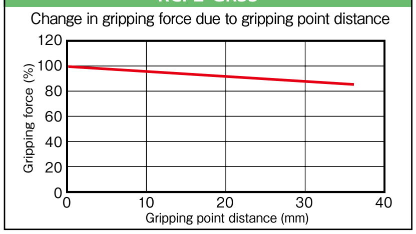
Model	Allowable vertical load F(N)	Max. allowable load moment (N·m)		
		Ma	Mb	Mc
RCP6-GRT7A	598	3.6	3.6	10.2
RCP6-GRT7B	898	7.5	7.5	15.3
RCP6(S)-GRST6	1080	48.5	69.3	103
RCP6(S)-GRST7	1400	115	115	229
RCP4-GRSML	356	1.9	2.7	4.6
RCP4-GRSLL	558	3.8	5.5	9.5
RCP4-GRSWL	651	5.1	7.2	12.4
RCP2-GRSS	60	0.5	0.5	1.5
RCP2-GRS	253	6.3	6.3	7.0
RCP2-GRM	253	6.3	6.3	8.3
RCP2-GRHM	390	11.7	16.7	46.5
RCP2-GRHB	502	15.7	26.4	59.8
RCP2-GRST	275	2.93	2.93	5.0
RCP2-GR3SS	169	3.8	3.8	3.0
RCP2-GR3SM	253	6.3	6.3	5.7
RCD-GRSNA	14	0.04	0.04	0.07
GRS-SEG/SIG	150	0.62	0.62	0.99
GRS-MEG/MIG	240	1.08	1.08	2.64

1. The above allowable values show static values.
2. The allowable values per finger are shown.

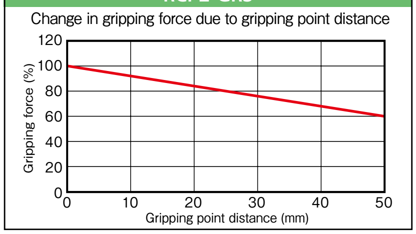
Approximate grip point distance and grip force

1. The graph shows the gripping force according to the gripping point distance when the maximum gripping force is taken as 100%.
2. The gripping point distance indicates the vertical distance from the finger attachment mounting surface to the gripping point.
3. Gripping force has variations due to individual differences. Please refer as a guide.

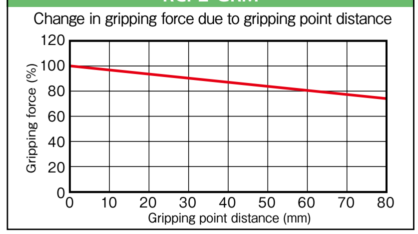
RCP2-GRSS



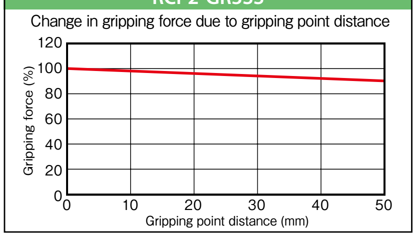
RCP2-GRS



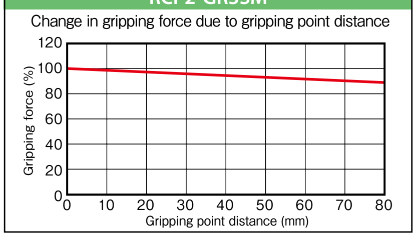
RCP2-GRM



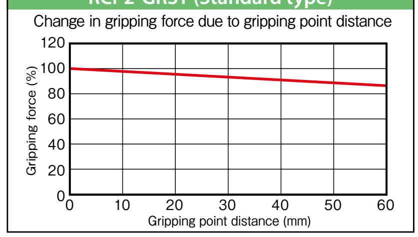
RCP2-GR3SS



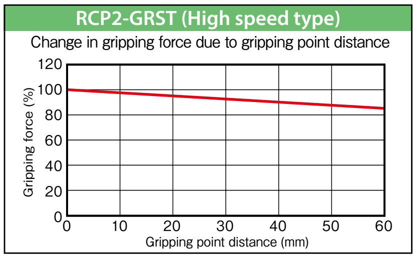
RCP2-GR3SM



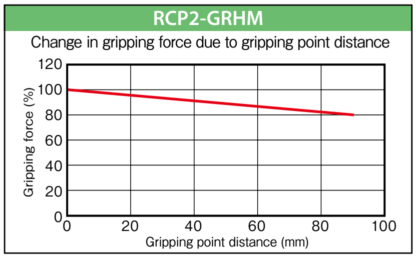
RCP2-GRST (Standard type)



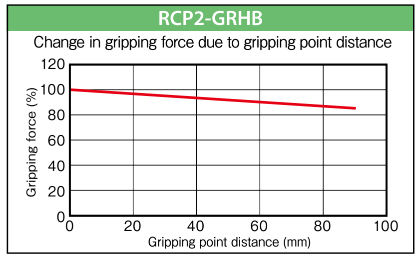
RCP2-GRST (High speed type)



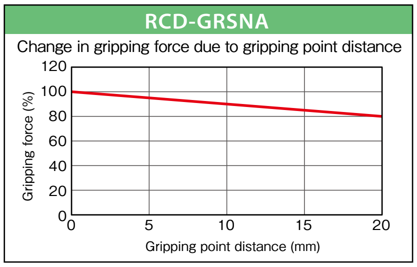
RCP2-GRHM



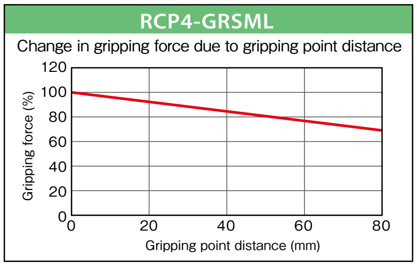
RCP2-GRHB



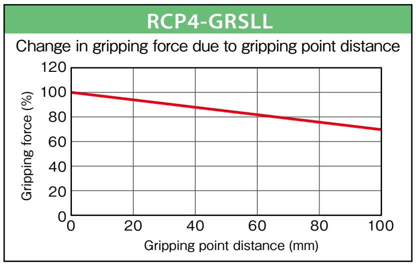
RCD-GRSNA



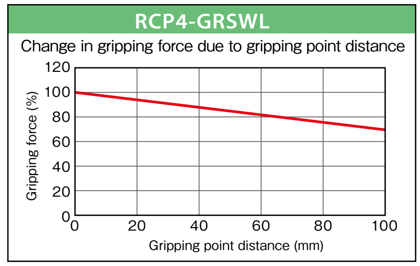
RCP4-GRSML



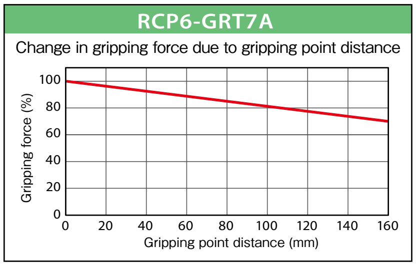
RCP4-GRSLL



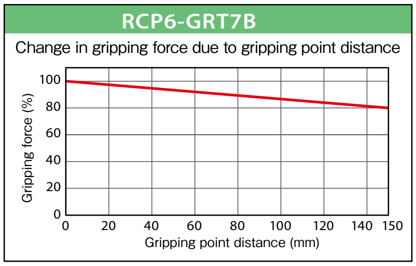
RCP4-GRSWL



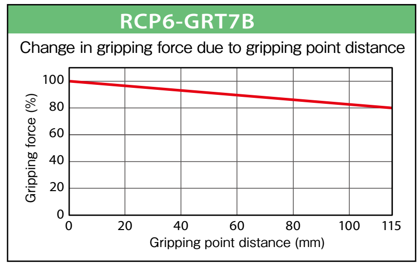
RCP6-GRT7A



RCP6-GRT7B



RCP6-GRT7B



Gripper Selection Method

Rotary chuck RCP6-RTCK

Step 1
Check necessary gripping force and transportable workpiece weight

↓

Step 2
Confirming the gripping point distance

↓

Step 3
Checking external force applied to finger

↓

Step 4
Checking moment of inertia

Step 1 Check necessary gripping force and transportable workpiece weight

When gripping with frictional force, calculate the necessary gripping force as shown below.

① Normal transportation

F : Gripping force [N] …… Sum of push forces
μ : Coefficient of static friction between the finger attachment and the work part
m: Work part weight [kg]
g : Gravitational acceleration [= 9.8m/s²]

- A condition in which a workpiece does not drop when the work part is:

$$F\mu > W \qquad F > \frac{mg}{\mu}$$

- Necessary gripping force that allows the recommended safety factor of 2 in normal transportation:

$$F > \frac{mg}{\mu} \times 2 \text{ (Safety factor)}$$

- When the friction coefficient μ is 0.1 - 0.2

$$F > \frac{mg}{0.1 \sim 0.2} \times 2 = (10 \sim 20) \times mg$$

Normal transport	
Necessary gripping force ▶	10 to 20 times the workpiece weight or more
Weight of the transportable workpiece weight ▶	Less than 1/10 to 1/20 of gripping force

② When considerable acceleration, deceleration and/or impact occurs during transportation of the workpieces

Larger moment is applied to the workpiece in addition to the gravity.
In such a case, consider a sufficient safety factor when selecting a model.

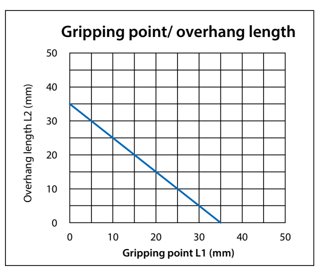
*Transportable workpiece weight increases as static friction coefficient becomes larger. Select a model that has more than 10 to 20 times of the gripping force to the workpiece considering safety.

When large moment and impact are applied.	
Necessary gripping force ▶	30 to 50 times the workpiece weight or more
Weight of the transportable workpiece ▶	Less than 1/30 to 1/50 of gripping force

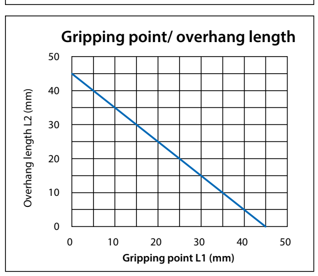
Step 2 Confirming the gripping point distance

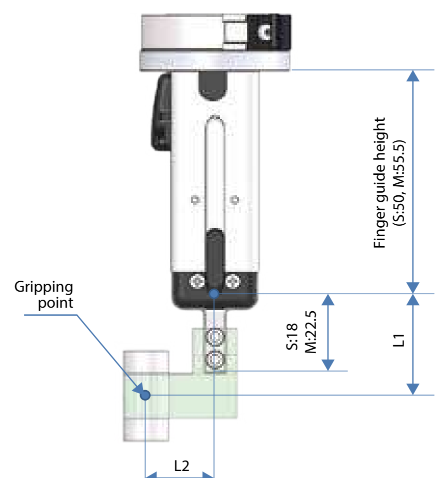
Keep the distance (L1, L2) from the finger (claw) mounting surface to the gripping point within the range shown in the following diagram. If it exceeds the range, excessive moment applies to the finger sliding part and internal mechanism, causing adverse effects on the service life.

RCP6-
RTCKSPE/
RTCKSPI/
RTCKSRE/
RTCKSRI



RCP6-
RTCKMPE/
RTCKMPI/
RTCKMRE/
RTCKMRI





Keep the finger attachment as small and light as possible, even if the distance to the gripping point distance falls within the limited range. If the finger is too long or too heavy, performance may be decreased or the guides may damaged due to inertial forces or bending moment.

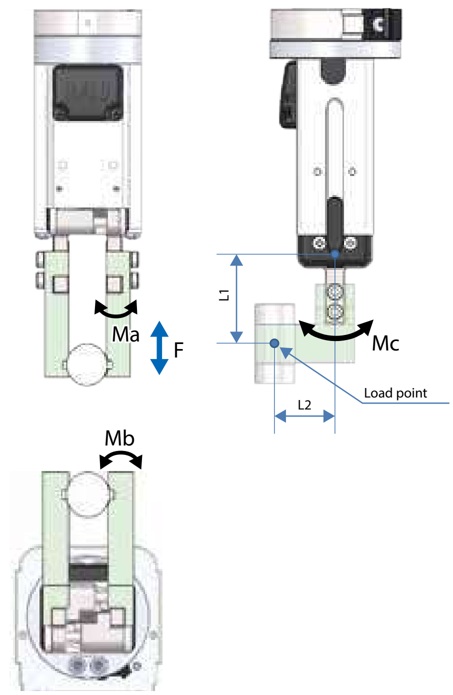
Step 3 Checking external force applied to finger

① Allowable vertical load

Confirm that the vertical load applied to each finger is less than the allowable load.

② Allowable load moment

Calculate Ma and Mc using L1 and Mb using L2. Confirm that the moment applied to each finger is less than the maximum allowable load moment.



● Allowable external force when moment load is applied to each claw:

$$\text{Allowable load F(N)} > \frac{\text{M (max. allowable moment (N·m))}}{\text{L(mm)} \times 10^{-3}}$$

Calculate the allowable loads F (N) for both of L1 and L2.
Confirm that the external force applied to finger is less than the calculated allowable load F (N) (L1 or L2, whichever is smaller).

Model	Allowable vertical load F(N)	Max. allowable load moment (N·m)		
		Ma	Mb	Mc
RCP6-RTCKSPE/RTCKSPI RTCKSRE/RTCKSRI	150	0.62	0.62	0.99
RCP6-RTCKMPE/RTCKMPI RTCKMRE/RTCKMRI	240	1.08	1.08	2.64

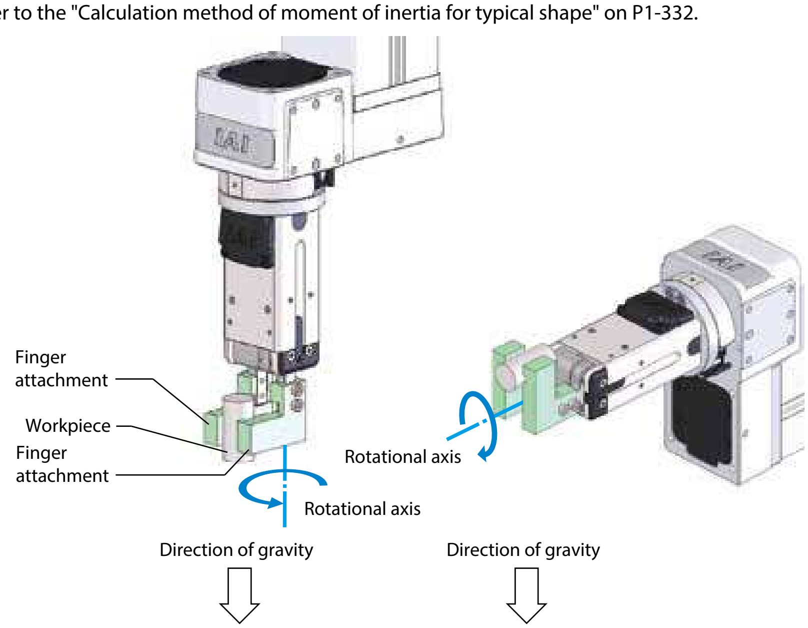
(Note) The above allowable values indicate the load position on the fingers.
(Note) The allowable values per finger are shown.

*Finger weight and work part weight are also a part of the external force.
Centrifugal force when the gripper rotated gripping a work part and inertial force due to acceleration or deceleration when moving are also the external force applied to the finger.

*The above load point indicates the load position on the fingers.
The position varies depending on the type of load.
· Load due to gripping force: Gripping point
· Gravity load: Center of gravity position
· Inertial force during moving, centrifugal force during turning and center of gravity position
The load moment is the total value calculated for each type of load.

Step 4 Checking the allowable moment of inertia

Calculate the moment of inertia of the transporting object such as workpiece, and confirm that it is under the allowable moment of inertia.
Refer to the "Calculation method of moment of inertia for typical shape" on P1-332.



Position of the rotational axis center

Allowable moment of inertia

Type	Allowable moment of inertial (kg·m^2)
RCP6-RTCKSPE/RTCKSPI/RTCKSRE/RTCKSRI	2.30×10^{-4}
RCP6-RTCKMPE/RTCKMPI/RTCKMRE/RTCKMRI	3.60×10^{-4}

Gripper Selection Method

Gripper Lever Type

Step 1
Check necessary gripping force and transportable work part weight

Step 2
Check moment of inertia of the finger attachment (claw)

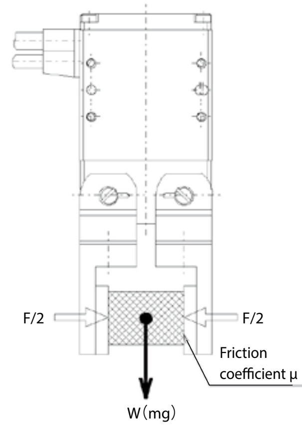
Step 3
Check external force applied to the finger

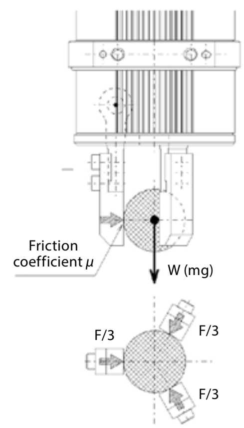
Step 1 Check necessary gripping force and transportable work part weight

Like Step 1 of Slide type, calculate the necessary gripping force and confirm that the gripping force meets conditions.

Normal work transportation	
Necessary gripping force	▶ 10 to 20 times the work part weight or more
Transportable work part weight	▶ One-tenth to one-twentieth or less of gripping force

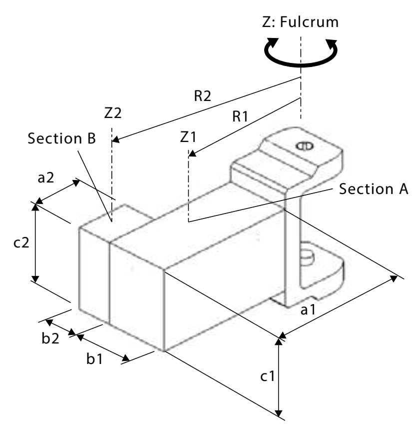
When remarkable acceleration, deceleration and/or impact occur	
Necessary gripping force	▶ 30 to 50 times the work part weight or more
Transportable work part weight	▶ One-thirtieth to one-fiftieth or less of gripping force





Step 2 Check moment of inertia of the finger attachment (claw)

Confirm that all moments of inertia around the Z axis (fulcrum) of the finger attachment (claw) fall within an allowable area. Depending on the configuration and/or shape of the finger, divide it into several elements when calculating. For your reference, an example of calculation by dividing into two elements is shown below.



① Moment of inertia around Z1 axis (the center of gravity of A) (section A)

m1: Weight of A [kg]
a1, b1, c1: Dimension of Section A [mm]

$$m1\,[kg] = a1 \times b1 \times c1 \times \text{specific gravity} \times 10^{-6}$$

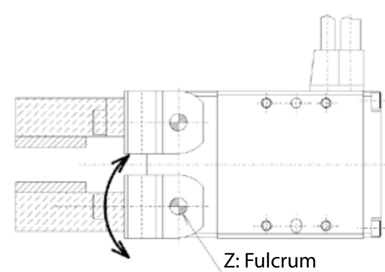
$$IZ1\,(kg.m^2) = \frac{m1\,(a1^2 + b1^2) \times 10^{-6}}{12}$$

② Moment of inertia around the Z2 axis (the center of gravity of B) (section B)

m2: Weight of B [kg]
a2, b2, c2: Dimension of Section B [mm]

$$m2\,[kg] = a2 \times b2 \times c2 \times \text{specific gravity} \times 10^{-6}$$

$$IZ2\,(kg.m^2) = \frac{m2\,(a2^2 + b2^2) \times 10^{-6}}{12}$$

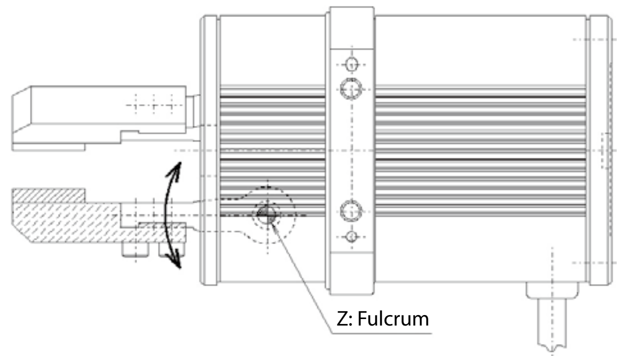


③ All moments of inertia around the Z axis (fulcrum)

R1 : Distance from the center of gravity of A to the finger opening/closing fulcrum [mm]	
R2 : Distance from the center of gravity of B to the finger [mm]	

$$I\ (kg.m^2) = (IZ1+m1R1^2\times10^{-6}) + (IZ2+m2R2^2\times10^{-6})$$

Model	Allowable moment of inertia [kg•m²]	Weight (Reference) [kg]
RCD-GRLS	1.5×10^{-4}	0.07
RCP4-GRLM	6.0×10^{-4}	0.15
RCP4-GRLL	1.3×10^{-3}	0.25
RCP4-GRLW	3.0×10^{-3}	0.4
RCP2-GR3LS	3.0×10^{-4}	0.15
RCP2-GR3LM	9.0×10^{-4}	0.5



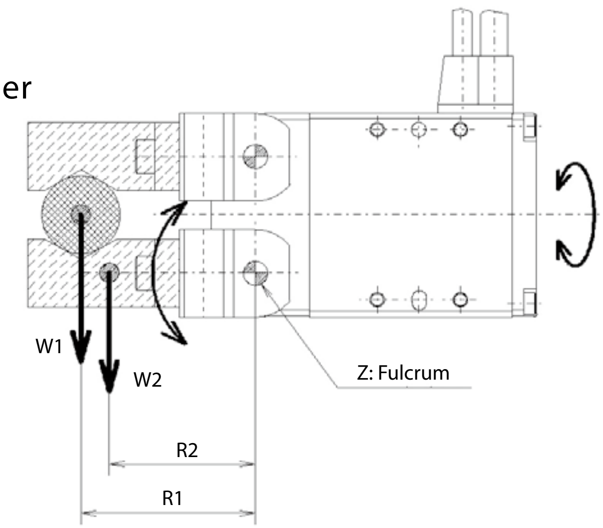
Step 3 Check external force applied to the finger

① Allowable load torque

Confirm that the load torque applied to the finger is the maximum allowable load torque or less.
The load torque is calculated by finger and work part weight as stated below.

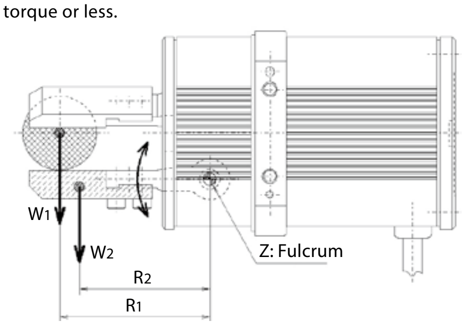
m1	:	Work part weight
R1	:	Distance from the center of gravity of work part to the finger opening/closing fulcrum
m2	:	Claw weight
R2	:	Distance from the center of gravity of the claw to the finger opening/closing fulcrum
g	:	gravitational acceleration (9.8 m / s²)

$$T = (W1\times R1\times10^{-3}) + (W2\times R2\times10^{-3}) + (\text{other load torque})$$
$$= (m1g\times R1\times10^{-3}) + (m2g\times R2\times10^{-3}) + (\text{other load torque})$$



* Centrifugal force when the gripper rotated gripping a work part and inertial force due to acceleration or deceleration when moving horizontally are also the load torque applied to the finger.
If applicable, confirm that the total torque including the torque above is the maximum allowable load torque or less.

Model	Maximum allowable load torque T [N•m]
RCP2-GRLS	0.05
RCP4-GRLM	0.35
RCP4-GRLL	0.70
RCP4-GRLW	1.50
RCP2-GR3LS	0.15
RCP2-GR3LM	0.4

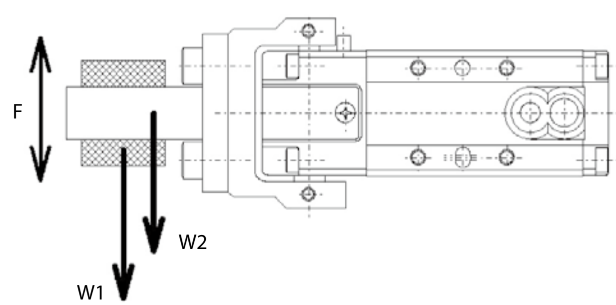


② Allowable thrust load

Confirm that the thrust load of finger opening/closing the axis is the allowable load or less.

$$F = W1 + W2 + (\text{other thrust load})$$
$$= m1g + m2g + (\text{other thrust load})$$

Model	Allowable thrust load F [N]
RCP2-GRLS	15
RCP4-GRLM	20
RCP4-GRLL	25
RCP4-GRLW	30
RCP2-GR3LS	–
RCP2-GR3LM	–



Rotary Selection Method

To use a rotary, it is required to meet the following conditions. Confirm it by calculations in steps 1 and 2.

When an optional shaft adaptor or a table adaptor is mounted, add mass and moment of inertia in the calculation (see P.2-386).

Step 1

Confirming the moment of inertia
(1) When load torque is not applied
(2) When load torque is applied
* The confirmation method of moment of inertia differs depending on the existence of load torque applied.

(1) When load torque is not applied

When used as the examples below, load torque by gravity is not applied. Calculate only the moment of inertial of the workpiece and confirm that it is within the allowable value.

Calculate the moment of inertia of the tool and the workpiece by the calculation method for typical shapes (P.1-316).

Example 1

Center of gravity of the workpiece: Output axis center
Mounting orientation: Horizontal, flat and ceiling mount

Example 2

Center of gravity of the workpiece: Output axis center
Mounting orientation: Side and vertical mount

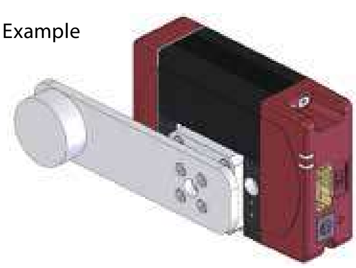
Example 3

Center of gravity of the workpiece: Offset from the output axis center
Mounting orientation: Horizontal, flat and ceiling mount

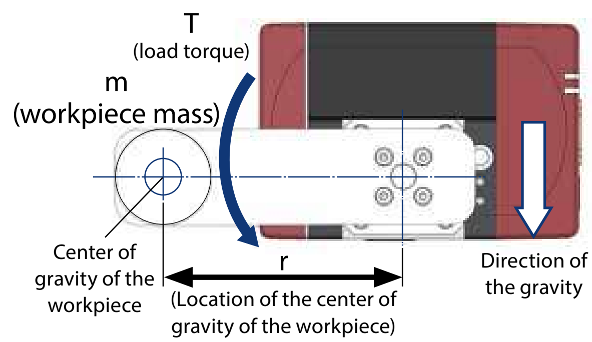
(2) When load torque is applied

When used as the examples below, load torque by gravity is applied, causing a reduction of allowable moment of inertia. First, calculate the load torque to find the compensated allowable moment of inertia. Then, calculate moment of inertia and confirm that it is equal or lower than the compensated allowable moment of inertial.

Example



Center of gravity of the workpiece: Offset from the output axis center
Mounting orientation: Side and vertical mount



Step 1: Calculating load torque T

$$T = mgr \times 10^{-3}$$

T: Load torque [N・m]
m: Workpiece mass [kg]
g: Gravitational acceleration [m/s²]
r: Center of gravity of the workpiece [mm]

Step 2: Calculating coefficient Cj of the allowable moment of inertia

$$Cj = \frac{T_{max} - T}{T_{max}}$$

T_{max}: Output torque [N・m]

* Refer to each product page for the output torque, T_{max}.

Step 3: Calculating compensated allowable moment of inertia, J_{tl}

$J_{tl} = J_{max} \times C_j$

J_{max}: allowable moment of inertia [kg・m²]

* Refer to each product page for the allowable moment of inertia, J_{max}.

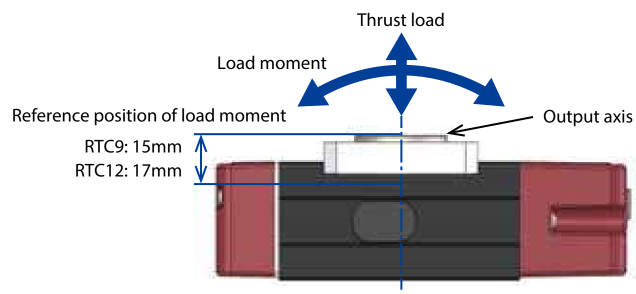
Step 4: Confirming the moment of inertia of the workpiece

Calculate the moment of inertia of the workpiece by the "Calculation method of typical shapes" below, and confirm that it is equal or lower than the compensated moment of inertia.

Step 2

Confirming the load moment and thrust load

Confirm that the load moment and the thrust load applied to the output axis are equal or lower than the allowable value. Use with an exceeding value may cause a shorter service life or malfunction.
Refer to each product page for the allowable dynamic thrust load and allowable dynamic load moment.



Calculating the Moment of Inertia for Typical Shapes

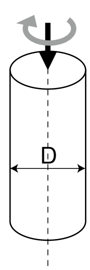
1. When the rotation axis passes through the center of the object

(1) Moment of inertia of cylinder 1

* The same formula can be applied irrespective of the height of the cylinder (even on a circular plate)

<Calculation formula> $J=M\times(D\times10^{-3})^2/8$

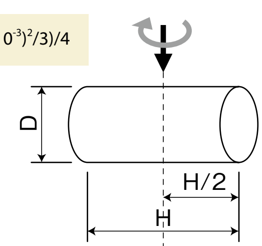
Moment of inertia of cylinder: J (kg · m²)
Mass of cylinder: M (unit kg)
Diameter of cylinder: D (mm)



(2) Moment of inertia of cylinder 2

<Calculation formula> $J=M\times((D\times10^{-3})^2/4+(H\times10^{-3})^2/3)/4$

Moment of inertia of cylinder: J (kg · m²)
Mass of cylinder: M (unit kg)
Diameter of cylinder: D (mm)
Cylinder length: H (mm)

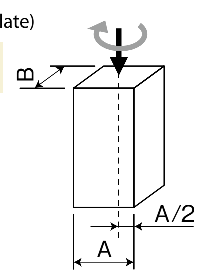


(3) Moment of inertia of prisms 1

* The same formula can be applied irrespective of the height of the cylinder (even on a four-side plate)

<Calculation formula> $J=M\times((A\times10^{-3})^2+(B\times10^{-3})^2)/12$

Moment of inertia of prisms: J (kg · m²)
One side of a rectangular column: A (mm)
One side of the rectangular column: B (mm)



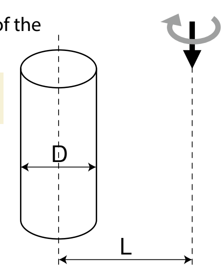
2. When the center of the object is offset from the rotation axis

(4) Moment of inertia of cylinder 3

* The same formula can be applied irrespective of the height of the cylinder (even on a circular plate)

<Calculation formula> $J=M\times(D\times10^{-3})^2/8+M\times(L\times10^{-3})^2$

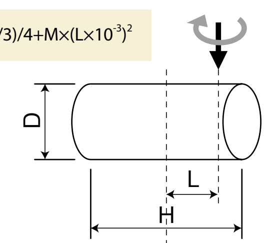
Moment of inertia of cylinder: J (kg · m²)
Mass of cylinder: M (unit kg)
Diameter of cylinder: D (mm)
Distance from rotation axis to center: L (mm)



(5) Moment of inertia of cylinder 4

<Calculation formula> $J=M\times((D\times10^{-3})^2/4+(H\times10^{-3})^2/3)/4+M\times(L\times10^{-3})^2$

Moment of inertia of cylinder: J (kg · m²)
Mass of cylinder: M (unit kg)
Diameter of cylinder: D (mm)
Cylinder length: H (mm)
Distance from rotation axis to center: L (mm)

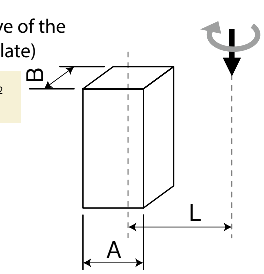


(6) Moment of inertia of prisms 2

* The same formula can be applied irrespective of the height of the cylinder (even on a four-side plate)

<Calculation formula> $J=M\times((A\times10^{-3})^2+(B\times10^{-3})^2)/12+M\times(L\times10^{-3})^2$

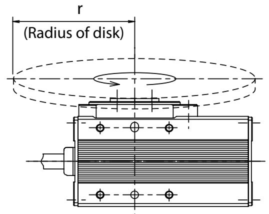
Moment of inertia of prisms: J (kg · m²)
Mass of prism: M (kg)
One side of a rectangular column: A (mm)
One side of the rectangular column: B (mm)
Distance from rotation axis to center: L (mm)



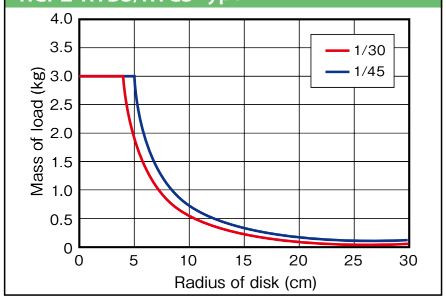
Rotary Selection Method

■ Estimate of load shape and mass

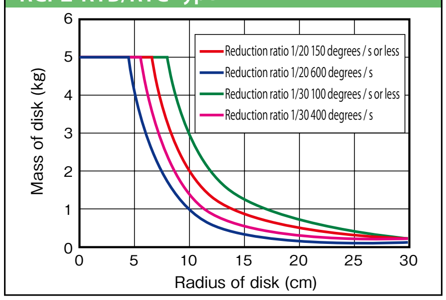
A. In the case of disc shaped loads centered on the output shaft



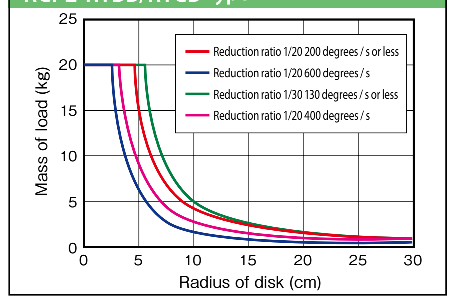
RCP2-RTBS/RTCS Type



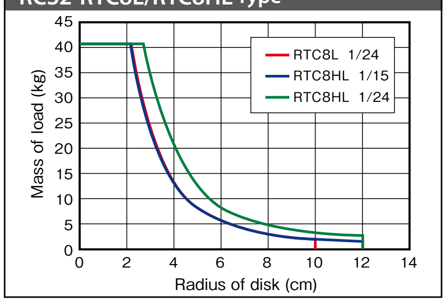
RCP2-RTB/RTC Type



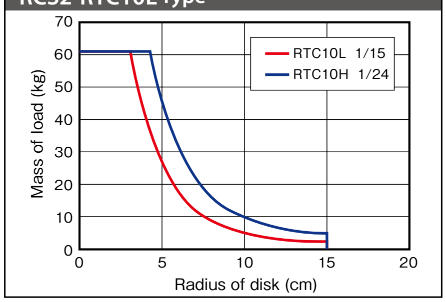
RCP2-RTBB/RTCB Type



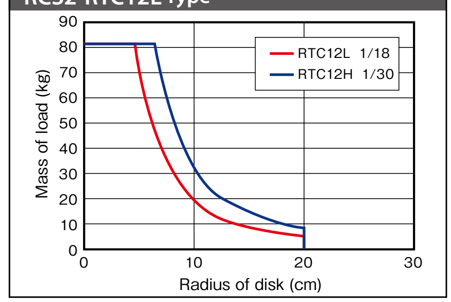
RCS2-RTC8L/RTC8HL Type



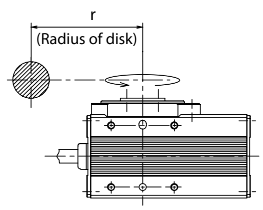
RCS2-RTC10L Type



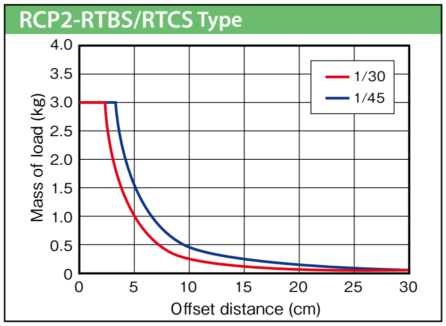
RCS2-RTC12L Type



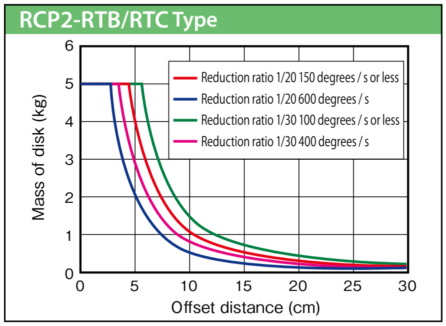
B. In the case of a load that is offset from the center of the output shaft



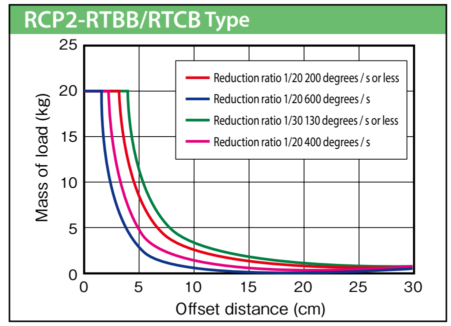
RCP2-RTBS/RTCS Type



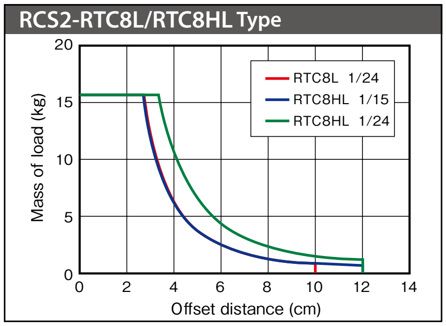
RCP2-RTB/RTC Type



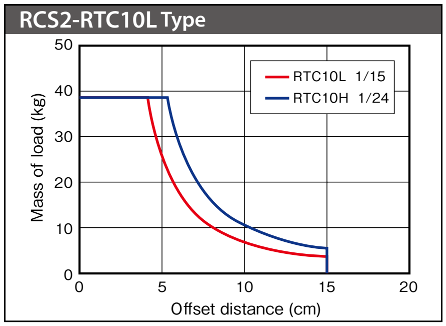
RCP2-RTBB/RTCB Type



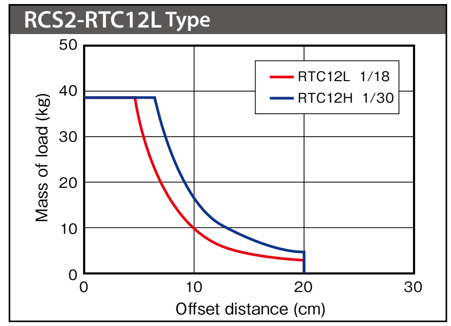
RCS2-RTC8L/RTC8HL Type



RCS2-RTC10L Type



RCS2-RTC12L Type



■ Calculation method for sideways installation

When using the rotary part of the rotary perpendicular to the floor surface,
please check whether it can be used by the following formula.

1. Calculate the differential torque. * The difference torque is the difference between the maximum torque of the main unit and the torque calculated in ①.

$\Delta T = (Tmax - Wg)$ ·····②

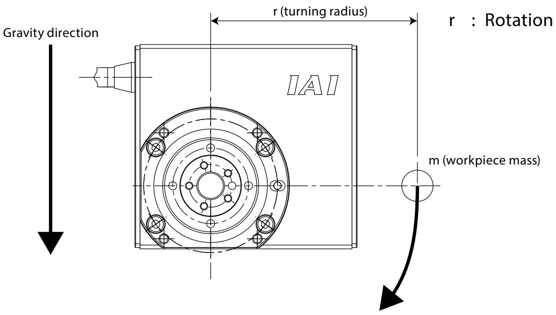
$Wg = mgr$ [N·m] ·····①

Tmax: Output shaft maximum torque [N · m]

m : Work mass [kg]

g : gravitational acceleration [m/s²]

r : Rotation radius [m]



Model	Reduction ratio	Maximum torque
RTBS, RTBSL, RTCS, RTCSL	1/30	0.24
	1/45	0.36
RTB, RTBL, RTC, RTCL	1/20	1.1
	1/30	1.7
RTBB, RTBBL, RTCB, RTCBL	1/20	3.0
	1/30	4.6
RTC8L	1/24	0.55
RTC8HL	1/15	0.53
	1/24	0.85
RTC10L	1/15	1.7
	1/24	2.8
RTC12L	1/18	5.2
	1/30	8.6

2. Check the difference torque to see if the desired model meets the torque.

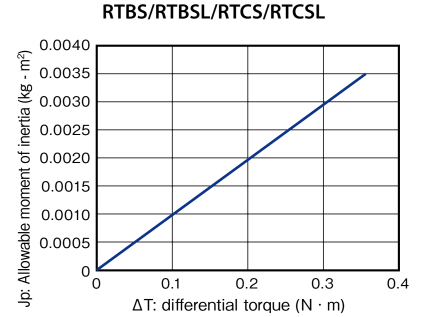
$\Delta T \leqq 0$ ····· Unusable. It is necessary to change to a high torque model or reduce the mass and turning radius.

$\Delta T > 0$ ····· Available. Proceed to the next confirmation.

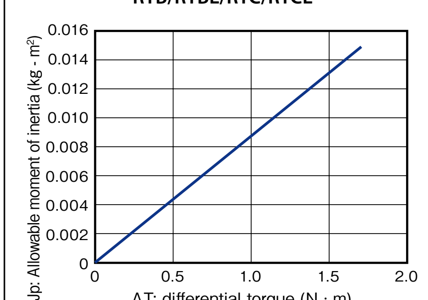
3. Calculate the allowable moment of inertia (Jp) when installing in sideways from the differential torque (ΔT) calculated in ②.
Since the allowable moment of inertia varies depending on the model, calculate from the graph below.
There is no difference depending on the speed reduction ratio of each model.

Example) When the differential torque is 0.6 N · m at RTB, the allowable moment of inertia is 0.005 kg · m².

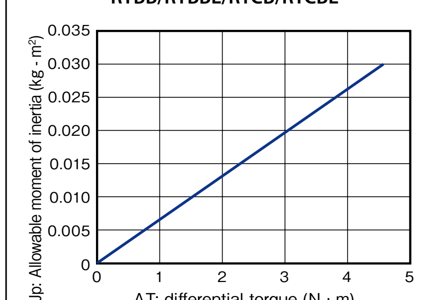
RTBS/RTBSL/RTCS/RTCSL



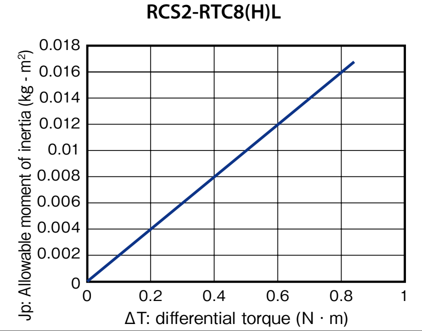
RTB/RTBL/RTC/RTCL



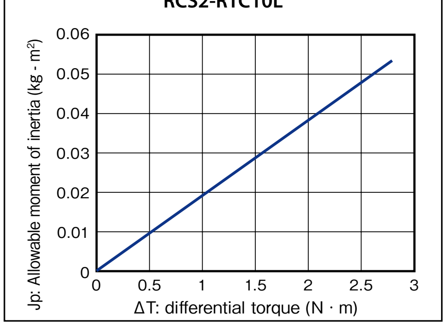
RTBB/RTBBL/RTCB/RTCBL



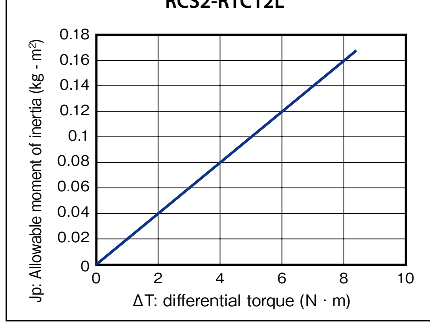
RCS2-RTC8(H)L



RCS2-RTC10L



RCS2-RTC12L



4. Determination of allowable moment of inertia

It can be used if the calculated allowable moment of inertia (Jp) is larger than the moment of inertia (Jw) of the workpiece.

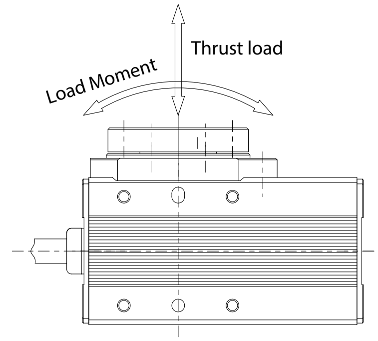
Allowable moment of inertia Jp> Moment of inertia Jw ······ It is available.
Allowable moment of inertia Jp ≤ moment of inertia Jw ····· It is unusable.

(It is necessary to change to a high torque model or reduce the mass and turning radius.)

Rotary Selection Method

Load Moment

If the inertial moment is a controllable (electrical) guide, the load moment is a guide for the limit to forced (mechanical) use.
Using the actuator body end of the output shaft mounting base as the reference position for moment, check whether the load moment exerted on the output axis is within the load moment tolerances in the catalog.
Use in excess of the allowable load moment may cause damage and shortened service life.

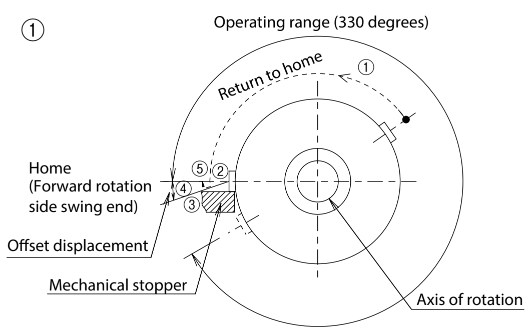


■ Notes on the origin of the RCP 2 rotary type

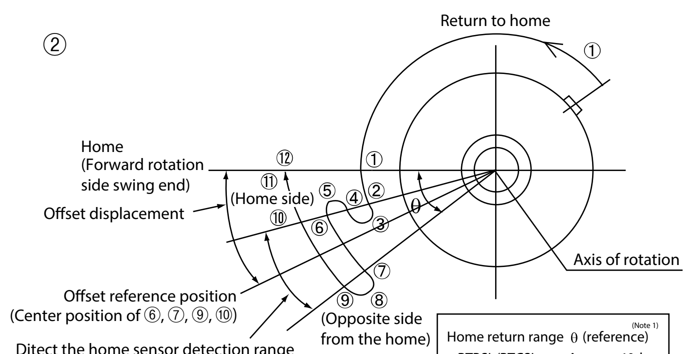
There are two types of "330 degree type" and "360 degree type" with different operating ranges for rotary type.
Both have the same home position, but please be careful about the following points when you change the home return operation and the operation (rotation) direction.

		330 degree type	360 degree type
Home return method (standard specification)		It rotates counterclockwise from the current position, pushes to the stopper, and reverses and becomes home. (See ① below)	It rotates counterclockwise from the current position, it becomes the home after confirming the position by reciprocating the home sensor detection range after sensing the sensor. (See ② below)
Reverse home specification (reverse rotation specification)		When returning to the home position, rotate clockwise from the current position, push to the stopper reverses and becomes home. In addition, the position of the stopper is different from the standard specification. Therefore, please note that the standard specification can not be reversed to the home origin later.	When returning to the home position, it rotates clockwise from the current position, it is the home after confirming the position by reciprocating the home detection range after sensing the sensor.
Home return accuracy	Small size	within ±0.05°	within ±0.05°
	Medium size	within ±0.01°	within ±0.05°
	Large size	within ±0.01°	within ±0.03°

330 degree rotation specification



Multi-turn specification
RTBSL/RTCSL, RTBL/RTCL, RTBBL/RTCBL



Home return range θ (reference) (Note 1)
- RTBSL/RTCSL : Approx. 40deg
- RTBL/RTCL : Approx. 30deg
- RTBBL/RTCBL : Approx. 10deg

(Note 1) There could be a slight dispersion depending on the distance of home sensor detection. Take these values as a reference.

[Detection of Home Sensor Detection Range (Home Side)]
① Home return start (search for the Home sensor detection range)
② Home sensor detection range (Home side) detected (B contact: falling signal or detection of signal OFF)
③ Inversion (Search for non-detection range of Home sensor)
④ Home sensor non-detection range (Detects the Home (rise of signal at B contact or detection of signal ON)
⑤ Inversion
[Detection of four points ⑥, ⑦, ⑨, ⑩ of the origin sensor detection range. Set the center position of ⑥, ⑦, ⑨, ⑩ to the offset reference position.]
⑥ Home sensor detection range (Home side) detected (B contact: falling signal or signal OFF detected), move to the home sensor non-detection range (anti-origin side)
⑦ Detection of home sensor non-detection range (The opposite side from home) (at B Contact: signal rise or signal on detection)
⑧ Move to the detection range of the inversion and origin (The opposite side from the home)
⑨ Ditect the home sensor detection range (The opposite side from the home)(At B contact: falling edge of signal or detection of signal OFF), and move to the home sensor non-detection range (the home side)
⑩ Ditect home sensor Detects non-detection range (home side) (B contact: rising of signal or detection of signal ON)
[Offset Movement Operation]
⑪ Determine the offset reference position from the center of ⑥, ⑦, ⑨, ⑩.
The position moved from the offset reference position by the offset movement amount is the home. Move from the current position to the home.
⑫ Home position

■ Caution on selection of rotary actuator

There are two control methods of the rotary type actuator: Index mode and Normal mode.

Operation mode	Description of operation	Operation range	Compatible encoder	Supported types
Index mode (limitless rotation)	One rotation of the rotating axis will make the current coordinate to become 0deg. It is used for an application to keep rotating to one direction.	0~359.99	I (incremental) (*2) AI (index absolute)	360° rotation only
Normal mode	It is used for an application to rotate within a certain scope. To return to 0deg, a reverse rotation is required.	0~9999.99 (*1)	I (incremental) (*2) AI (index absolute) AM (multi-rotation absolute)	330° rotation 360° rotation

*1: A manual setting of software limit parameter is required.
*2: It also supports the simple absolute.

Please note that it can not be operated in the index mode when used in combination with the following table.
* The 330° type and with absolute encoder type do not support the index mode.

Combinations that can not operate in index mode		
Actuator	Encoder	Controller
RCP2（CR）（W）-RTBBL	I	PCON-CB/CGB PCON-PLB/POB MCON-C/CG RCON * 1 The above pulse train control EtherCAT motion SSCNET MECHATROLINK III
RCP2（CR）（W）-RTBL		
RCP2（CR）（W）-RTBSL		
RCP2（CR）（W）-RTCBL		
RCP2（CR）（W）-RTCL		
RCP2（CR）（W）-RTCSL		
RCS2-RTC10L	I	SCON-CB/CGB RCON * 1 The above pulse train control EtherCAT motion SSCNET MECHATROLINK III
RCS2-RTC12L		
RCS2-RTC8HL		
RCS2-RTC8L		
RS All models		
DD/DDA（CR）（W） All models	AI	

* 1 The network that can be selected differs depending on the controller.

Hollow Type Rotary (RCP6-RTFML) Selection Method

When using, it is necessary to meet the following conditions.

Step 1

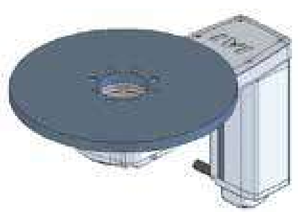
Checking moment of inertia.
(1) In case load torque is not applied
(2) In case load torque is applied
*The checking method is different depending on whether or not a load torque is applied.

(1) When load torque is not applied

When used as shown below, load torque by gravity is not applied. Calculate only the moment of inertia of the load and confirm that it is under the allowable inertial moment.

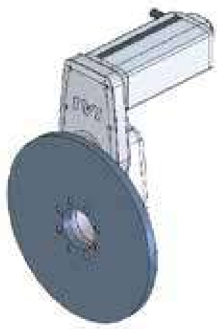
Calculate the tools and moment of inertia, referring to the "Calculation method for moment of inertia of typical shapes" on P1-332.

Ex. 1



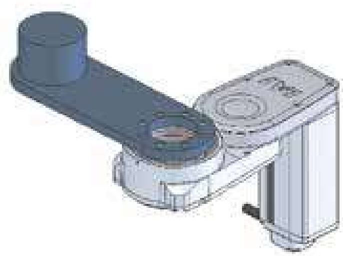
Center of gravity of the load:
Center of output shaft
Mounting of the unit:
Output shaft upward or downward

Ex. 2



Center of gravity of the load:
Center of output shaft
Mounting of the unit:
Output shaft side mounted

Ex. 3



Center of gravity of the load:
Offset from the center of output shaft
Mounting of the unit:
Output shaft upward or downward

[Allowable moment of inertia by speed, acceleration / deceleration]

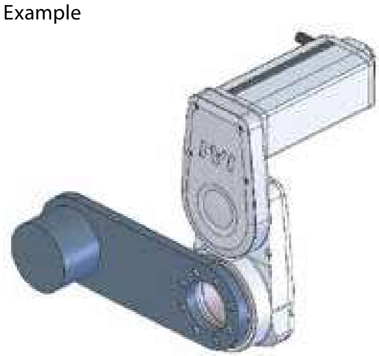
(unit: kg·m^2)

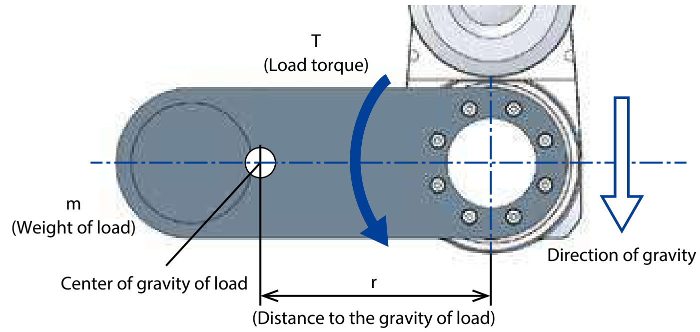
Speed (degree/s)	Acceleration/Deceleration	
	0.3G	0.7G
0	0.080	0.054
100	0.080	0.054
200	0.072	0.036
300	0.063	0.032
400	0.059	0.032
500	0.050	0.027
600	0.041	0.018
700	0.018	0.009
800	0.014	0.005

(2) In case load torque is applied

When used as shown below, load torque by gravity is applied and allowable moment of inertia is decreased. First, calculate the load torque to obtain calibrated moment of inertia. Then, calculate the moment of inertia and confirm that it is under the calibrated moment of inertia. A calculation example is shown based on the illustrations below.

Example





Load: Offset distance from the center of output shaft
Mounting of the main unit: Output shaft side mounted

(Step 1) Calculation of load torque T

$T = mgr \times 10^{-3}$ [N·m]

- **T: Load torque [N·m]**
- **m: Weight of the transporting object [kg]**
- **g: Acceleration of gravity [m/s²]**
- **r: Center of gravity of the transporting object [mm]**

(Step 2) Calculating calibration coefficient Cj of allowable moment of inertia

$$Cj + \frac{T_{max} - T}{T_{max}}$$

T_{max}: Output torque [N·m]

*** Refer to the table below for output torque, Tmax.**

【Output torque by speed T_{max}】 (unit: N·m)

Speed (degree/s)	Output torque
0	5.2
100	5.2
200	4.3
300	3.7
400	3.0
500	2.6
600	2.1
700	1.7
800	1.4

Hollow Type Rotary (RCP6-RTFML) Selection Method

(Step 3) Calculating calibrated allowable moment of inertia J_{t1}.

J_{t1} = Jmax × Cj

Jmax: Allowable moment of inertia [kg·m^2]

*** Refer to the table below for allowable moment of inertia Jmax.**

[Allowable inertial moment by speed and acceleration Jmax]

(unit: kg·m^2)

Speed (degree/s)	Acceleration/deceleration	
	0.3G	0.7G
0	0.080	0.054
100	0.080	0.054
200	0.072	0.036
300	0.063	0.032
400	0.059	0.032
500	0.050	0.027
600	0.041	0.018
700	0.018	0.009
800	0.014	0.005

(Step 4) Checking inertial moment of transporting object

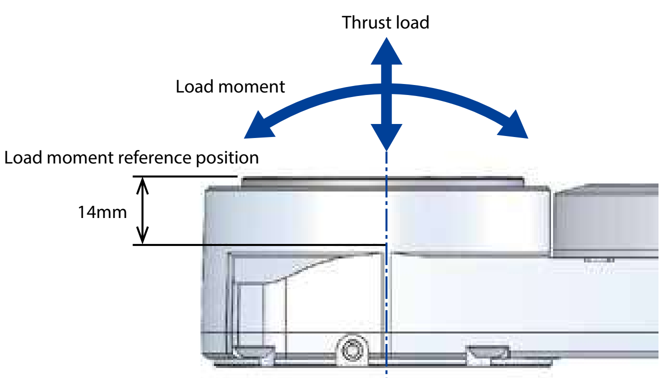
Calculate moment of inertia of the load, referring to the "Calculation method of inertial moment of typical shapes" on P1-332, and confirm that it is under the calibrated allowable moment of inertia obtained in Step 3.

Step 2

Checking load moment and thrust load

Confirm that the load moment and thrust load applied to the output shaft are less than the allowable values.
Use with excess values causes failures or reduced service life.

Item	Load / moment
Dynamic allowable thrust load	600N
Dynamic allowable load moment	30N・m



DD Motor Selection Method

Selection condition

Please confirm the following contents as to whether this product can be used under customer's desired conditions.

1 Check load condition

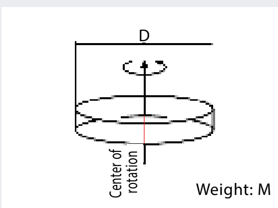
For the following three points, confirm that the conditions actually used are below the allowable value of the product.

① Thrust load	**Total load** of items to be mounted on actuator
② Load moment load	**Total load moment** of items to be mounted on actuator
③ Load inertia	**Load inertia** of the object to be mounted on the actuator

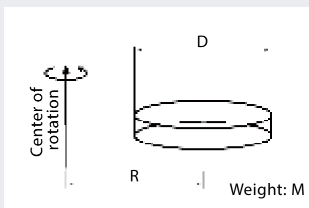
To calculate the load condition, calculate the load inertia of the object to be mounted on the actuator and check with the DD motor selection software. Then, we will post a load inertia calculation formula of a typical shape, so please refer to it.

DD motor selection software download address http://www.iai-robot.co.jp/knowledge/index.html

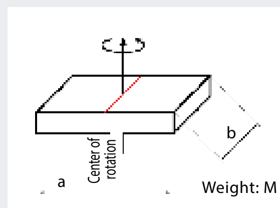
$J = 1/8 \times M \times D^2$



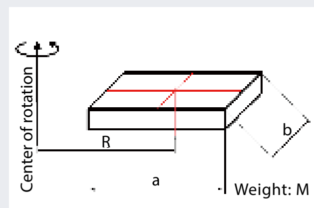
$J = M \times R^2 + 1/8 \times M \times D^2$



$J = 1/12 \times M \times (a^2 + b^2)$



$J = MxR^2 + 1/12xMx (a^2 + b^2)$



2 Confirm operating condition

From the conditions such as actual distance, speed, acceleration, deceleration, and stop time, check whether the specifications of DD motor can be used under operating conditions.

For calculation of operating conditions, please use DD motor selection software.

DD motor selection software download address http://www.iai-robot.co.jp/knowledge/index.html

3 Estimated travel time

The travel time varies depending on load inertia. Please confirm the standard of travel time from the table below.

* Since the figures in the table are approximate, it is not a guarantee of traveling time.

DD-LT18/DDA-LT18C

Load inertia lower limit [kg·m²]	0	0.005	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.2	0.3	0.4	0.5
Load inertia upper limit [kg·m²]	0.005	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.2	0.3	0.4	0.5	0.6
45 degree travel time [sec]	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.17	0.19	0.21	0.23	0.39	0.62	0.70	0.87	1.11
90 degree movement time [sec]	0.12	0.12	0.14	0.16	0.17	0.18	0.20	0.22	0.24	0.26	0.29	0.48	0.73	0.83	1.02	1.23
180 degree movement time [sec]	0.17	0.17	0.19	0.21	0.23	0.24	0.27	0.29	0.32	0.35	0.37	0.60	0.89	1.01	1.22	1.42
270 degree movement time [sec]	0.22	0.22	0.24	0.26	0.27	0.29	0.32	0.35	0.38	0.41	0.44	0.69	1.00	1.14	1.36	1.68

(Note) The time in the above table is the time from receipt of the movement command until convergence to the positioning width 0.028 degrees (about 100 angular seconds).

DD-LH18/DDA-LH18C

Load inertia lower limit [kg·m²]	0	0.005	0.01	0.02	0.02	0.03	0.04	0.06	0.08	0.10	0.15	0.2	0.3	0.4	0.6	0.8	1.0	1.2	1.4
Load inertia upper limit [kg·m²]	0.005	0.01	0.015	0.02	0.03	0.04	0.06	0.08	0.1	0.15	0.2	0.3	0.4	0.6	0.8	1	1.2	1.4	1.8
45 degree travel time [sec]	0.098	0.096	0.096	0.097	0.099	0.104	0.113	0.12	0.126	0.14	0.157	0.207	0.257	0.352	0.447	0.53	0.629	0.795	0.875
90 degree movement time [sec]	0.129	0.128	0.127	0.128	0.131	0.136	0.144	0.153	0.163	0.184	0.208	0.268	0.329	0.44	0.549	0.646	0.758	0.941	1.035
180 degree movement time [sec]	0.192	0.19	0.19	0.191	0.193	0.199	0.207	0.215	0.225	0.249	0.279	0.354	0.428	0.562	0.692	0.806	0.933	1.133	1.257
270 degree movement time [sec]	0.254	0.252	0.252	0.253	0.256	0.262	0.27	0.278	0.288	0.312	0.341	0.42	0.504	0.655	0.8	0.925	1.064	1.274	1.415

(Note) The time in the above table is the time from receipt of the movement command until convergence to the positioning width 0.028 degrees (about 100 angular seconds).

DD Motor Selection Method

Notes

Operation type

Two types of operation can be selected for this product depending on usage conditions.
Please check the features and caution points of each type before use.

In the case of 20 bits in ( )

Operation type	Index absolute type		Multi-turn absolute type	
Controller type	SCON-CB (*5)	XSEL (*1)	SCON-CB	XSEL (*1)
Operating range	0～359.999°		Up to ± 9999 ° (± 2520 °)	
Maximum movement amount of one movement command	360°	180° (*2)	The operating range	
Infinite rotation action	Possible (*3)		Impossible	
Home return operation	No need		Unnecessary (*4)	
Absolute battery	No need		necessary	

(*1) High resolution specification can not be connected to XSEL-P / Q.

(*2) When moving the index absolute type of XSEL 180 ° or more from the current position, it moves to the target position by rotating in the direction of less movement amount.
Please note that the direction of rotation changes depending on the current position and amount of movement.
To specify the moving direction, use SCON - CB.

(*3) The index absolute type can rotate indefinitely in the same direction, however since one movement amount of XSEL is 180 degrees maximum, it can not rotate continuously in the same direction without stopping like a motor.
Please use SCON-CB when you want to perform continuous rotation.

(*4) Multiple revolution absolute requires home return when initial setting or when absolute battery is replaced.

(*5) When SCON-CB index absolute type and pulse string control is used, it is necessary to change the parameters.
For details, please refer to the instruction manual.

Controller

- Although the motor output of the DD motor is 200 W, the external dimension of the SCON - CB controller is 400 W spec. (Refer to P7-196 for outer dimensions of SCON-CB.)
- When operating the DD motor with SCON - CB, one regenerative resistor unit is required for LT18 □ and two LH 18 □.
- When operating the DD motor with the XSEL controller, the regenerative resistance unit is required as follows.

Number of DD motors		1	2	3	4	5	6	7	8
Regereneative resistor units	LT18□	1		2		3		4	
	LH18□	2	4	(Can not connect)					

- When connecting multiple DD motors to the XSEL controller, up to 8 LT18 types and up to 2 LH 18 types are connected.
- When operating the DD motor with SCON - CB, please note that it can not be connected to the robot cylinder gateway function of the XSEL controller.
- For LT18 type, calculate the power capacity as 600W single phase specification 200W, three phase specification 200W for LH18 type, single phase specification 1200W · three phase specification 600W.

RS Series Selection Method

When selecting a model, decide from the following points, taking into consideration the operation, the load of loads to be installed, etc.

●Speed and load inertia of each model

For the required operation speed by the use method, the load inertia is obtained from the weight and the shape such as the arm chuck to attach to the spindle tip, and the value indicated by the catalog load inertia, please use the model that is larger than this load inertia demanded.

Model	RS-30W		RS-60W	
Reduction ratio	1/50	1/100	1/50	1/100
Rated speed (degrees / S)	360	180	360	180
Load inertia kg · m^2 (kgf · cm - S^2)	0.058 (0.59)	0.23 (2.35)	0.11 (1.1)	0.42 (4.3)

●Motor load capacity and load inertia

The load inertia is determined by the intrinsic value of the object determined by mass and shape, $J = \int r^2 dM$, and those with simple shape are represented by $J = MK^2$.

The RS series (rotary actuator) is an actuator that provides rotational power to the loading, resulting in rotational motion of the loaded object. The torque is used to represent the rotational force, and the torque is also called the moment of force. When the linear motion is compared with the rotational motion, the force is applied to the mass (inertia), and the acceleration is generated in the direction of the force.

$F = M \cdot \alpha$

F : force N (kgf)
M : Mass kg
α : Acceleration cm/s^2

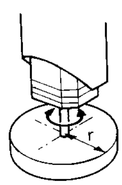
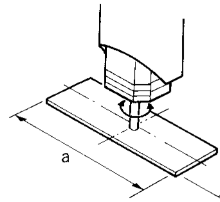
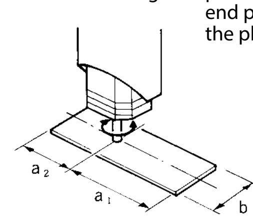
In the rotational force, the relationship between this force, mass and acceleration becomes torque, load inertia, angular acceleration. When torque is applied to an object with load inertia, angular acceleration is generated. Therefore, the load capacity is expressed in rotary with this load inertia.

$T = J \cdot \omega$

T : Torque N・m (kgf・cm)
J : Load inertia kg・m^2 (kgf・cm-s^2)
ω: Angular acceleration rad rad/s^2

●Calculation method of load inertia of typical shape

Calculation of Load Inertia J / J: Load inertia kg/m^2 M: Load weight kg r, a, a_1, A_2, B: Distance m

① Cylindrical (including thin circular plate)	② Thin rectangle (rectangular box)	③ Thin rectangular plate (rectangular box)
Position of rotating axis: central axis  $J = M \cdot \frac{r^2}{2}$	Position of of rotating axis: through the center of gravity of the board, perpendicular to the plate (same as the thick box)  $J = M \cdot \frac{a^2 + b^2}{12}$	Position of rotating axis: passing through one end perpendicular to the plate  $J = M_1 \cdot \frac{4a_1^2 + b^2}{12} + M_2 \cdot \frac{4a_2^2 + b^2}{12}$

RS Series Lineup

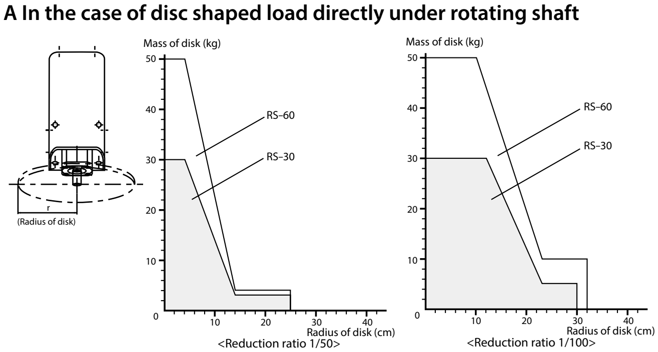
RS-60W

RS-30W

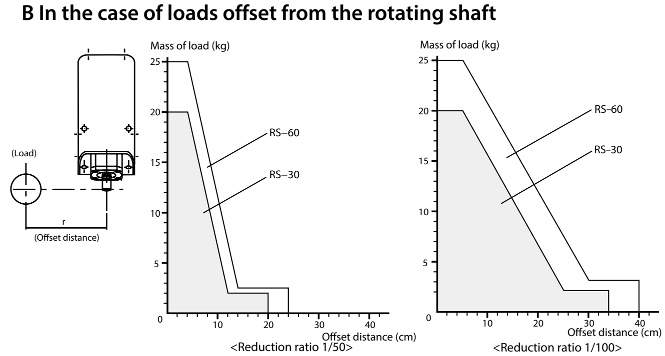
●Reference for model selection

Depending on the state of the load of the load on the rotary shaft output shaft, select the model based on the following chart as a reference.

A In the case of disc shaped load directly under rotating shaft



B In the case of loads offset from the rotating shaft

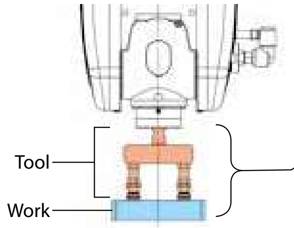


Wrist Unit (WU) Selection Method

Follow steps 1-4 to confirm. Please check the following page for the selection example.

Step 1

Check the amount of transported material

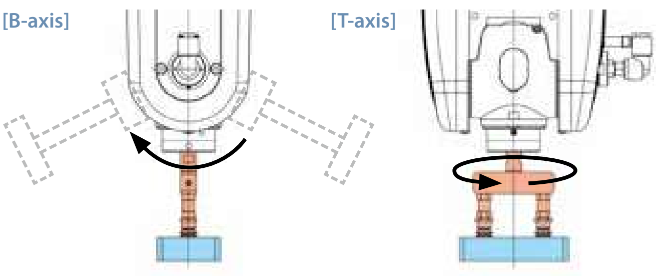


Transport material amount ≦ maximum loaded mass

Step 2

Check moment of inertia

If the load torque is applied to the B-axis or T-axis, the allowable moment of inertia of the wrist unit decreases.
First, calculate the load torque and obtain the allowable moment of inertia of compensation.



"Calculating the Moment of Inertia for Typical Shapes" is posted on page 1-332.

Check the existence of "load torque" on the B-axis and T-axis

In case of "Yes"

Moment of inertia on B and T axes ≦ Compensation allowable moment of inertia of small type / medium type

* It changes according to speed and acceleration / deceleration.

In case of "No"

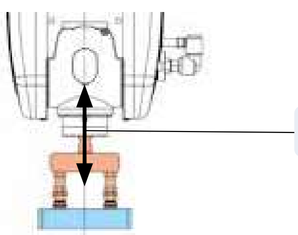
Moment of inertia on B and T axes ≦ Compensation allowable moment of inertia of small type / medium type

* It changes according to speed and acceleration / deceleration.

Step 3

Check dynamic allowable thrust load

Make sure that the thrust load (the load in the vertical direction to the mounting surface) is less than the dynamic permissible thrust load.

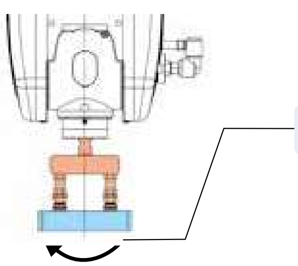


Dynamic permissible thrust load: F ≦ Dynamic permissible thrust load

Step 4

Check the dynamic allowable load moment

Make sure that the load moment is less than the dynamic allowable moment.



Dynamic load moment: M ≦ Dynamic allowable load moment

Wrist Unit (WU) Model Selection Example

The model selection example is posted based on application examples "Inspection Device for Automotive Connector".

Inspection Device for Automotive Connector

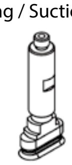
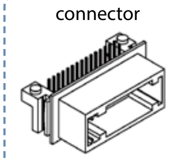
[Overview]

It is a device to inspect the exterior of the automobile connector with a camera.
Rotate the connector with the wrist unit and inspect from various angles.

Step 1 Check the amount of transported material

< Amount of transport material
= Mass of tool + Mass of work piece>

	Maximum loaded mass
WU-S: Small type	1kg
WU-M: Medium type	2kg

Transport material = Piping / Suction pad  0.02[kg] + connector  0.013[kg] =0.033**[kg]**

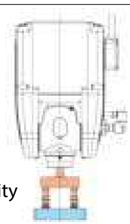
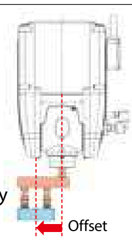
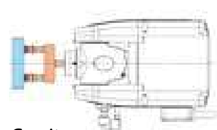
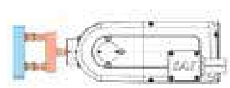
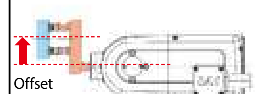
Both WU-S (small) and WU-M (medium) can be used

Step 2 Check moment of inertia

Check the existence of "load torque" on the B-axis and T-axis

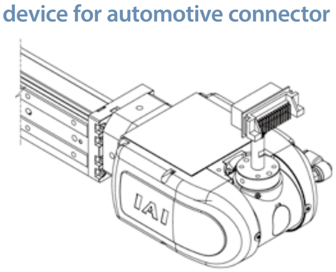
- **In case of "Yes"** → Calculate the load torque and obtain the allowable moment of inertia of compensation. Then, calculate the moment of inertia and confirm that it is less than the allowable value.
- **In case of "No"** → Calculate the moment of inertia and confirm that it is less than the allowable moment of inertia.

Conditions under load torque

	Presence or absence of load torque				
	①	②	③	④	⑤
Mounting posture					
B-axis	Yes	Yes	No	Yes	Yes
T-axis	No	Yes	No	No	Yes

Because this case "Inspection device for automotive connector" is applied to it, we calculate and confirm check about B-axis and T-axis as described below.

Inspection device for automotive connector [Case study]



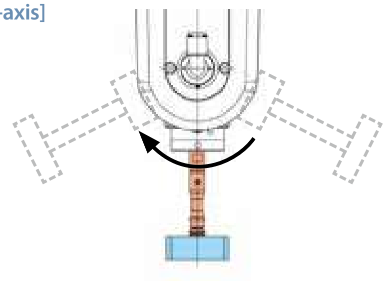
1 [B-axis] **Load torque "Yes"**

2 [T-axis] **Load torque "No"**

Wrist Unit (WU) Model Selection Example

1. Check B-axis

[B-axis]



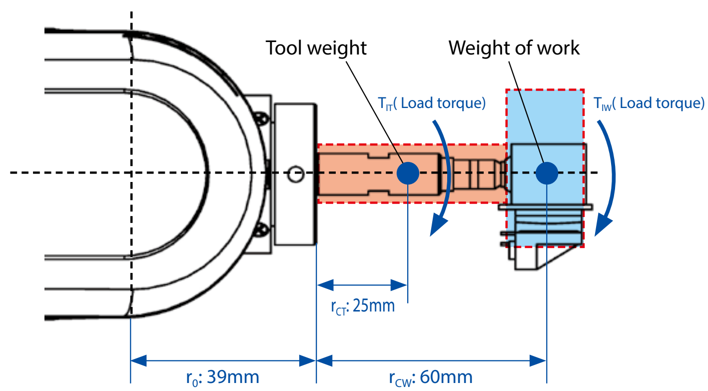
Load torque "Yes"

Moment of inertia on B-axis < Compensation allowable moment of inertia of small type / medium type

* It changes according to speed and acceleration / deceleration.

(1) Calculation of load torque Tl

T_{IT}: Load torque by tool weight [N · m]
T_{IW}: Load torque by weight of work [N · m]
m_T: Mass of tool [kg]
m_W: Mass of work [kg]
g: Gravitational acceleration[m/s^2]
r_0: Mounting surface distance[mm]
r_{CT}: Position of tool center of gravity [mm]
r_{CW}: Position of workpiece center of gravity [mm]



$T_l=T_{IT}+T_{IW}$

$=m_T \cdot g(r_0+r_{CT})\times10^{-3}+m_W \cdot g(r_0+r_{CW})\times10^{-3}$

$=0.02\times9.8\times(39+25)\times10^{-3}+0.013\times9.8\times(39+60)\times10^{-3}$

$=0.025$[Nm] Calculation result

(2) Calculation of allowable moment of inertia compensation coefficient CJ

$$C_j=\frac{T_{max}-T_l}{T_{max}}$$

T_{max}: Output torque (Right table) [Nm]
T_l: Calculation result of load torque (1)

[Operating conditions of the wrist unit]

B-axis rotation — Speed: 600 [degrees / s], Acceleration: 0.3 [G]

Calculate by the numerical value of small size (s)

$$C_j=\frac{T_{max}-T_l}{T_{max}}=\frac{0.58-0.025}{0.58}$$

$=0.96$ Calculation result

■ Output torque of inertia by speed [Nm]

WU-S: Small type

Speed Degrees / s	B-axis	T-axis
0	0.65	0.65
150	0.65	0.65
300	0.62	0.62
450	0.6	0.6
600	0.58	0.58
750	0.52	0.52
900		0.45
1050		0.45
1200		0.45

WU-M: Medium type

Speed Degrees / s	B-axis	T-axis
0	1.65	1.65
150	1.65	1.65
300	1.65	1.65
450	1.65	1.65
600	1.58	1.58
750	1.36	1.36
900	1.14	1.14
1050		0.96
1200		0.79

(3) Calculation of compensation allowable moment of inertia Jtl

$J_{tl}=J_{max}C_j$ (kgm^2)

J_{max}: Allowable moment of inertia (right table)[kgm^2]
C_j: Calculation result of allowable moment of inertia moment (2)

$J_{tl}=0.008\times0.96$

$=0.0077$ Calculation result

■ Allowable moment of inertia by speed acceleration[kgm^2]

WU-S: Small type

Speed	B-axis	T-axis
	Acceleration / deceleration	
Degrees / s	0.3G	0.3G
0	0.008	0.0035
150	0.008	0.0035
300	0.008	0.0035
450	0.008	0.0035
600	0.008	0.0035
750		0.0035
900		0.0035
1050		0.0035
1200		0.0025

WU-M: Medium type

Speed	B-axis	T-axis
	Acceleration / deceleration	
Degrees / s	0.3G	0.3G
0	0.0150	0.0126
150	0.0150	0.0126
300	0.0118	0.0072
450	0.0055	0.0054
600	0.0055	0.0054
750		0.0054
900		0.0036
1050		0.0036
1200		0.0036

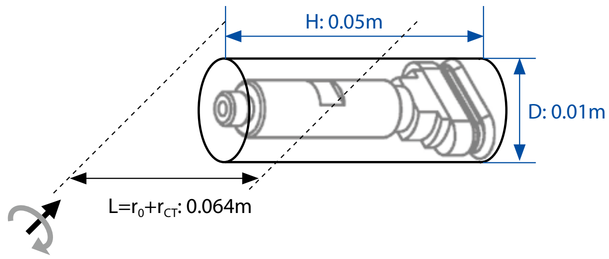
(4) Check the moment of inertia of transport material

Calculate the moment of inertia of the tool and the workpiece in the formula for calculating the moment of inertia of a typical shape (P1-332), and check that the calibrated allowable moment of inertia obtained by (3) is less than (4) ≤ (3).

Point
The shape can be calculated easily by simplifying it.

① Moment of inertia of piping and suction pads: J_{BT}

Calculate by simplifying to cylinder



Use the formula 2.(5) on P1-332.

m_T: Mass of cylinder 0.02 [kg]
D: Cylinder diameter 0.01 [m]
H: Cylinder length 0.05 [m]

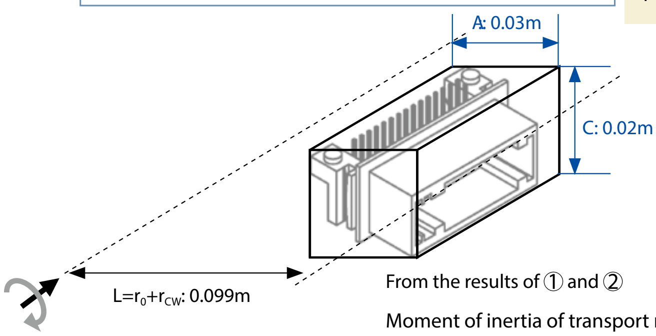
$$J_{BT}=\frac{m_T\left(\frac{D^2}{4}+\frac{H^2}{3}\right)}{4}+m_T(r_0+r_{CT})^2$$

$$=\frac{0.02\times\left(\frac{0.01^2}{4}+\frac{0.05^2}{3}\right)}{4}+0.02\times(0.039+0.025)^2$$

$$=8.62\times10^{-5}$$

② Moment of inertia of the connector: J_{BW}

Calculate by simplifying to rectangular parallelepiped



1-332 page 2. (6) is used

m_W: Mass of rectangular parallelepiped 0.013 [kg]
A: One side of the rectangular parallelepiped 0.03 [m]
C: One side of a rectangular parallelepiped 0.02 [m]

$$J_{BW}=\frac{m_W(A^2+C^2)}{12}+m_W(r_0+r_{CW})^2$$

$$=\frac{0.013\times(0.03^2+0.02^2)}{12}+0.13\times(0.039+0.06)^2$$

$$=1.28\times10^{-4}$$

From the results of ① and ②

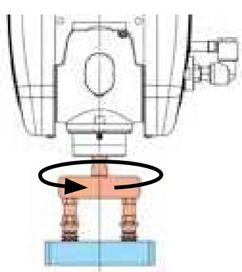
Moment of inertia of transport material around B axis

$=J_{BT}+J_{BW}$
$=8.62\times10^{-5}+1.28\times10^{-4}$
$=2.1\times10^{-4}$

Available because it is less than the compensation allowable moment of inertia.

2. Check T-axis

[T-axis]



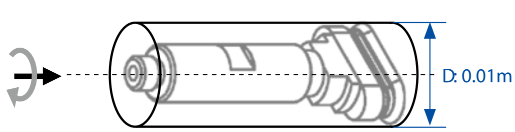
Load torque "No"

Moment of inertia on T-axis < Compensation allowable moment of inertia of small type / medium type

* It changes according to speed and acceleration / deceleration.

When no load torque is applied, calculate the moment of inertia of the tool and the workpiece in the formula for calculating the moment of inertia of a typical shape (page 1-332), and check that it is less than allowable moment of inertia.

① Moment of inertia of piping and suction pads: J_{TT}



Use the formula 2.(1) on P1-332.

m_T: Mass of cylinder 0.02 [kg]
D: Diameter of cylinder 0.01 m

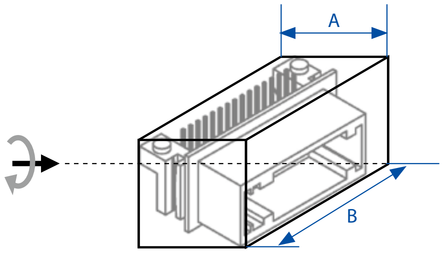
$$J_{TT}=\frac{m_T\times D^2}{8}$$

$$=\frac{0.02\times0.01^2}{8}$$

$$=2.50\times10^{-7}$$

Wrist Unit (WU) Model Selection Example

② Moment of inertia of the connector: J_{TW}



Use the formula 1(.3) on P1-332.

m_W: Mass of rectangular parallelepiped 0.013 [kg]
A: One side of the rectangular parallelepiped 0.03 [m]
B: One side of a rectangular parallelepiped 0.05 [m]

$$J_{TW}=\frac{m_W(A^2+B^2)}{12}$$

$$=\frac{0.013\times(0.03^2+0.05^2)}{12}$$

$$=3.68\times10^{-6}$$

From the results of ① and ②

Moment of inertia of transport material around T axis

$=J_{TT}+J_{TW}$
$=2.50\times10^{-7}+3.68\times10^{-6}$
$=3.9\times10^{-6}$[kgm²]

From the allowable moment of inertia (table below), WU-S (compact) is available.

[Operating conditions of the wrist unit]

T axis rotation — Speed: 600 [degrees / s]
Acceleration: 0.3 [G]

■ Allowable moment of inertia by speed acceleration [kgm²]

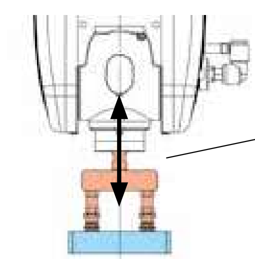
WU-S: Small type

Speed	B-axis		T-axis	
	Acceleration / deceleration			
Degrees / s	0.3G	0.7G	0.3G	0.7G
0	0.0085	0.0065	0.0075	0.0035
150	0.0085	0.0065	0.0075	0.0035
300	0.0085	0.005	0.0065	0.0035
450	0.0085	0.005	0.0065	0.0025
600	0.0085	0.005	0.0065	0.0025
750		0.005	0.0065	0.0025
900			0.0065	0.0025
1050			0.0065	0.0025
1200			0.0065	0.0025

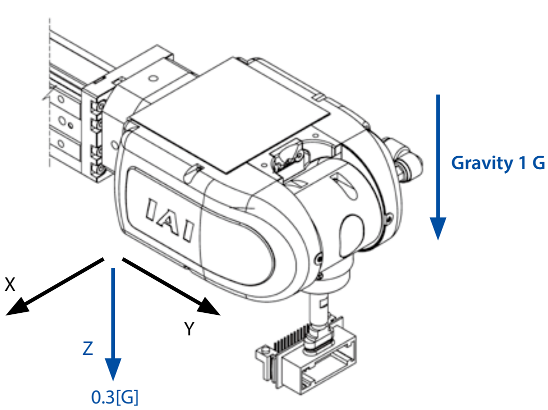
WU-M: Medium type

Speed	B-axis		T-axis	
	Acceleration / deceleration			
Degrees / s	0.3G	0.7G	0.3G	0.7G
0	0.0150	0.0145	0.0165	0.0126
150	0.0150	0.0145	0.0165	0.0126
300	0.0150	0.0127	0.0165	0.0090
450	0.0099	0.0045	0.0126	0.0063
600	0.0090	0.0036	0.0108	0.0054
750		0.0036	0.0099	0.0054
900		0.0036	0.0099	0.0045
1050			0.0081	0.0045
1200			0.0081	0.0045

Step 3 Check dynamic allowable thrust load



Dynamic thrust load: F ≦ Dynamic allowable thrust load



$F=(m_T+m_W)\cdot(a+g)\cdot9.8$[N]

m_T: Mass of tool 0.02 [kg]
m_W: Mass of workpiece 0.013 [kg]
g: Gravitational acceleration 1.0 [G]
a: Z axis movement acceleration 0.3 [G]

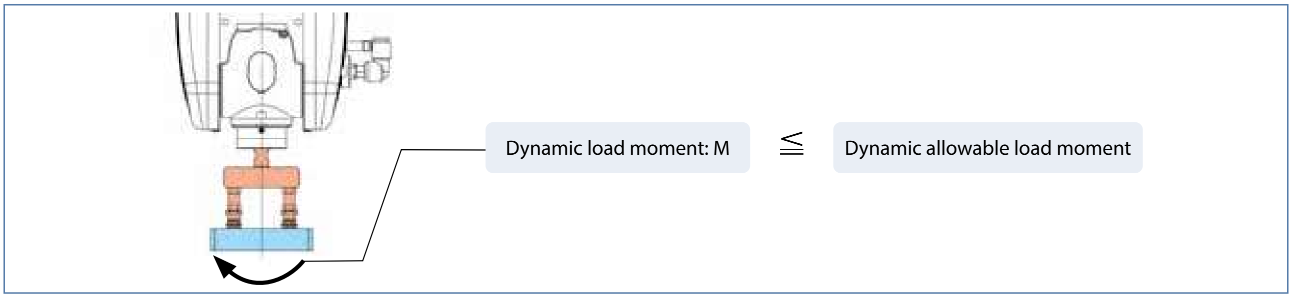
$F=(0.02+0.13)\times(0.3+1.0)\times9.8$
$=0.033\times1.3\times9.8$
$=0.42$[N]

From dynamic allowable thrust load (lower table), Wu-s (small) is available.

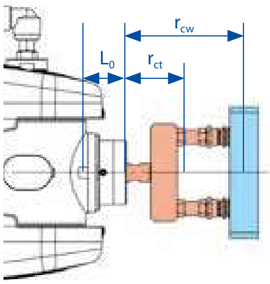
■ Dynamic allowable thrust load

	Allowable thrust load
WU-S: Small type	330N
WU-M: Medium type	450N

Step 4 Check the dynamic allowable load moment



$M = m_T \cdot a \cdot 9.8(L_0 + r_{CT}) \times 10^{-3} + m_W \cdot a \cdot 9.8(L_0 + r_{CW}) \times 10^{-3}$ [Nm]



m_T: Mass of tool 0.02 [kg]
m_W:Mass of workpiece 0.013 [kg]
a: X axis movement acceleration 0.3 [G]
L_0: Load moment reference position
WU-S (Small) 17.5 [mm]
WU-M (medium size) 21.5 [mm]
r_{CT}T: Tool center of gravity position 25 [mm]
r_{CW}: Work center of gravity position 60 [mm]

$M = 0.02 \times 0.3 \times 9.8 \times (17.5 + 25) \times 10^{-3}$
$+ 0.013 \times 0.3 \times 9.8 \times (17.5 + 60) \times 10^{-3}$
$= 0.0025 + 0.0030$
$= 0.0055$ [Nm]

From dynamic allowable thrust load (lower table), Wu-s (small) is available.

■ Dynamic allowable thrust load

	Allowable thrust load
WU-S: Small type	1.4Nm
WU-M: Medium type	4.2Nm

WU-S (Compact) is available from the result of Procedure 1.4

Calculation Method of Inertia Moment of Typical Shape

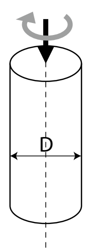
1.The rotation axis passes through the center of the object

(1) Moment of inertia of the cylinder 1

*Regardless of the height of the cylinder (even disc), the same formula can be applied.

<Calculation formula>$I = M \times D^2/8$

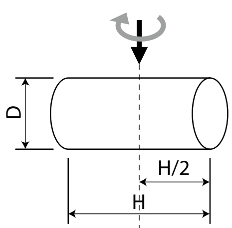
Moment of inertia of cylinder: I ($kg \cdot m^2$)
Mass of cylinder: M (kg)
Diameter of cylinder: D (m)



(2) Moment of inertia of the cylinder 2

<Calculation formula>$I = M \times (D^2/4 + H^2/3)/4$

Moment of inertia of cylinder: I ($kg \cdot m^2$)
Mass of cylinder: M (kg)
Diameter of cylinder: D (m)
Cylinder length: H (m)

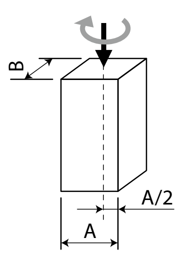


(3) Moment of inertia of the prism 1

* Regardless of the height of the prism (even on the four sides plate), the same formula can be applied.

<Calculation formula>$I = M \times (A^2 + B^2)/12$

Moment of inertia of cylinder: I ($kg \cdot m^2$)
One side of a rectangular column: A (m)
One side of the rectangular column: B (m)



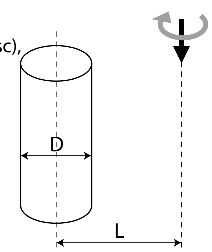
2. The center of the object is offset from the rotation axis

(4) Moment of inertia of the cylinder 3

*Regardless of the height of the cylinder (even disc), the same formula can be applied.

<Calculation formula>$I = M \times D^2/8 + M \times L^2$

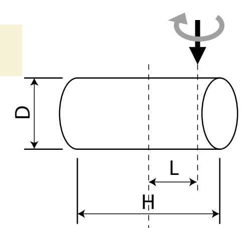
Moment of inertia of cylinder: I ($kg \cdot m^2$)
Mass of cylinder: M (kg)
Diameter of cylinder: D (m)
Distance from rotation axis to center: L (m)



(5) Moment of inertia of the cylinder 4

<Calculation formula>$I = M \times (D^2/4 + H^2/3)/4 + M \times L^2$

Moment of inertia of cylinder: I ($kg \cdot m^2$)
Mass of cylinder: M (kg)
Diameter of cylinder: D (m)
Cylinder length: H (m)
Distance from rotation axis to center: L (m)

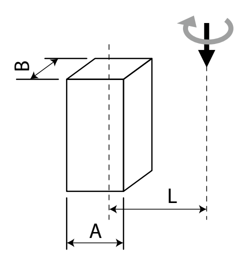


(6) Moment of inertia of the prism 2

* Regardless of the height of the prism (even on the four sides plate), the same formula can be applied.

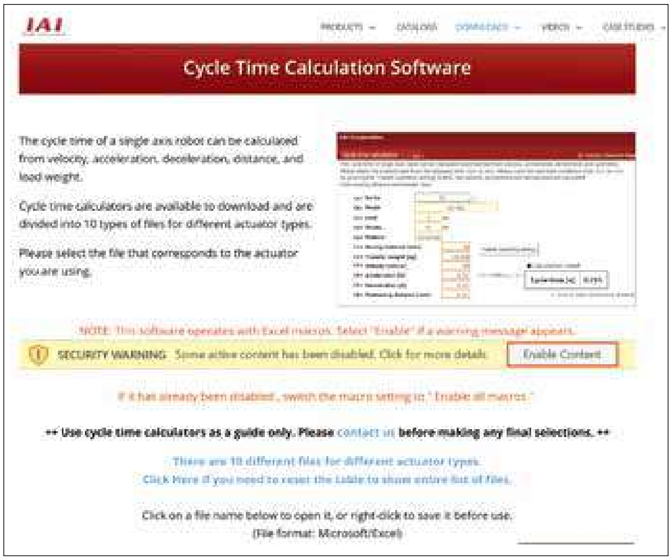
<Calculation formula>$I = M \times (A^2 + B^2)/12 + M \times L^2$

Moment of inertia of cylinder: I ($kg \cdot m^2$)
Mass of cylinder: M (kg)
One side of a rectangular column: A (m)
One side of the rectangular column: B (m)
Distance from rotation axis to center: L (m)



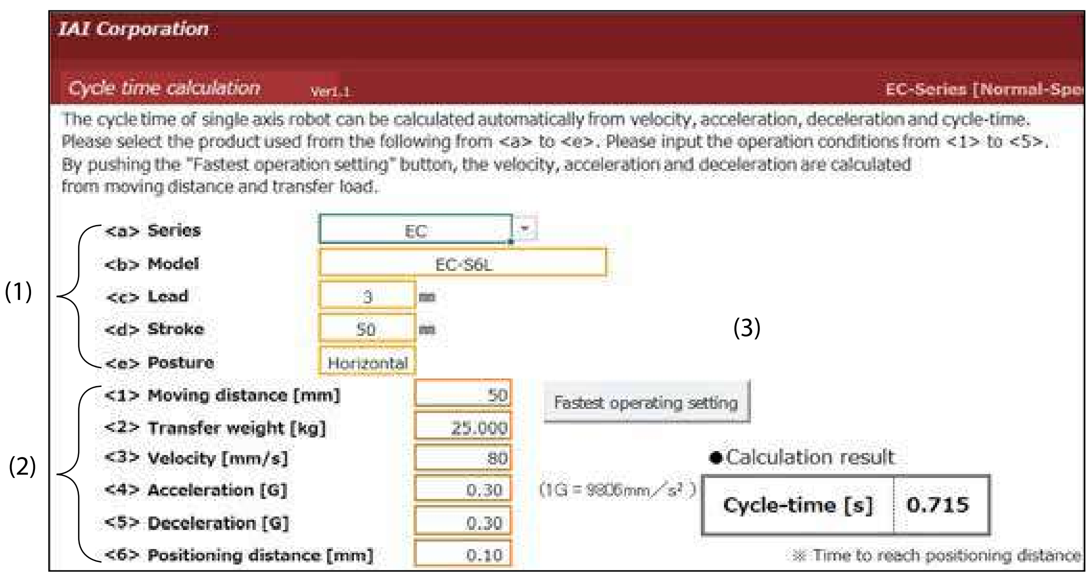
Cycle time calculation software

If you want to check the actuator positioning time (cycle time), please use the cycle time calculation software (free of charge). Cycle time calculation software can be obtained from our website.



Please visit our website: www.intelligentactuator.com/cycle-time-calculation-software/

The cycle time calculation software automatically displays the maximum value according to the transport mass and acceleration / deceleration for each model, so the shortest positioning time according to the operating conditions can be easily calculated.



(1) Input the specifications and the mounting posture of the actuator whose cycle time is to be calculated

(2) The maximum values of payload, speed, acceleration and deceleration of the model specified in the above (1) are displayed. Input actual conditions within the maximum values.

(3) The positioning time will be displayed on the conditions entered in the above (1) and (2).

Note

* The cycle time calculation software calculates based on the relationship of the payload and acceleration/ deceleration of each model (series and types). Use the right software for the right model that is actually used.

Off-board Tuning Function

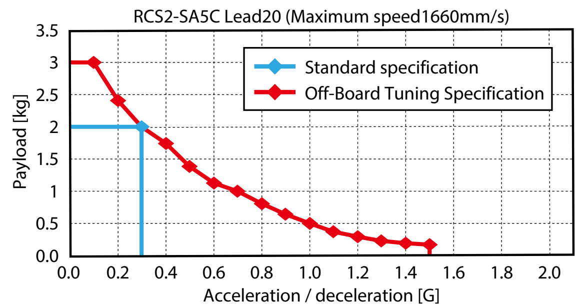
Increases transfer capability of actuator

The off-board tuning function improves the payload and acceleration / deceleration by setting the optimum gain automatically according to the load, enabling to increase the payload and shorten the takt time.

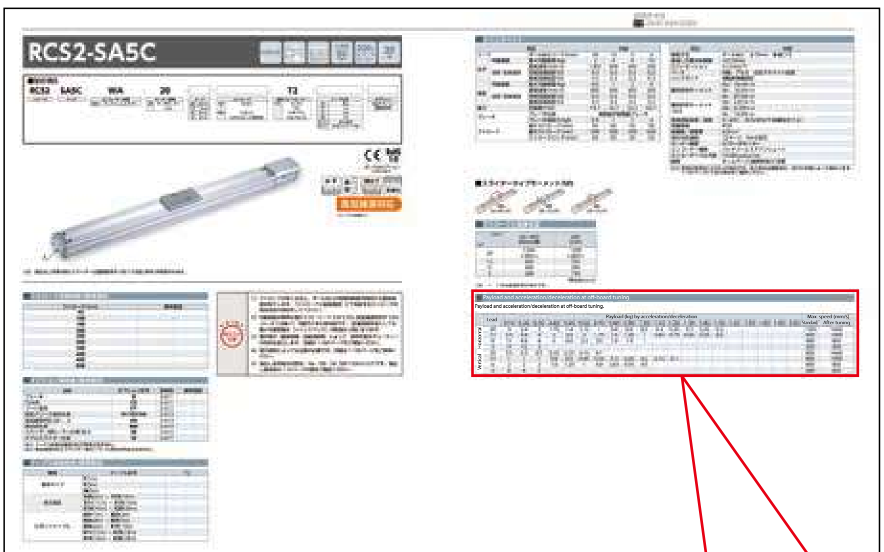
Supported PC software ver.8.05.00.00 or later

By performing off-boat tuning, the following three effects can be obtained.
①By setting the acceleration / deceleration low, it is possible to transfer more than the rated payload.
②If the payload is smaller than the rated value, acceleration / deceleration can be increased.
③It is possible to increase the maximum.

Example) The graph at right shows the off-board tuning effect of RCS2-SA5C lead 20.
①When lowering the acceleration / deceleration from the rated value from 0.3G to 0.1G, the maximum payload will be increased from 2 kg to 3 kg.
②If the payload is low, acceleration / deceleration can be increased up to 1.5 G.
③The maximum speed can be increased from the standard 1300 mm/s to 1660 mm/s.



Refer to each product page for details.



Payload and acceleration/deceleration at off-board tuning.

Payload and acceleration/deceleration at off-board tuning.

	Lead	Payload (kg) by acceleration/deceleration																				Max. speed (mm/s)	
		0.1G	0.2G	0.3G	0.4G	0.5G	0.6G	0.7G	0.8G	0.9G	1.0G	1.1G	1.2G	1.3G	1.4G	1.5G	1.6G	1.7G	1.8G	1.9G	2.0G	Standard	After tuning
Horizontal	20	3	2.4	2	1.75	1.4	1.15	1	0.8	0.6	0.5	0.4	0.35	0.3	0.25	0.2						1300	1660
	12	5.5	4.8	4	3	2.5	2	1.75	1.5	1.25	1	0.85	0.75	0.65	0.55	0.5						800	1000
	6	11	9.6	8	6	4.5	3.3	2.5	1.9	1.4	1											400	400
	3	17	12	3																		200	200
Vertical	20	0.5	0.5	0.5	0.35	0.25	0.16	0.1														800	1660
	12	1	1	1	0.8	0.6	0.45	0.35	0.3	0.25	0.2	0.15	0.1									800	1000
	6	2	2	2	1.6	1.25	1	0.8	0.65	0.55	0.5											400	400
	3	4	4	2																		200	200

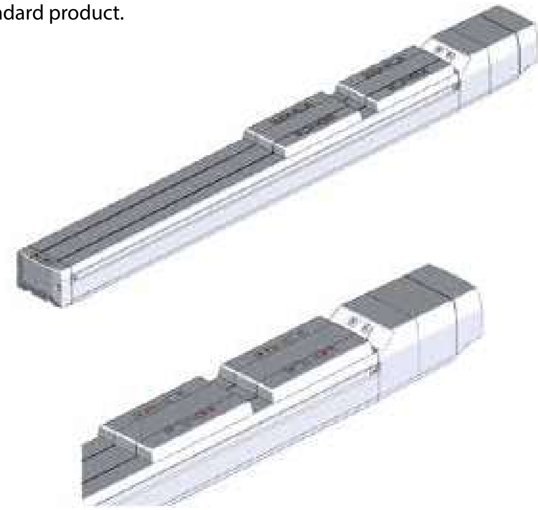
Special Specification

In addition to the standard products that are listed in the catalog, I have been dealing with various special specification products.
If you do not have your desired product, please feel free to contact our sales office or Customer center eight (see the back cover).

Special Product Examples

Double Slider

It is effective when the actuator protrudes from the slider a lot and it exceeds the overhang load length or when it exceeds the allowable load moment.
By adding a free slider, the effective stroke will be shorter than the standard product.



No motor / Special motor

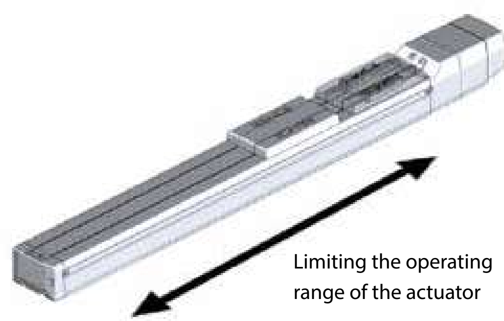
When customer prepares motor and driver, only actuator without motor can be shipped.
In addition, we can ship it by installing the motor specified by the customer.

Special ball screw lead

It is possible to use lead screw ball screws not available in standard products.

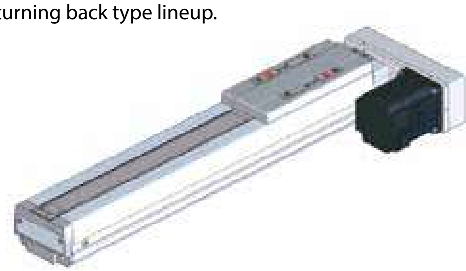
Special home position

It is possible to change the home position.(mechanical end)



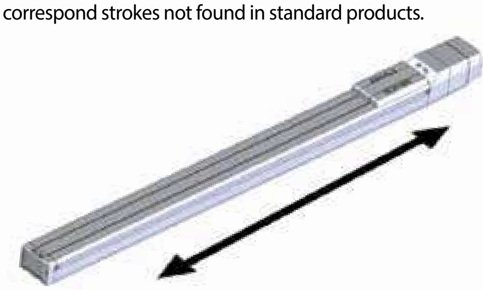
Turning back motor

Motor turning back can be prepared even for models that do not have motor- turning back type lineup.



Special Stroke

We can correspond strokes not found in standard products.



Special Product Examples

Surface treatment

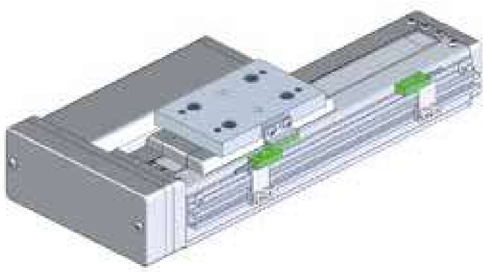
Surface treatment can be changed by black alumite treatment or hard alumite treatment.

Air purge specification

By air purge, it is possible to make it harder for foreign matter to enter the inside of the actuator and the motor part than standard parts.

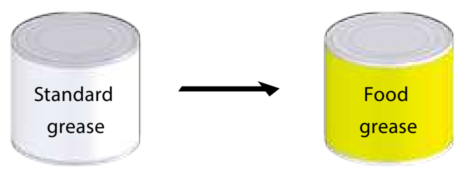
Sensor specifications

Sensors can be installed on models that do not have sensor options.



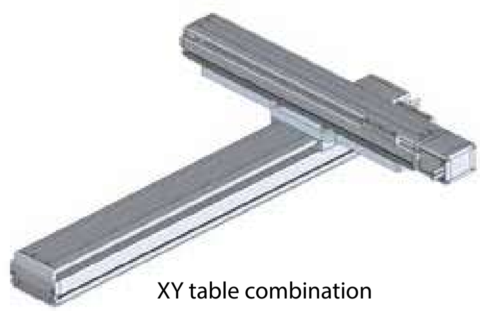
Grease

It is possible to change grease such as food grease, low dust grease, and customer specified grease.



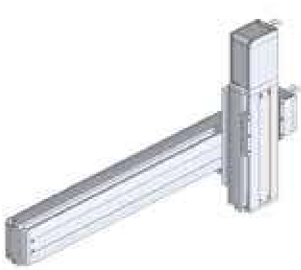
Special orthogonal robot combination

Clean room specification product combination



XY table combination

Special orthogonal robot combination



XY table combination

Xθ combination

Special table top type robot combination

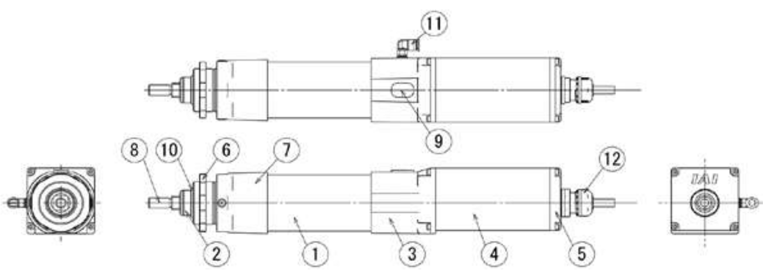
Table top robot +
rotary shaft

EC Dust-proof/Splash-proof Specification: Exterior Component Materials

■EC-R6□W/R7□W

	Name			Material	Treatment
Exterior components	① Frame			Extruded aluminum	Black alumite
	② Rod			Drawn aluminum	Hard alumite
	③ Rear bracket			Aluminum die cast	
	④ Motor cover			Extruded aluminum	Black alumite
	⑤ End cover			Aluminum die cast	
	⑥ Front fixing nut			Steel	Trivalent chromate
	⑦ Front bracket			Aluminum die cast	
	⑧ Tip bracket			Stainless steel	
	⑨ Rubber cap (greasing port)		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	
	⑩ Scraper		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	
	⑪ Exhaust/intake port		Standard	NBR + resin (PBT/POM) + brass	Nickel plated
			Option	FKM + resin (PBT/POM) + brass	Nickel plated
	⑫ Actuator cable	Cap cone	Standard	Rubber (NBR) + PBT resin + nylon	
			Option	Rubber (FKM) + PBT resin + PP	
		Cable sheath	Standard	Vinyl chloride (PVC)	
			Option	Rubber (FKM)	
	Exterior bolts			Stainless steel	
	Sealing materials		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	

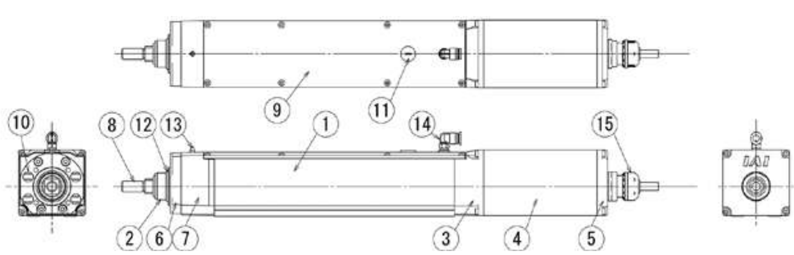
R□W



■EC-RR6□W/RR7□W

	Name			Material	Treatment
Exterior components	① Base			Extruded aluminum	Black alumite
	② Rod			Drawn aluminum	Hard alumite
	③ Bare housing			Aluminum die cast	
	④ Motor cover			Extruded aluminum	Black alumite
	⑤ End cover			Aluminum die cast	
	⑥ Scraper case			Aluminum die cast	
	⑦ Front bracket			Aluminum die cast	
	⑧ Tip bracket			Stainless steel	
	⑨ Frame cover			Extruded aluminum	Black alumite
	⑩ Cap		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	
	⑪ Rubber cap (greasing port)		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	
	⑫ Scraper		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	
	⑬ Grease port		Standard	Brass (C3604)	
			Option	Stainless steel	
	⑭ Exhaust/intake port		Standard	NBR + resin (PBT/POM) + brass	Nickel plated
			Option	FKM + resin (PBT/POM) + brass	Nickel plated
	⑮ Actuator cable	Cap cone	Standard	Rubber (NBR) + PBT resin + nylon	
			Option	Rubber (FKM) + PBT resin + PP	
		Cable sheath	Standard	Vinyl chloride (PVC)	
			Option	Rubber (FKM)	
	Exterior bolts			Stainless steel	
	Sealing materials		Standard	Rubber (NBR)	
			Option	Rubber (FKM)	

RR□W



EC Dust-proof/Splash-proof Specification: Solvent Resistance of Materials Used

■ EC-R□W/RR□W

Name		NBR (nitrile rubber)	PVC (polyvinyl chloride)	FKM (fluoro-rubber)
		Standard specification	Standard specification	Option
Water-soluble cutting oil		○	○	△
Water-insoluble cutting oil		△	○	○
Cleaning fluid		○	○	○
Lubricating oil	Engine oil	○	○	○
	Gear oil	○	○	○
	Torque converter oil	○		○
	Brake oil (glycol-based)	△		×
	Brake oil (silicone-based)	○		○
	Machine oil	○		○
	Spindle oil	○		○
	Refrigerant oil (mineral-based)	○		○
	Cap grease	○		○
	Lithium grease	○	○	○
	Silicon grease	○	○	○
Hydraulic oil	Standard petroleum oil-based	○	○	○
	Low temperature petroleum oil-based	○	○	○
	Fatty acid ester-based	○		○
	Phosphate ester-based	×		△
	Water/glycol-based	○	○	△
	Water/oil emulsion-based	○	○	△
	Type II turbine oil	○		○
	Silicone-based	○		○
	Brake oil	△		△
Chemicals	10% hydrochloric acid fluid	○	○	○
	30% sulphuric acid fluid	△		△
	10% nitric acid fluid	×		△
	40% sodium hydroxide fluid	○		×
	Benzene	×	×	×
	Alcohol	○		○
	Methyl ethyl ketone	×	×	×
	Trichlene	×	×	△
	Ethylene glycol	○	×	○
	Acetone	×	×	×
Other	Gasoline	△	×	○
	Light oil/kerosene	△		○
	Heavy oil	○		○
	Antifreeze (ethylene glycol-based)	○		×
	Cold/warm water	○	○	○
	Saltwater	○		○

Rating	Effect on solvent sealing materials
○	Minor effect, can be used
△	Moderate effect, use must be confirmed
×	Major effect, use not recommended

*1 Rating may differ by brand.

*2 Resistance table created based on internal IAI evaluations and standard evaluations. Use this data as a selection guideline.

*3 Rating may differ by environmental conditions and operating conditions. Select solutions only after confirming any effects they may have.

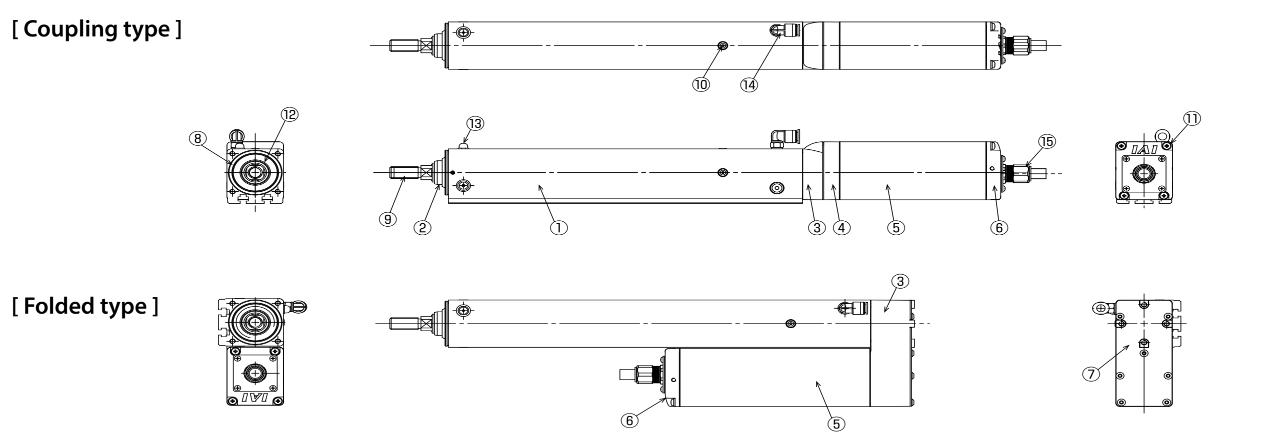
*4 We can conduct resistance tests for specified solutions. Please contact us for details.

RCP6W Exterior Components Material of each part

■ RCP6W-RA4

	Name		Material	Processing	Finishing	RA4C	RA4R
Exterior components	① Body frame		Aluminum extruded material	White alumite		○	○
	② Rod		Aluminum drawing material	Hard alumite	Buffing finish	○	○
	③ Rear bracket		Aluminum die cast	Design surface coating		○	○
	④ Motor bracket		Aluminum die cast	Design surface coating		○	
	⑤ Motor cover		Aluminum extruded material	White alumite		○	○
	⑥ End cover		Aluminum die cast	Design surface coating		○	○
	⑦ Pulley cover		Stainless steel				○
	⑧ Rod seal housing IP		Aluminum	White alumite		○	○
	⑨ Tip bracket		Stainless steel			○	○
	⑩ Cap		Stainless steel			○	○
	⑪ Bolts and screws of the exterior part		Stainless steel			○	○
	⑫ Dust seal		Rubber (NBR)			○	○
	⑬ Grease nipple		Brass (C3604)	Electroless nickel plating		○	○
	⑭ Intake and exhaust port		Resin (PBT, POM), Brass Nickel plating processing			○	○
	⑮Actuator cable	Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○
		Cable Sheath	Vinyl chloride (PVC)			○	○
	Hexagon nut		Stainless steel			○	○
	Square nut		Stainless steel			○	○
	Each part gasket		Rubber (NBR)			○	○

RA4

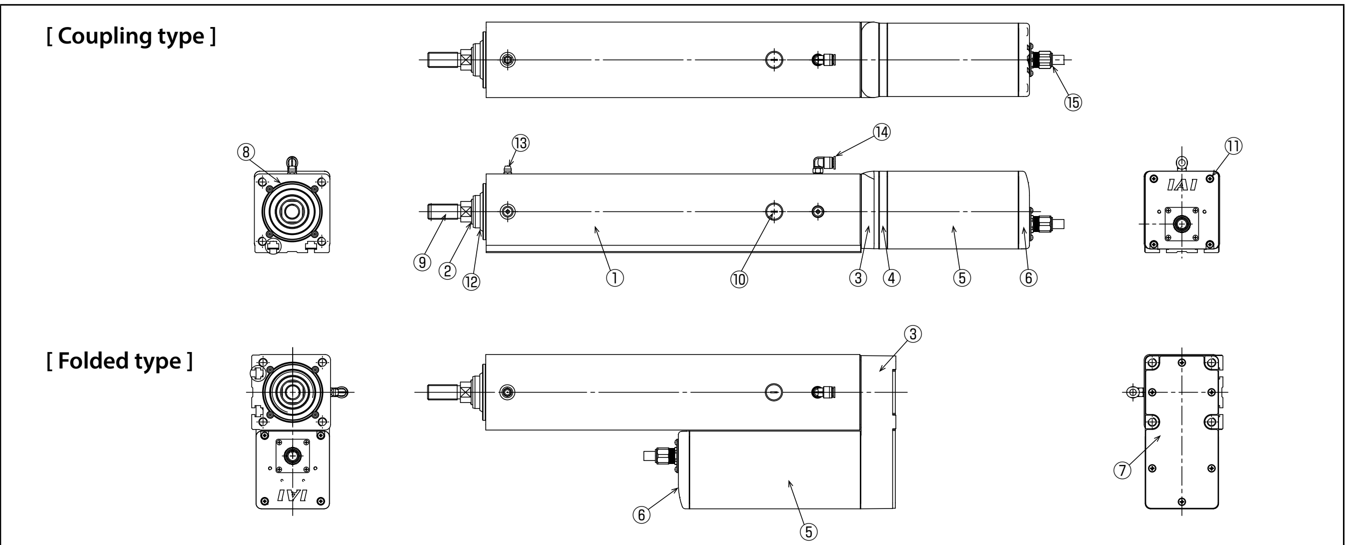


RCP6W-RA6/RA7/RA8

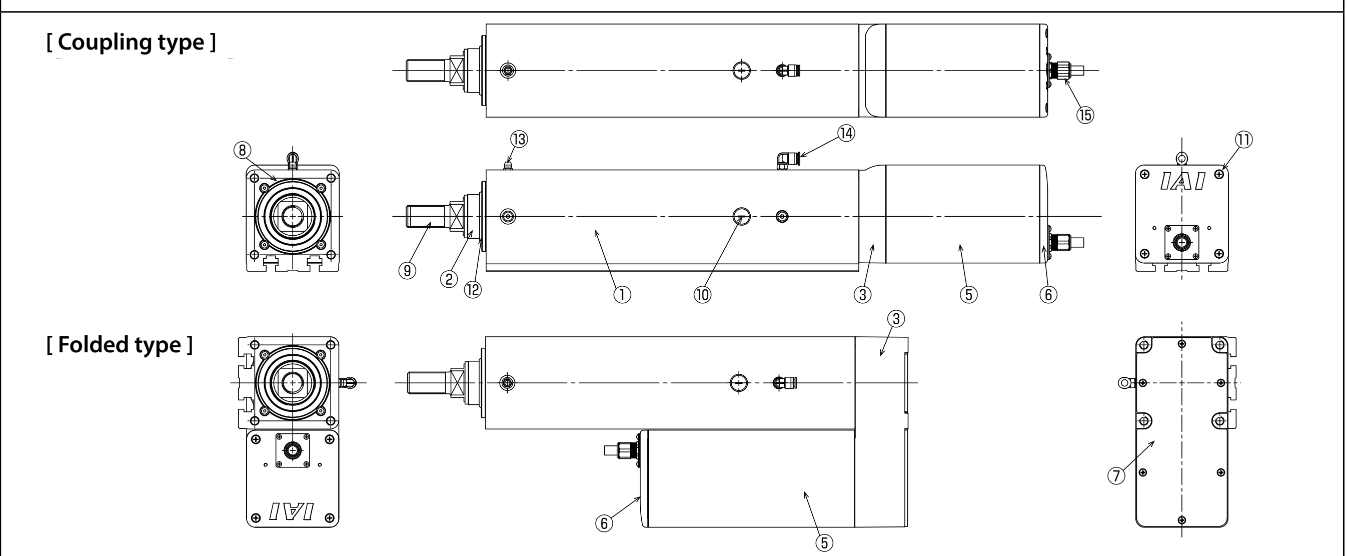
Exterior components

Name	Material	Processing	Finishing	RA6C	RA6R	RA7C	RA7R	RA8C	RA8R
① Body frame	Aluminum extruded material	White alumite		○	○	○	○	○	○
② Rod	Aluminum drawing material	Hard alumite	Buffing finish	○	○	○	○	○	○
③ Rear bracket	Aluminum die cast	Design surface coating		○	○	○	○	○	○
④ Motor bracket	Aluminum die cast	Design surface coating		○		○			
⑤ Motor cover	Aluminum extruded material	White alumite		○	○	○	○	○	○
⑥ End cover	Aluminum die cast	Design surface coating		○	○	○	○	○	○
⑦ Pulley cover	Stainless steel				○		○		○
⑧ Rod seal housing IP	Aluminum	White alumite		○	○	○	○	○	○
⑨ Tip bracket	Stainless steel			○	○	○	○	○	○
⑩ Cap	Stainless steel			○	○	○	○	○	○
⑪ Bolts and screws of the exterior part	Stainless steel			○	○	○	○	○	○
⑫ Dust seal	Rubber (NBR)			○	○	○	○	○	○
⑬ Grease nipple	Brass (C3604)	Electroless nickel plating		○	○	○	○	○	○
⑭ Intake and exhaust port	Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
⑮Actuator cable – Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
⑮Actuator cable – Cable Sheath	Vinyl chloride (PVC)			○	○	○	○	○	○
Hexagon nut	Stainless steel			○	○	○	○	○	○
Square nut	Stainless steel			○	○	○	○	○	○
Each part gasket	Rubber (NBR)			○	○	○	○	○	○

RA6/7



RA8



RCP6W Exterior Components Material of each part

RCP6W-RRA4/RRA6/RRA7

	Name		Material	Processing	Finishing	RRA4C	RRA4R	RRA6C	RRA6R	RRA7C	RRA7R
Exterior components	① Frame		Aluminum extruded material	White alumite		○	○	○	○	○	○
	② Rod		Aluminum drawing material	Hard alumite	Buffing finish	○	○	○	○	○	○
	③ Rear bracket		Aluminum die cast	Design surface coating		○	○	○	○	○	○
	④ Motor bracket		Aluminum die cast	Design surface coating		○		○		○	
	⑤ Reverse Bracket		Aluminum die cast	Design surface coating			○		○		○
	⑥ Motor cover		Aluminum extruded material	White alumite		○	○	○	○	○	○
	⑦ End cover		Aluminum die cast	Design surface coating		○	○	○	○	○	○
	⑧ Pulley cover		Stainless steel				○		○		○
	⑨ Front bracket IP		Aluminum	White alumite		○	○	○	○	○	○
	⑩ Rod tip bracket		Stainless steel			○	○	○	○	○	○
	⑪ Hole cap (Filler port)		Rubber (NBR)			○	○	○	○	○	○
	⑫ Dust seal		Rubber (NBR)			○	○	○	○	○	○
	⑬ Grease nipple		Brass (C3604)	Electroless nickel plating		○	○	○	○	○	○
	⑭ Intake and exhaust port		Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
	⑮ Actuator cable	Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
		Cable Sheath	Vinyl chloride (PVC)			○	○	○	○	○	○
	Bolts and screws of the exterior part Stainless steel		Stainless steel			○	○	○	○	○	○
	Hexagon nut		Stainless steel			○	○	○	○	○	○
	Square nut		Stainless steel			○	○	○	○	○	○
	Each part gasket		Rubber (NBR)			○	○	○	○	○	○

RRA4

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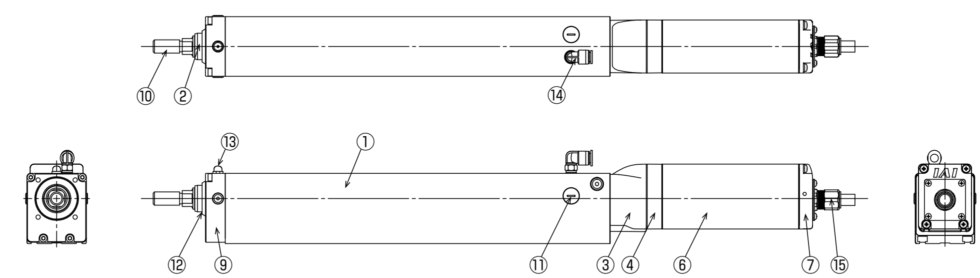

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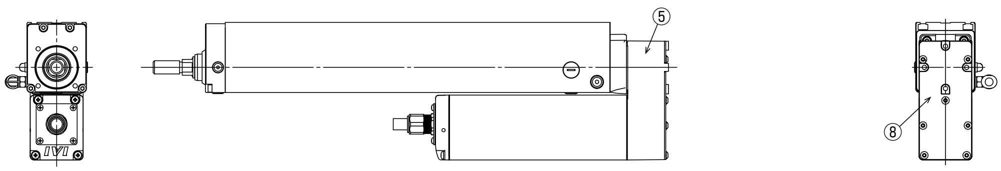

RRA6/7

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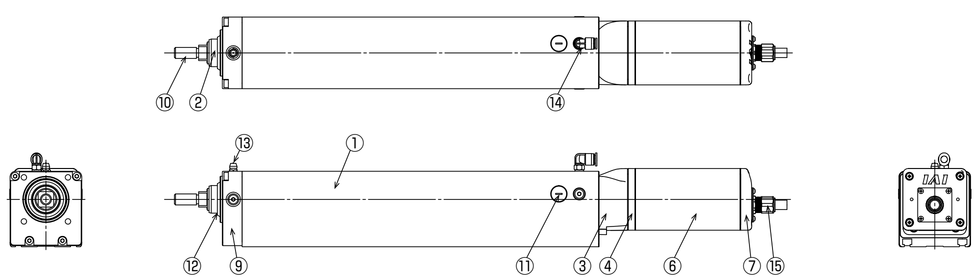

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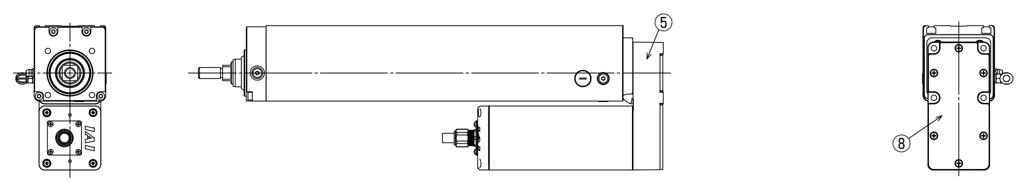
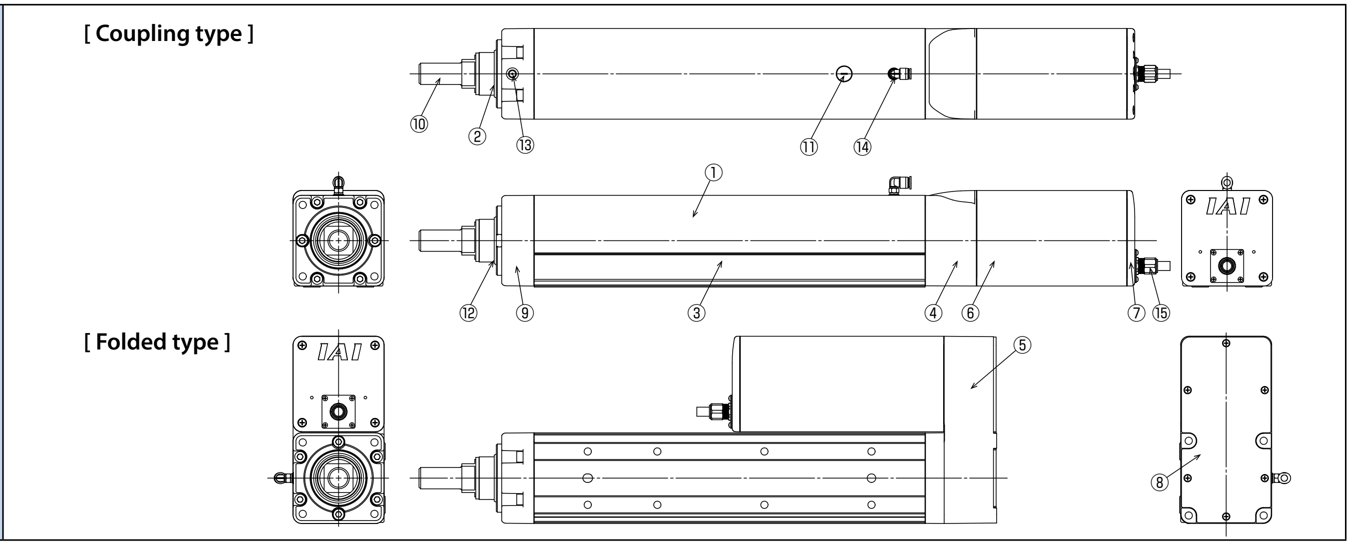


RCP6W-RRA8

Exterior components

Name	Material	Processing	Finishing	RRA8C	RRA8R
① Frame	Aluminum extruded material	White alumite		○	○
② Rod	Aluminum drawing material	Hard alumite	Buffing finish	○	○
③ Rear bracket	Aluminum die cast	Design surface coating		○	○
④ Motor bracket	Aluminum die cast	Design surface coating		○	○
⑤ Reverse Bracket	Aluminum die cast	Design surface coating			○
⑥ Motor cover	Aluminum extruded material	White alumite		○	○
⑦ End cover	Aluminum die cast	Design surface coating		○	○
⑧ Pulley cover	Stainless steel				○
⑨ Front bracket IP	Aluminum die cast	Design surface coating		○	○
⑩ Rod tip bracket	Stainless steel			○	○
⑪ Hole cap (Filler port)	Rubber (NBR)			○	○
⑫ Dust seal	Rubber (NBR)			○	○
⑬ Grease nipple	Brass (C3604)	Electroless nickel plating		○	○
⑭ Intake and exhaust port	Resin (PBT, POM), Brass Nickel plating processing			○	○
⑮Actuator cable – Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○
⑮Actuator cable – Cable Sheath	Vinyl chloride (PVC)			○	○
Bolts and screws of the exterior part Stainless steel	Stainless steel			○	○
Hexagon nut	Stainless steel			○	○
Each part gasket	Rubber (NBR)			○	○

RRA8



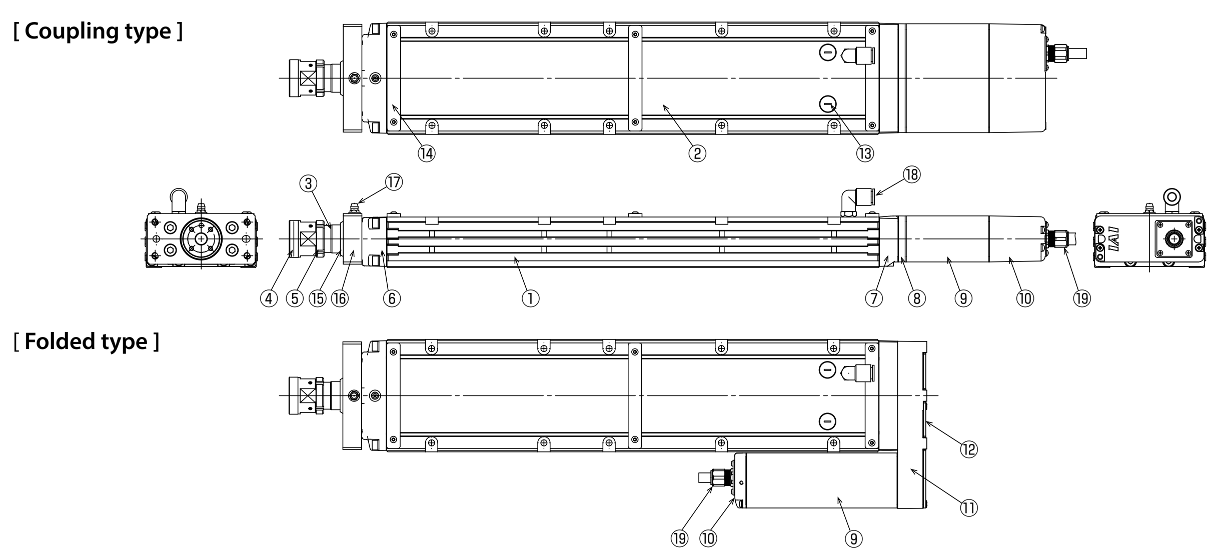
RCP6W Exterior Components Material of each part

■ RCP6W-WRA10

Exterior components

Name		Material	Processing	Finishing	WRA10C	WRA10R
① Base		Aluminum extruded material	White alumite		○	○
② Frame cover		Aluminum extruded material	White alumite		○	○
③ Rod		Stainless steel pipe	Hard chrome plating	Buffing finish	○	○
④ Tip bracket		Stainless steel			○	○
⑤ Lock nut		Stainless steel			○	○
⑥ Front bracket		Aluminum die cast	Design surface coating		○	○
⑦ Rear bracket		Aluminum die cast	Design surface coating		○	○
⑧ Motor bracket		Aluminum die cast	Design surface coating		○	
⑨ Motor cover		Aluminum extruded material	White alumite		○	○
⑩ Motor end cover		Aluminum die cast	Design surface coating		○	○
⑪ Reverse Bracket		Aluminum die cast	Design surface coating			○
⑫ Pulley cover		Stainless steel				○
⑬ Cap		Rubber (NBR)			○	○
⑭ Frame cover holder		Aluminum	White alumite		○	○
⑮ Dust seal		Rubber (NBR)			○	○
⑯ Dust seal housing		Aluminum	White alumite		○	○
⑰ Grease nipple		Brass (C3604)	Electroless nickel plating		○	○
⑱ Intake and exhaust port		Resin (PBT, POM), Brass Nickel plating processing			○	○
⑲ Actuator cable	Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○
	Cable Sheath	Vinyl chloride (PVC)			○	○
Bolts and screws of the exterior part Stainless steel		Stainless steel			○	○
Each part gasket		Rubber (NBR)			○	○

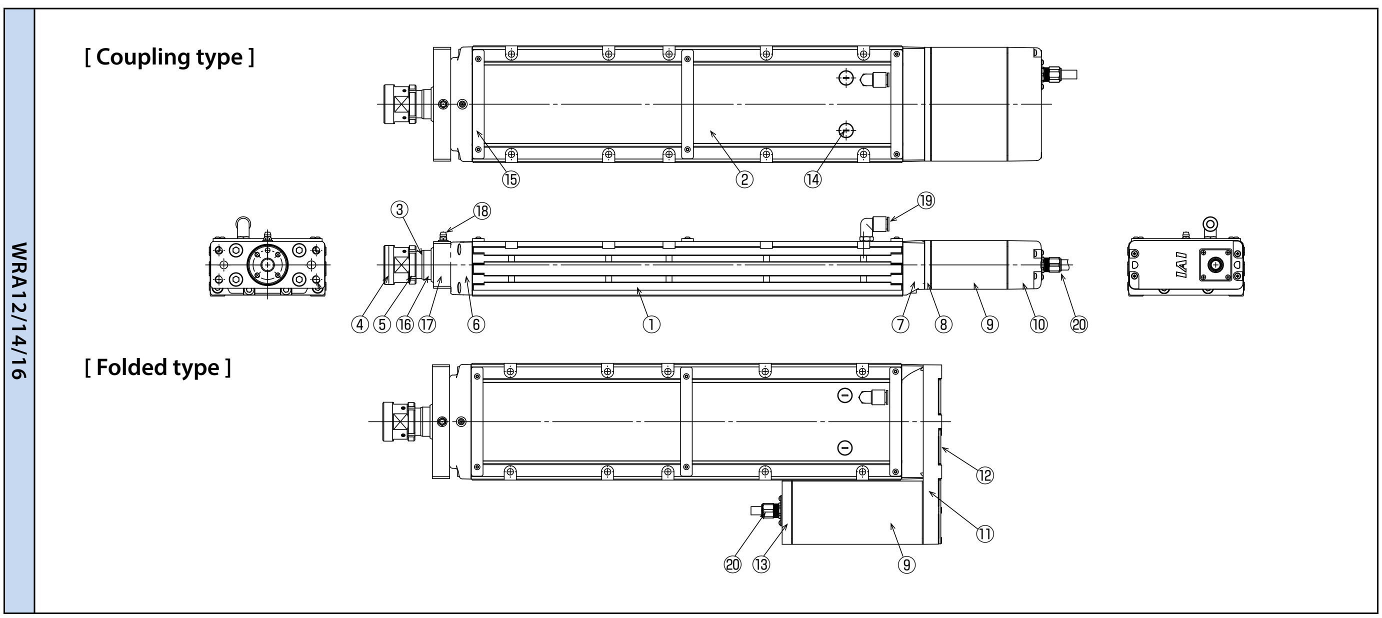
WRA10



RCP6W-WRA12/WRA14/WRA16

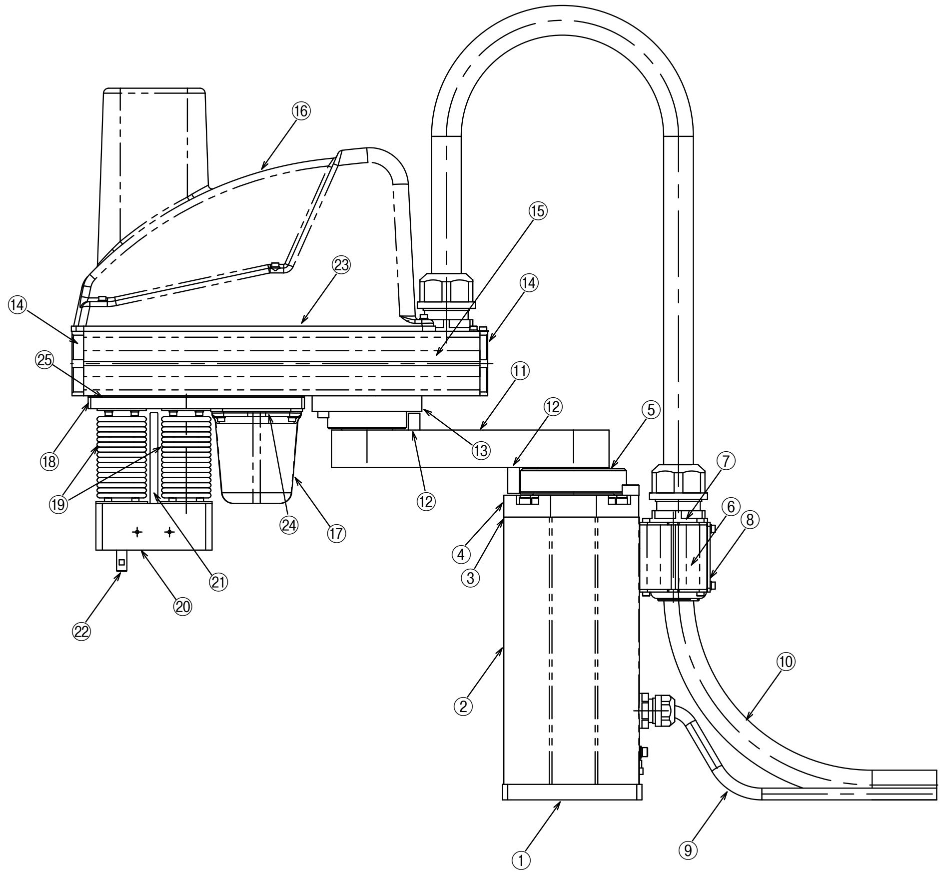
Exterior components

Name		Material	Processing	Finishing	WRA12C	WRA12R	WRA14C	WRA14R	WRA16C	WRA16R
① Base		Aluminum extruded material	White alumite		○	○	○	○	○	○
② Frame cover		Aluminum extruded material	White alumite		○	○	○	○	○	○
③ Rod		Stainless steel pipe	Hard chrome plating	Buffing finish	○	○	○	○	○	○
④ Tip bracket		Stainless steel			○	○	○	○	○	○
⑤ Lock nut		Stainless steel			○	○	○	○	○	○
⑥ Front bracket		Aluminum die cast	Design surface coating		○	○	○	○	○	○
⑦ Rear bracket		Aluminum die cast	Design surface coating		○	○	○	○	○	○
⑧ Motor bracket		Aluminum die cast	Design surface coating		○		○		○	
⑨ Motor cover		Aluminum extruded material	White alumite		○	○	○	○	○	○
⑩ Motor end cover(Coupling)		Aluminum die cast	Design surface coating		○		○		○	
⑪ Reverse Bracket		Aluminum die cast	Design surface coating			○		○		○
⑫ Pulley cover		Stainless steel				○		○		○
⑬ Motor end cover (Folded)		Aluminum	White alumite			○		○		○
⑭ Cap		Rubber (NBR)			○	○	○	○	○	○
⑮ Frame cover holder		Aluminum	White alumite		○	○	○	○	○	○
⑯ Dust seal		Rubber (NBR)			○	○	○	○	○	○
⑰ Dust seal housing		Aluminum	White alumite		○	○	○	○	○	○
⑱ Grease nipple		Brass (C3604)	Electroless nickel plating		○	○	○	○	○	○
⑲ Intake and exhaust port		Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
⑳ Actuator cable	Cable ground	Rubber (NBR) Resin (PBT, POM), Brass Nickel plating processing			○	○	○	○	○	○
	Cable Sheath	Vinyl chloride (PVC)			○	○	○	○	○	○
Bolts and screws of the exterior part Stainless steel		Stainless steel			○	○	○	○	○	○
Each part gasket		Rubber (NBR)			○	○	○	○	○	○



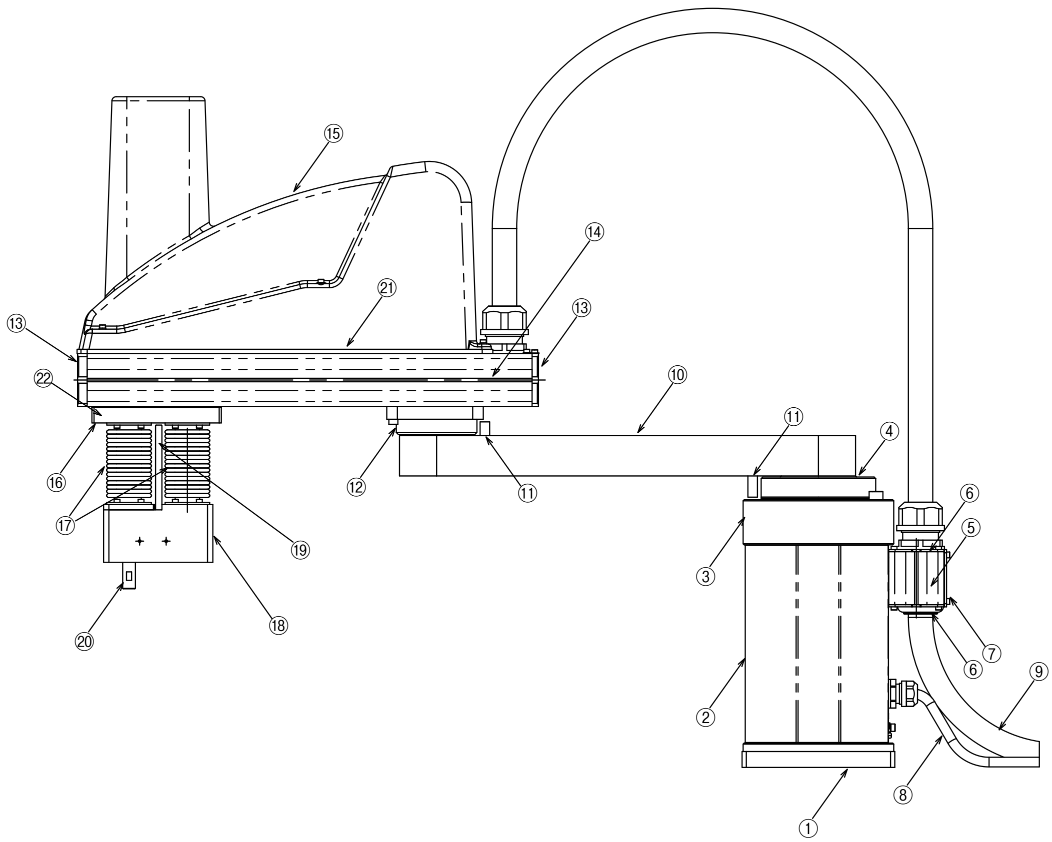
IXP Dust- and Splash-proof   Main part materials

IXP-3W3515/4W3515/3W4515/4W4515 Main parts materials



No.	Part Name	Material	Surface treatment
①	Base plate	Aluminium (A2017-T451)	White alumite treatment
②	Base pipe	Extruded aluminium (A6NO1S-T5)	White alumite treatment
③	Base flange (lower)	Aluminium (A2017-T451)	White alumite treatment
④	Base flange (upper)	Carbon steel (S45C)	Hard chromium plating after electroless nickel plating
⑤	Base cover	Aluminium (A2017-T451)	White alumite treatment
⑥	Cable fixing bracket	Extruded aluminium (A6NO1S-T5)	White alumite treatment
⑦	Cable stay	Aluminium (A5052P)	White alumite treatment
⑧	Cable fixing bracket cover	Aluminium (A5052P)	White alumite treatment
⑨	MPG1 cable	Polyvinyl chloride (PVC)	
⑩	MPG composite cable	Polyvinyl chloride (PVC)	
⑪	1st arm	Aluminium (A2017-T451)	White alumite treatment
⑫	Stopper block	Carbon steel (S45C)	Electroless nickel plating
⑬	Seal housing	Aluminium (A2017-T451)	White alumite treatment
⑭	Side cover	Aluminium (A5052P)	White alumite treatment
⑮	2nd arm	Extruded aluminium (A6NO1S-T5)	White alumite treatment
⑯	Arm cover	Resin (ABS)	
⑰	Motor cover	Resin (ABS)	
⑱	Bellow fixing plate	Aluminium (A5052P)	White alumite treatment
⑲	Bellow	Nitrile rubber (NBR)	
⑳	Joint bracket	Aluminium (A5052P)	White alumite treatment
㉑	Z stopper	Aluminium (A5052P)	White alumite treatment
㉒	Tip axis	High carbon chromium bearing steel (SUJ2)	Low temperature black chrome plating
㉓	Packing (arm cover)	Chloroprene rubber (CR)	
㉔	Packing (motor cover)	Chloroprene rubber (CR)	
㉕	Packing (bellow fixing plate)	Ethylen-propylene rubber (EPDM)	

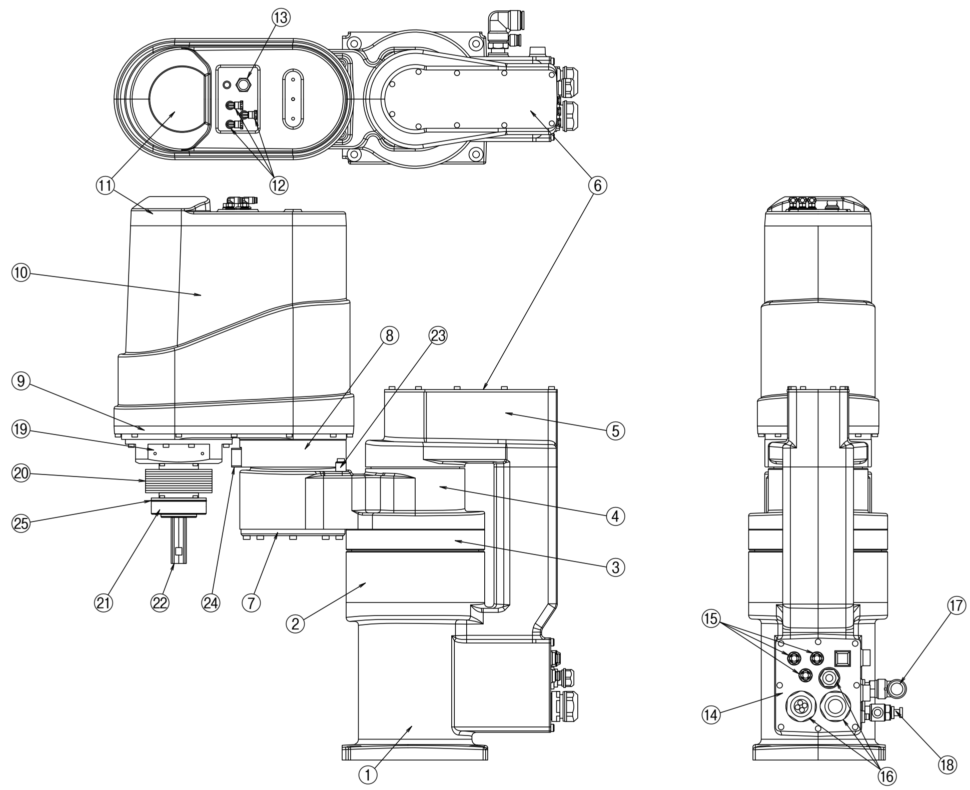
IXP-3W5520/4W5520/3W6520/4W6520 Main parts materials



No.	Part Name	Material	Surface treatment
①	Base plate	Aluminium (A2017-T451)	White alumite treatment
②	Base pipe	Extruded aluminium (A6NO1S-T5)	White alumite treatment
③	Base flange	Carbon steel (S45C)	Hard chromium plating after electroless nickel plating
④	Base cover	Aluminium (A2017-T451)	White alumite treatment
⑤	Cable fixing bracke	Extruded aluminium (A6NO1S-T5)	White alumite treatment
⑥	Cable stay	Aluminium (A5052P)	White alumite treatment
⑦	Cable fixing bracket cover	Aluminium (A5052P)	White alumite treatment
⑧	MPG1 cable	Polyvinyl chloride (PVC)	
⑨	MPG composite cable	Polyvinyl chloride (PVC)	
⑩	1st arm	Aluminium (A2017-T451)	White alumite treatment
⑪	Stopper block	Carbon steel (S45C)	Eelectroless nickel plating
⑫	Seal housing	Aluminium (A2017-T451)	White alumite treatment
⑬	Side cover	Aluminium (A5052P)	White alumite treatment
⑭	2nd arm	Extruded aluminium (A6NO1S-T5)	White alumite treatment
⑮	Arm cover	Resin (ABS)	
⑯	Bellow fixing plate	Aluminium (A5052P)	White alumite treatment
⑰	Bellow	Nitrile rubber (NBR)	
⑱	Joint bracket	Aluminium (A5052P)	White alumite treatment
⑲	Z stopper	Aluminium (A5052P)	White alumite treatment
⑳	Tip axis	High carbon chromium bearing steel (SUJ2)	Low temperature black chrome plating
㉑	Packing (arm cover)	Chloroprene rubber (CR)	
㉒	Packing (bellow fixing plate)	Ethylen-propylene rubber (EPDM)	

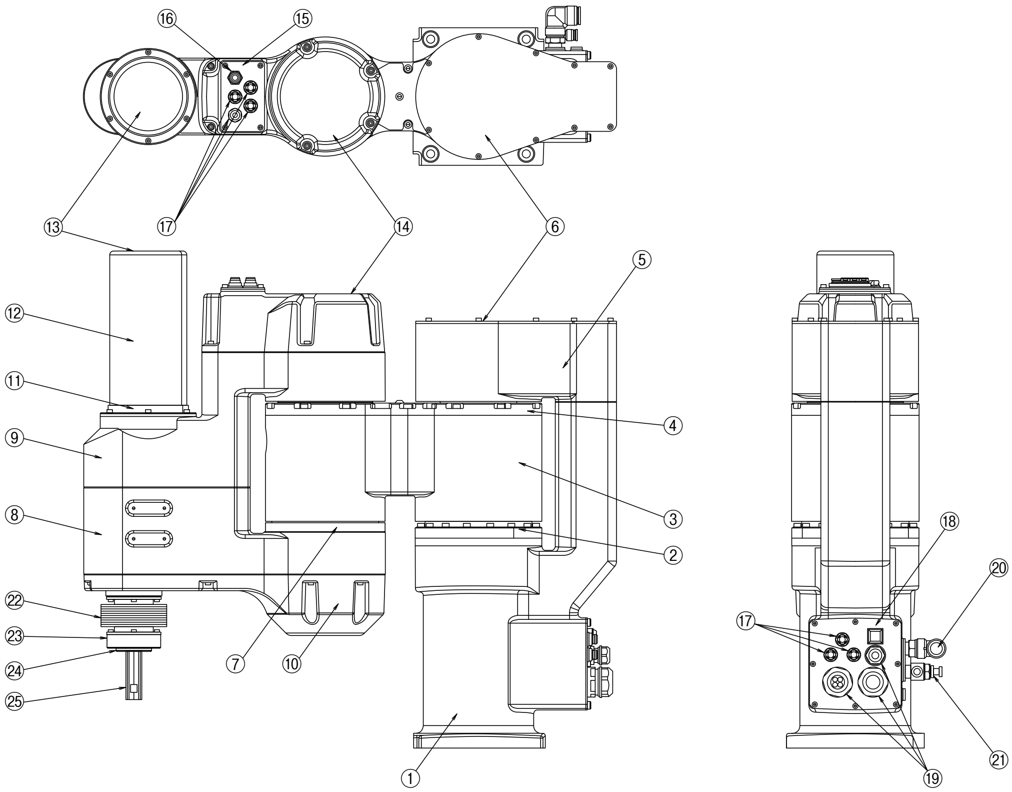
IXA Dust- and Splash-proof Main part materials

XA-4NSW3015



	No.	Name	Material	Surface treatment
Exterior component	①	J1 Base	Aluminum diecast	Design surface coating
	②	J1 Base flange	Aluminum	Design surface coating
	③	J1 Flange cover	Carbon steel	Low temperature black chromium plating
	④	J1 Arm	Aluminum diecast	Design surface coating
	⑤	J1 Joint bracket	Aluminum diecast	Design surface coating
	⑥	J1 JB cover	Stainless steel	Design surface coating
	⑦	J2 Under cover	Aluminum	White alumite
	⑧	J2 OS housing	Aluminum	Black alumite
	⑨	J2 Main arm	Aluminum diecast	Design surface coating
	⑩	J2 Arm cover	Aluminum diecast	Design surface coating
	⑪	J2 Spline cover	Aluminum diecast	Design surface coating
	⑫	One-touch joint elbow	Resin (PBT, POM), Brass nickel plating processing	
	⑬	Metal round connector	Zinc nickel plating, Rubber (CR)	
	⑭	External wiring panel	Stainless steel	
	⑮	One-touch joint, Partition union pea	Resin (PBT, POM), Rubber (CR) Brass nickel plating processing	
	⑯	Cable ground	Resin (nylon 66), Rubber (NBR)	
		Cable sheath	Vinyl chloride (PVC)	
	⑰	One-touch joint elbow	Resin (PBT, POM), Brass nickel plating processing	
	⑱	Speed controller	Resin (PBT, POM), Brass nickel plating processing	
	⑲	Bellows flange	Aluminum	Black alumite
	⑳	Bellows	Urethane	
	㉑	Bearing case B	Aluminum	White alumite
	㉒	Ball screw spline	High-carbon chromium bearing steel	Low temperature black chromium plating
	㉓	Stopper ring	Stainless steel	
	㉔	Movable stopper	Carbon steel	Low temperature black chromium plating
	㉕	Plate A (bellows)	Stainless steel	
	Bolt and screw for exterior parts		Stainless steel	
	Each part gasket (O-ring, Packing)		Rubber (NBR)	
	Each part oil seal		Rubber (FKM)	

IXA-4NSW45 □□ /4NSW60 □□



	No.	Name	Material	Surface treatment
Exterior component	①	J1 Base	Aluminum diecast	Design surface coating
	②	J1 Base flange	Aluminum	Black alumite
	③	J1 Arm L/L-600	Aluminum diecast	Design surface coating
	④	J1 Arm U/L-600	Aluminum	Design surface coating
	⑤	J1 Joint bracket	Aluminum diecast	Design surface coating
	⑥	J1 JB cover	Stainless steel	Design surface coating
	⑦	J2 Under cover	Aluminum	Black alumite
	⑧	J2 Main arm	Aluminum diecast	Design surface coating
	⑨	J2 Joint bracket	Aluminum diecast	Design surface coating
	⑩	J2 Arm cover	Aluminum diecast	Design surface coating
	⑪	J2 ZR DC flange	Aluminum	Design surface coating
	⑫	ZR Dust cover	Aluminum drawing round pipe	Design surface coating
	⑬	ZR DC cap	Aluminum	Design surface coating
	⑭	J2 Cover U	Aluminum diecast	Design surface coating
	⑮	J2 User panel	Stainless steel	Design surface coating
	⑯	Metal round connector	Zinc nickel plating, Rubber (CR)	
		One-touch joint, Partition union pea	Resin (PBT, POM), Rubber (CR), Brass nickel plating processing	
	⑰	External wiring panel	Stainless steel	Design surface coating
	⑱	Cable ground	Resin (nylon 66), Rubber (NBR)	
	⑲	Cable sheath	Vinyl chloride (PVC)	
	⑳	One-touch joint elbow	Resin (PBT, POM), Brass nickel plating	
	㉑	Speed controller	Resin (PBT, POM), Brass nickel plating	
	㉒	Bellows	Urethane	
	㉓	Bearing case B	Aluminum	White alumite
	㉔	Set collar	Aluminum	White alumite
	㉕	Ball Spline	High-carbon chromium bearing steel	Low temperature black chromium plating
	Bolt and screw for exterior parts		Stainless steel	
	Each part gasket (O-ring, Packing)		Rubber (NBR)	
	Each part oil seal		Rubber (FKM)	

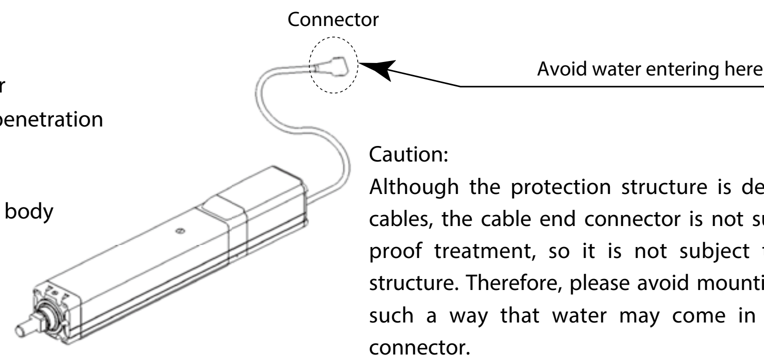
Protection Structure

Protection structure refers to the level of protection from water, human body, and solid foreign objects. The the levels indicated below are based on the standards of IEC (International Electrotechnical Commission), JIS (Japanese Industrial Standards), and JEMA (Japan Electrical Manufacturers' Association).

IEC standard

I P □□

- Second indicating number
  Protection against water penetration
- First indicating number
  Protection against human body and solid foreign objects



Caution:
Although the protection structure is designed to include cables, the cable end connector is not subjected to splash proof treatment, so it is not subject to the protection structure. Therefore, please avoid mounting the actuator in such a way that water may come in contact with the connector.

■ Level of protection indicated by the first indicating number

First indicating number	Details
0	Unprotected
1	Things like human hands do not touch the internal charging section. (φ50mm) φ50
2	Things like human fingertips do not touch the internal charging section. (φ12mm) φ12
3	Solids such as tools and wires exceeding 2.5 mm in diameter or thickness do not enter. Thickness 2.5
4	Solids such as tools and wires exceeding 1.0 mm in diameter or thickness do not enter. Thickness 1.0
5	No harmful effects from dust that enters the inside.
6	Dust does not enter the inside. (Completely prevented)

■ Level of protection indicated by the second indicating number

Second indicating number	JIS standard	Details
0		Unprotected
1	Drip-resistant 1 type	No harmful effect from vertical drips of water
2	Drip-resistant 2 type	No harmful effects from drips of water from angles within 15 degrees of the vertical 15° 15°
3	Rain-resistant type	No harmful effects from drips of water from angles within 60 degrees of the vertical 60° 60°
4	Splash-resistant type	No harmful effects from splashes of water from any direction
5	Jet-resistant type	No harmful effects from direct jets of water from any direction
6	Water-resistant type	No water enters the inside when direct jets of water from any direction hits
7	Immersion type	No water enters the inside when immersed in water under certain conditions
8	Submersion type	It can be used at all times by submerging into water of specified pressure.

MEMO

Overseas Standard

1. RoHS Directive

RoHS Directive (2002/95/EC) was enacted on July 1, 2006 to regulate the use of certain hazardous substances for electric and electronic equipment in EU.
An official bulletin "EU 2015/863" was published on June 4, 2015, which replaced Annex II of 2011/65/EU that specifies hazardous substances. This was enforced as from July 22, 2019 (July 22, 2021 for Category 9).
In addition to the previous six restricted substances, four substances (DEHP, BBP, DBP, DIBP) were added, making a total of 10 substances (see the table below).

	6 substances	10 substances
Restricted substances	Lead	Lead
	Mercury	Mercury
	Cadmium	Cadmium
	Hexavalent chromium	Hexavalent chromium
	Polybrominated biphenyls (PBB)	Polybrominated biphenyls (PBB)
	Polybrominated diphenyl ether (PBDE)	Polybrominated diphenyl ether (PBDE)
		Bis(2-ethylhexyl) phthalat (DEHP)
		Butyl benzyl phthalate (BBP)
		Dibutyl phthalate (DBP)
		Diisobutyl phthalate (DIBP)

IAI products belong to Category 9 (monitoring and control equipment).
We have been steadily complying with RoHS 10 since January 2020.
Our products except special specification and some discontinued products will have been compliant by July 22, 2021.
Details of the compliance are shown in the attached table.

2. CE Marking

Products sold in the European Union (EU) area are obliged to indicate CE marking.
The CE marking indicates compliance with the EU (EC) Directive's mandatory safety requirements, and the manufacturer will display it at its own risk. The essential safety requirements are specified by the adoption of the New Approach Directive in 1985, such as "EMC Directive", "Low Voltage Directive", "Machine Directive", etc. are stipulated. These directives stipulate the consistent provisions that embody and embody the essential requirements that each product must observe.

(1) EMC Directive
It is a directive concerning products that emit electromagnetic waves or that may be affected by functions by external electromagnetic waves.
A design that does not emit strong electromagnetic waves to the outside or is not affected by external electromagnetic waves is required.
Our products decide wiring / installation model (condition) of controller, actuator, and peripheral equipment and conform to the relevant standards of EMC directive.

(2) Low Voltage Directive
It is a directive on the safety of electrical machinery driven by a power supply of AC 50 to 1000 V, DC 75 to 1500 V.
The actuators (see the table of compliance) are designed to conform to the low voltage directive in combination with the controller.
This command is not applicable for 24 V series ROBO Cylinder.

(3) Machinery Directive
For general products, especially industrial machinery, those for which moving parts are recognized as dangerous are targeted.
TTA (Safety Category Specification), IX, IXP and IXA series are in compliant with the Machine Directive.
Other IAI products are not in compliant with the Machine Directive (as of March 1, 2021).

(4) IAI’s policy on the EC Directive
Our actuator and controllers (hereinafter referred to as our components) are treated as parts (embedded devices) to be incorporated in customer's equipment.
Our components are declared as "semi-finished products" of the machine Directive "machine Directive 2006/42/EC". However, this does not guarantee that your device conforms to the EC Directive.
When customers complete the equipment incorporating our components and ship them to Europe within the European region as final products, always make sure that you comply with the EC Directive by yourself.

Our components are required to comply with the low voltage "Directive 2014/35/EU" and "EMC Directive 2014/30/EU" as a necessary condition of compliance of the customer's equipment to EN60204-1, which is one of the harmonization standards and regulates electric safety of industrial equipment.

In connection with the low voltage "Directive 2014/35 / EU," our components are roughly divided into two categories: those operating only with DC 24V power supply and those operating on AC 200V. The former is lower than the voltage of the low voltage Directive (AC50 - 1000V or DC75- 1500V), and therefore they are not subject to the Directive. The latter can be considered to be compliant with the low voltage Directive on condition that they are used in accordance with the overseas standard manual (MJ0287-13A 1.3.1 Note 1).

We declare that our components conform to the EMC "Directive 2014/30/EU" according to our limited terms of use and by taking measures for radio interference indicated in the overseas standard manual. In the end, however, the customer is required to confirm it after installing our product.

Apart from these regulations, there is the "RoHS Directive" in the EC Directive, which requires that hazardous substances be below specified values.

According to the foregoing points, the CE marks attached to our individual components indicate that they comply with the RoHS directive/EMC directive (DC24V) or the RoHS Directive/EMC directive and the low voltage directive (200V) under the limited operating conditions.
English is the original language used for the instruction manuals and warning labels of our components.
Customers who need support in other languages should contact our sales representatives.
In some warning/caution labels, Japanese language may also be added where some notes are stated.
If the customers are to make their equipment CE compliant, they should select products (such as safety relays) that correspond to the safety category required for the equipment, and should make sure to construct external safety circuits by themselves.

3. UL standard

UL (Underwriters Laboratories Inc American Insurer Safety Test Laboratory) was a non-profit organization founded by the American fire insurance association in 1984 and was established to protect human life and property from fire, disaster, theft and other accidents We conduct research, testing and inspection.
The UL standard is a product safety standard relating to functions and safety, UL can test and evaluate samples of the product, UL required products can be shipped with UL certification mark attached.
For details, refer to P.1-353, UL Listed models.

4. KCs Marking

The KCs definition of industrial robots include "Cartesian robots and fixed type robots capable of programming and automatic control, which are equipped with a manipulator of 3 axes or more (including control equipment and communication interface such as actuator and teaching pendant). Products that fall into this category should be declared to KOSHA (Korea Occupational Safety and Health Agency) and registered if no problem is found.
IAI products that have been declared and registered with the KCs are as follows:

- All the IX/IXP/IXA SCARA robot series (high-speed specification)
- Some of the combinations of single-axis robots (Contact our sales representative for details)
- TTA table top robot series

Compliant Product Table for Revised RoHS Directive/CE Mark/UL Standard

(manufactured as of June 2021)

■ Actuator

◎: Standard / ○: Option / ×: No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
ELECYLINDER	EC	Slider (standard)	(D)S3/(D)S4/(D)S6/(D)S7	◎	◎	
			Slider (wide)	◎	◎	
		Slider (high-rigidity)	(D)WS10/(D)WS12	◎	◎	
		Slider (high-rigidity)	(D)S6□AH/(D)S7□AH	◎	◎	
			(D)S6□AHR/(D)S7□AHR	◎	◎	
		Slider (belt-driven)	(D)B6/(D)B7	◎	◎	
		Slider (large slider)	S10/S10X/S13/S13X/S15/S15X	◎	◎	
		Rod (standard)	(D)R6/(D)R7	◎	◎	
		Rod (short overall length)	RP4/GS4/GD4/RP5/GD5	◎	◎	
		Radial cylinder (standard)	(D)RR3/(D)RR4/(D)RR6/(D)RR7	◎	◎	
			(D)RR3□R/(D)RR4□R/(D)RR6□R/(D)RR7□R	◎	◎	
		Radial cylinder (high rigidity)	(D)RR6□AH/(D)RR6X□AH/	◎	◎	
			(D)RR7□AH/(D)RR7X□AH	◎	◎	
			(D)RR6□AHR/(D)RR7□AHR	◎	◎	
		Table (short overall length)	TC4/TW4/TC5/TW5	◎	◎	
		Gripper	GRB8/GRB10/GRB13	◎	◎	
		Rotary	RTC9/RTC12	◎	◎	
		Stopper cylinder	ST15	◎	◎	
	EC (cleanroom specification)	Slider (standard)	(D)S□CR	◎	◎	
		Slider (high-rigidity)	(D)S□AHCR	◎	◎	
	EC (dust- and splash-proof)	Rod (standard)	R6W/R7W	◎	◎	
		Rod (high-rigidity)	RR6W/RR7W	◎	◎	
ROBO Cylinder	RCP6 RCP6S	Slider (standard)	SA4C/SA6C/SA7C/SA8C	◎	◎	
			SA4R/SA6R/SA7R/SA8R	◎	◎	
		Slider (wide)	WSA10C/WSA12C/WSA14C/WSA16C	◎	◎	
			WSA10R/WSA12R/WSA14R/WSA16R	◎	◎	
		Rod (standard)	RA4C/RA6C/RA7C/RA8C	◎	◎	
			RA4R/RA6R/RA7R/RA8R	◎	◎	
		Rod (radial cylinder)	RRA4C/RRA6C/RRA7C/RRA8C	◎	◎	
			RRA4R/RRA6R/RRA7R/RRA8R	◎	◎	
		Rod (wide)	WRA10C/WRA12C/WRA14C/WRA16C	◎	◎	
			WRA10R/WRA12R/WRA14R/WRA16R	◎	◎	
		Table	TA4C/TA6C/TA7C	◎	◎	
			TA4R/TA6R/TA7R	◎	◎	
		Gripper	GRST6C/GRST7C	◎	◎	
			GRST6R/GRST7R	◎	◎	
			GRT7A/GRT7B	◎	◎	
		Rotary chuck	RTCKSPE/RTCKMPE	◎	◎	
			RTCKSPI/RTCKMPI	◎	◎	
		Hollow rotary	RTFML	◎	◎	
	RCP6CR RCP6SCR	Slider (standard)	SA4C/SA6C/SA7C/SA8C	◎	◎	
		Slider (wide)	WSA10C/WSA12C/WSA14C/WSA16C	◎	◎	
	RCP6W RCP6SW	Rod (standard)	RA4C/RA6C/RA7C/RA8C RA4R/RA6R/RA7R/RA8R	◎	◎	
		Rod (radial cylinder)	RRA4C/RRA6C/RRA7C/RRA8C RRA4R/RRA6R/RRA7R/RRA8R	◎	◎	
		Rod (wide)	WRA10C/WRA12C/WRA14C/WRA16C WRA10R/WRA12R/WRA14R/WRA16R	◎	◎	
	RCP5	Slider (standard)	SA4C/SA6C/SA7C	◎	◎	
			SA4R/SA6R/SA7R	◎	◎	
		Slider (belt drive)	BA4/BA6/BA7/BA4U/BA6U/BA7U	◎	◎	
		Rod	RA4C/RA6C/RA7C/RA8C/RA10C	◎	◎	
			RA4R/RA6R/RA7R/RA8R/RA10R	◎	◎	
	RCP5CR	Slider	SA4C/SA6C/SA7C	◎	◎	
	RCP5W	Rod	RA6C/RA7C/RA8C/RA10C	◎	◎	
	RCP4	Slider	SA3C/SA5C/SA6C/SA7C	◎	◎	
			SA3R/SA5R/SA6R/SA7R	◎	◎	
		Rod	RA3C/RA5C/RA6C	◎	◎	
			RA3R/RA5R/RA6R	◎	◎	
		Gripper	GRSML/GRSLL/GRSWL/GRLM/GRLL/GRLW	◎	◎	
		Stopper cylinder	ST68E/ST615E/ST4525E	◎	◎	
	RCP4CR	Slider	SA3C/SA5C/SA6C/SA7C	◎	◎	
	RCP4W	Slider	SA5C/SA6C/SA7C	◎	◎	
		Rod	RA6C/RA7C	◎	◎	
	RCP3	Slider	SA2AC/SA2BC/SA3C/SA4C/SA5C/SA6C	◎	◎	
			SA2AR/SA2BR/SA3R/SA4R/SA5R/SA6R	◎	◎	
		Rod	RA2AC/RA2BC	◎	◎	
			RA2AR/RA2BR	◎	◎	
		Table	TA3C/TA4C/TA5C/TA6C/TA7C	◎	◎	
			TA3R/TA4R/TA5R/TA6R/TA7R	◎	◎	
	RCP2	Slider (standard)	SA5C/SA6C/SA7C/SS7C/SS8C	◎	◎	
			SA5R/SA6R/SA7R/SS7R/SS8R	◎	◎	
		Slider (belt drive)	BA6/BA7/BA6U/BA7U	◎	◎	
		Slider (high-speed)	HS8C/HS8R	◎	◎	
		Rod (standard)	RA2C/RA3C/RA4C/RA6C/RA8C/RA10C	◎	◎	
			RA3R/RA4R/RA6R/RA8R/SRA4R	◎	◎	
		Rod (with guide)	RGS4C/RGS6C/RGD3C/RGD4C/RGD6C	◎	◎	
			SRGS4R/SRGD4R	◎	◎	

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
ROBO Cylinder	RCP2	Gripper	GRLS/GRSS/GRS/GRM/GRHM/GRHB	◎	◎	
			GR3LM/GR3LS/GR3SM/GR3SS	◎	◎	
			GRST	◎	◎	
		Rotary	RTBS/RTBSL/RTB/RTBL/RTBB/RTBBL	◎	◎	
			RTCS/RTCSL/RTC/RTCL/RTCB/RTCBL	◎	◎	
		Simple absolute type	Simple absolute supported model	◎	◎	
	RCP2CR	Slider	SA5C/SA6C/SA7C/SS7C/SS8C/HS8C	◎	◎	
		Gripper	GRSS/GRLS/GRS/GRM/GR3SS/GR3SM	◎	◎	
		Rotary	RTBS/RTBSL/RTCS/RTCSL/RTB/RTBL/RTC/RTCL/RTBB/RTBBL/RTCB/RTCBL	◎	◎	
	RCP2W	Rod (standard)	RA4C/RA6C	◎	◎	
		Rod (High thrust)	RA10C	◎	◎	
		Gripper	GRSS/GRLS/GRS/GRM/GR3SS/GR3SM	◎	◎	
		Rotary	RTBS/RTBSL/RTCS/RTCSL/RTB/RTBL/RTC/RTCL/RTBB/RTBBL/RTCB/RTCBL	◎	◎	
	ERC3	Slider	SA5C/SA7C	◎	◎	
		Rod	RA4C/RA6C	◎	◎	
	ERC3D	Slider	SA5C/SA7C	◎	◎	
	ERC3CR	Slider	SA5C/SA7C	◎	◎	
	ERC2	Slider	SA6C/SA7C	◎	◎	
		Rod (standard)	RA6C/RA7C	◎	◎	
		Rod (with guide)	RGS6C/RGS7C/RGD6C/RGD7C	◎	◎	
	ERC	Slider	SA6/SA7	◎	◎	
		Rod	RA54/RD64	◎	◎	
	RCD	Rod	RA1DA/RA1D	◎	◎	
		Gripper	GRSNA/GRSN	◎	◎	
	RCA2	Slider	SA2AC/SA3C/SA4C/SA5C/SA6C	◎	◎	
			SA2AR/SA3R/SA4R/SA5R/SA6R	◎	◎	
		Rod	RA2AC/RA2AR/RN3N/RN4N/RP3N/RP4N	◎	◎	
			GS3N/GS4N/GD3N/GD4N/SD3N/SD4N	◎	◎	
			RN3NA/RN4NA/RP3NA/RP4NA/GS3NA/GS4NA	◎	◎	
			GD3NA/GD4NA/SD3NA/SD4NA	◎	◎	
		Table (short length type)	TC(N)3N/TC(N)4N/TW(N)3N/TW(N)4N/TF(N)3N/TF(N)4N	◎	◎	
			TCA3N/TCA4N/TWA3N/TWA4N/TFA3N/TFA4N	◎	◎	
			TCN3NA/TCN4NA/TWN3NA/TWN4NA/TFN3NA/TFN4NA	◎	◎	
			TCA3NA/TCA4NA/TWA3NA/TWA4NA/TFA3NA/TFA4NA	◎	◎	
		Table (standard)	TA4C/TA5C/TA6C/TA7C	◎	◎	
			TA4R/TA5R/TA6R/TA7R	◎	◎	
		Gripper	GRKS	◎	◎	
	RCA2CR	Rod	RN3NA/RN4NA/RP3NA/RP4NA/GS3NA/GS4NA	◎	◎	
			GD3NA/GD4NA/SD3NA/SD4NA	◎	◎	
	RCA2W	Rod	RN3NA/RN4NA/RP3NA/RP4NA/GS3NA/GS4NA	◎	◎	
			RN3NA/RN4NA/RP3NA/RP4NA/GS3NA/GS4NA	◎	◎	
			GD3NA/GD4NA/SD3NA/SD4NA	◎	◎	
	RCA	Slider (standard)	SA4C/SA5C/SA6C	◎	◎	
			SA4D/SA5D/SA6D/SS4D/SS5D/SS6D	◎	◎	
		Slider (motor return back type)	SA4R/SA5R/SA6R	◎	◎	
		Rod (standard)	RA3C/RA4C/RA3D/RA4D/RA3R/RA4R	◎	◎	
			SRA4R	◎	◎	
		Rod (with guide)	RGS3C/RGS4C/RGS3D/RGS4D/SRGS4R	◎	◎	
			RGD3C/RGD4C/RGD3D/RGD4D	◎	◎	
			RGD3R/RGD4R/SRGD4R	◎	◎	
		Arm	A4R/A5R/A6R	◎	◎	
		Absolute type	All models	◎	◎	
	RCACR	Slider (standard)	SA4C/SA5C/SA6C	◎	◎	
		Slider (motor direct connection)	SA5D/SA6D	◎	◎	
	RCAW	Rod	RA3C/RA3D/RA3R/RA4C/RA4D/RA4R	◎	◎	
	RCS4	Slider (standard)	SA4C/SA6C/SA7C/SA8C SA4R/SA6R/SA7R/SA8R	◎	◎	
		Slider (Wide)	WSA10C/WSA12C/WSA14C/WSA16C WSA10R/WSA12R/WSA14R/WSA16R	◎	◎	
		Rod (standard)	RA4C/RA6C/RA7C/RA8C RA4R/RA6R/RA7R/RA8R	◎	◎	
		Rod (Radial cylinder)	RRA4C/RRA6C/RRA7C/RRA8C RRA4R/RRA6R/RRA7R/RRA8R	◎	◎	
		Rod (Wide)	WRA10C/WRA12C/WRA14C/WRA16C WRA10R/WRA12R/WRA14R/WRA16R	◎	◎	
		Table	TA4C/TA6C/TA7C TA4R/TA6R/TA7R	◎	◎	
	RCS4CR	Slider (standard)	SA4C/SA6C/SA7C/SA8C	◎	◎	
		Slider (Wide)	WSA10C/WSA12C/WSA14C/WSA16C	◎	◎	
	RCS3	Slider (high-speed)	CT8C	◎	◎	
		Rod (servo press)	RA4R	◎	○	
			RA6R/RA7R/RA8R/RA10R/RA15R/RA20R	◎	◎	
		Table (high-speed)	CTZ5C	◎	◎	
	RCS3/RCS3P	Slider	SA8C/SS8C	◎	○	
			SA8R/SS8R	◎	○	
	RCS3CR/RCS3PCR	Slider	SA8C/SS8C	◎	○	

Compliant Product Table for Revised RoHS Directive/CE Mark/UL Standard

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
ROBO Cylinder	RCS2	Slider (standard)	SA4C/SA5C/SA6C/SA7C/SS7C/SS8C	◎	○	
			SA4R/SA5R/SA6R/SA7R/SS7R/SS8R	◎	○	
		Slider (motor direct connection)	SA4D/SA5D/SA6D	◎	○	
		Rod (standard)	RN5N/RP5N/RA4C/RA5C/RA4D/RA4R/RA5R	◎	○	
			SRA7BD	◎	×	
		Rod (servo press)	RA13R	◎	◎	
		Rod (with guide)	GS5N/GD5N/SD5N	◎	○	
			RGS4C/RGS5C/RGS4D/RGD4C/RGD5C	◎	○	
			RGD4D/RGD4R	◎	○	
			SRGS7BD/SRGD7BD	◎	×	
		Table	TCA5N/TWA5N/TFA5N	◎	○	
		Arm	A4R/A5R/A6R	◎	○	
		Flat	F5D	◎	○	
		Gripper	GR8/GRKL	◎	○	
		Rotary	RT6/RT6R/RT7R/RTC8L/RTC10L/RTC12L	◎	○	
		Absolute type	All models	◎	○	
	RCS2CR	Slider (coupling)	SA4C/SA5C/SA6C/SA7C/SS7C/SS8C	◎	○	
		Slider (motor direct connection)	SA5D/SA6D	◎	○	
		Rod	RN5N/RP5N/GS5N/GD5N/SD5N	◎	○	
	RCS2W	Rod	RN5N/RP5N/GS5N/GD5N/SD5N	◎	○	
			RA4C/RA4R/RA4D	◎	○	
Single axis robot	ISB/ISPB	Standard	SXM/SXL/MXM/MXL/MXMX/LXM/LXL/LXMX/LXUWX	◎	◎	
	ISDB/ISPDB	Simple dust protection	S/M/MX/L/LX	◎	◎	
	ISDBCR/ISPDBCR	Clean	S/M/MX/L/LX	◎	◎	
	SSPA	High rigidity (iron base)	SXM/MXM/LXM	◎	◎	
	SSPDACR	Clean high rigidity (iron base)	S/M/L	◎		
	ISA/ISPA	Standard	SXM/SYM/SZM/MXM/MYM/MZM/MXMXLXM/LYM/LZM/LXMX/ LXUWX/WXM/WXMX	◎	◎	
	ISDA/ISPDA	Simple dust protection	S/M/MX/L/LX	◎	◎	
	ISDACR/ISPDACR	Clean	S/M/MX/L/LX/W/WX	◎	◎	
	ISWA/ISPWA	Dust-proof and drip-proof	S/M/L	◎	◎	
	NSA	Standard	MXMS/MXMM	◎	◎	
			LXMS/LXMM/LXMXS/LXMXM	◎	◎	
			WXMS/WXMM/WXMXS/WXMXM	◎	◎	
	NS	Standard	SXMSA/SXMMA/SZMSA/SZMMA	◎	◎	
			MXMSA/MXMMA/MXMXSA/MZMSA/MZMMA	◎	◎	
			LXMSA/LXMMA/LXMXSA/LZMSA/LZMMA	◎	◎	
	IF	Standard	SA*L/SA*R/MA*L/MA*R (*:1 or 2 or3)	◎	×	
	RS	Axis of rotation	30/60	◎	×	
	ZR	Vertical/rotation integrated type	S/M	◎	×	
Direct drive motor	DDA	Standard	LT18□/LH18□	◎	◎ (*1)	
	DDACR	Clean	LT18□/LH18□	◎	◎	
	DD	Standard	T18□/LT18□/H18□/LH18□	◎	◎	
	DDCR	Clean	T18C□/LT18C□/H18C□/LH18C□	◎	×	
	DDW	Dust-proof and drip-proof	LH18C□	◎	×	
Linear	RCL	Slider (single slider)	SA1L/SA2L/SA3L/SA4L/SA5L/SA6L	◎	×	
		Slider (multi slider)	SM4L/SM5L/SM6L	◎	×	
		Rod	RA1L/RA2L/RA3L	◎	×	
	LSA LSAS	Small size	H	◎	×	
		Medium size	N	◎	×	
		Large size	W	◎	×	
		Shaft	S	◎	×	
		Flatness	L	◎	×	
High-speed orthogonal type	CT4	Standard	G1	◎	×	
		Specification with rotary shaft	G1RT	◎	×	
		Pick & rotary specification	G1PR	◎	×	
Orthogonal robot	ICSA/ICSPA	—	—	◎	×	
	ICSB/ICSPB	—	—	◎	×	
	IK	—	—	◎	×	
Cartesian type 6-axis robot	CRS	—	—	◎	×	
Table top	TT	—	TT-A2/A3/C2/C3	×	×	
	TTA	—	TTA-A2□/A3□/A4□/C2□/C3□/C4□	◎	◎ (*2)	
Scalar	IXA	Standard	3NNN1805/4NNN1805	◎	◎	
			3NNN3015/4NNN3015	◎	◎	
			3NNN45□□/4NNN45□□	◎	◎	
			3NNN60□□/4NNN60□□	◎	◎	
			4NNN80□□	◎	◎	
			4NNN100□□	◎	◎	
		High speed	3NSN3015/4NSN3015	◎	◎	
			3NSN45□□/4NSN45□□	◎	◎	
			3NSN60□□/4NSN60□□	◎	◎	
			4NSN80□□	◎	◎	
			4NSN100□□	◎	◎	
		Dust- and splash-proof	4NSW3015	◎	◎	
			4NSW45□□	◎	◎	
			4NSW60□□	◎	◎	
	IXP	Standard	3N1808/3N2508/4N1808/4N2508	◎	◎	
			3N3515/3N4515/4N3515/4N4515	◎	◎	
			3N5520/4N5520/3N6520/4N6520	◎	◎	

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
Scalar	IXP	With gripper	3N1808GM/3N2508GM/3N3515GM/ 3N4515GM/3N3510GL/3N4510GL	◎	◎	
			3N5515GL/3N5515GW/3N6515GL/3N6515GW	◎	◎	
		Clean	3C3515/4C3515/3C4515/4C4515/	◎	◎	
			3C5520/4C5520/3C6520/4C6520	◎	◎	
		Dust-proof and drip-proof	3W3515/4W3515/3W4515/4W4515	×	×	
			3W5520/4W5520/3W6520/4W6520	×	×	
	IX	Standard (NNN)	1205/1505/1805	◎	○	
			2515H/3515H	◎	○	
			50□□H/60□□H/70□□H/80□□H	◎	○	
		Clean/Dust-proof and drip-proof Ceiling mounted, high speed, wall hanging	1205/1505/1805/2515H/3515H/3015H 50□□H/60□□H/70□□H/80□□H	◎	○	
Wrist unit	WU	—	S/M	◎	◎	
Solenoid gripper	GRS	—	SEG/MEG	◎	◎	
		—	SIG/MIG	◎	◎	
Other	Motor unit	ISAC	200W/400W	◎	×	
		ISAC High rigidity (T1)	60W(RS)/100W/150W	◎	×	

(*1) Excluding the brake option.
(*2) Limited to Safety category compliant specification.

Compliant Product Table for Revised RoHS Directive/CE Mark/UL Standard

■Controller

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
Controller for ROBO Cylinder	MSEP	Incremental	C/LC	◎	◎	◎
		Simple Absolute	C-ABB/LC-ABB	◎	◎	◎
	MCON	—	C/CG/LC/LCG	◎	◎ (*1)	◎
	R-unit	Master unit	RCON-GW/GWG	◎	◎	◎
			RSEL-G	◎	◎	◎
			REC-GW	◎	◎	To be acquired
		Driver unit	RCON-PC-1/RCON-PC-2	◎	◎	◎
			RCON-PCF-1	◎	◎	◎
			RCON-AC-1/RCON-AC-2	◎	◎	◎
			RCON-DC-1/RCON-DC-2	◎	◎	◎
			RCON-SC1	◎	◎	To be acquired
		Power supply unit	RCON-PS2-3	◎	◎	To be acquired
		EC connection unit	RCON-EC-4	◎	◎	To be acquired
		Simple absolute unit	RCON-ABU-P	◎	◎	◎
			RCON-ABU-A	◎	◎	◎
		Extension unit	RCON-EXT	◎	◎	◎
			RCON-EXT-NP/PN	◎	◎	◎
			RCON-NP/PN	◎	◎	◎
	PCON	—	CB/CGB/CFB/CGFB	◎	◎ (*2)	◎
		—	CBP/CGBP (only for pulse press)	◎	◎ (*2)	
		—	CA/CF/CFA	◎	◎ (*3)	◎
		—	C/CG	◎	◎ (*3)	◎
		—	CY/SE/PL/PO	◎	◎	◎
		—	CYB/PLB/POB	◎	◎	◎
	ACON	—	CB/CGB	◎	◎ (*2)	◎
		—	CA	◎	◎ (*3)	◎
		—	C/CG	◎	◎ (*3)	◎
		—	CY/SE/PL/PO	◎	◎	◎
		—	CYB/PLB/POB	◎	◎	◎
	DCON	—	CB/CGB	◎	◎ (*2)	◎
		—	CA	◎	◎ (*3)	◎
		—	CYB/PLB/POB	◎	◎	◎
	SCON	—	CB/LC	◎	◎ (*3)	◎ (*4)
		—	CB-F (Servo press only)/LC-F	◎	◎ (*3)	◎ (*4)
		—	CA	◎	◎ (*3)	◎
		—	C	◎	◎	×
		—	CAL/CGAL	◎	◎ (*3)	×
	MSCON	—	C	◎	◎	
	RCM-P6	RCM-P6PC	—	◎	◎	◎
		RCM-P6AC	—	◎	◎	◎
		RCM-P6DC	—	◎	◎	◎

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
for single-axis for Cartesian for SCARA Controllers	PSEL	—	—	◎	◎	
	ASEL	—	—	◎	◎	
	SSEL	—	—	◎	◎	×
	MSEL	Standard	PC	◎	◎	×
		Safety category supported type	PG	◎	◎	×
		56SP/60P/86P motor-compatible type	PCF	◎	◎	×
		Safety Category Supported Type 56SP/60P/86P motor-compatible type	PGF	◎	◎	×
	ROBONET	Gateway R unit	RGW-DV/RGW-CC	◎	◎	◎
			RGW-PR/RGW-SIO	◎	◎	◎
		Controller Unit	RACON/RPCON	◎	◎	◎
		Simple Absolute R Unit	RABU	(*5)	◎	◎
		Expansion Unit	REXT	◎	◎	◎
		Expansion Unit (unit turn back)	REXT-SIO	◎	◎	◎
		Expansion unit (controller connection)	REXT-CTL	◎	◎	◎
	MSEL	Standard	PCX3/PCX4	◎	×	×
		Safety category supported type	PGX3/PGX4	◎	◎	×
	XSEL-RA/SA	Standard	RA/RAX/RAXD8	◎ (*6)	◎ (*6)	×
		Safety category supported type	SA/SAX/SAXD8	◎ (*6)	◎ (*6)	◎
	XSEL-R/S	Standard	R/RX/RXD8	×	×	×
		Safety category supported type	S/SX/SXD8	×	×	×
	XSEL-P/Q	Standard	P	◎	◎	
		Safety category supported type	Q	◎	◎	◎
		Scalar	PX/QX	◎	◎	
		CT4	PCT/QCT	◎	◎	◎
Driver box	GRS	—	GRS-DB	◎	◎	

(*1) Not compliant when connecting with IX-NNN 10040/12040.
(*2) The EU Battery Directive is applied, and RoHS Order is not applicable.
(*3) Field networks of CC-Link IE and MECHATROLINK-I/II are not supported.
(*4) Field network of MECHATROLINK-I/II is not supported.
(*5) 3000 and 3300W types are not supported.
(*6) XSSEL-SAX/SAXD8 are not supported.

Compliant Product Table for Revised RoHS Directive/CE Mark/UL Standard

■ Option

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE mark	UL standard
Controller for ROBO Cylinder	Position controller/ Program controller dual use	Standard	TB-01	◎	◎	×
			TB-02	◎	◎	×
		With deadman switch	TB-01D/DR	◎	◎	×
			TB-02D	◎	◎	×
		Standard	TB-03	◎	◎	×
		Actuator driving power unit	ADTB	◎	◎	×
	RC system	Universal touch panel teaching Standard type (color liquid crystal type)	CON-PTA-C	◎	◎	×
		Universal Touch Panel Teaching Type with enable switch (same as above)	CON-PDA-C	◎	◎	×
		Universal Touch Panel Teaching Safety category supported type (same as above)	CON-PGAS-C	◎	◎	×
Quick teach	ERC3	RCM-PST	—	◎	×	×
MPG cable MPG cable	EC (200V system)	Motor cable	CB-EC-PW***-RB	◎	◎	×
	IXP/RCP6/RCP5/ RCP4-SA3·RA3/ RCP2/RCD	Motor/Encoder integrated cable	CB-CAN-MPA	◎	◎	×
			CB-CAN-MPA***-RB	◎	◎	×
			CB-ADPC-MPA***	◎	◎	×
			CB-ADPC-MPA***-RB	◎	◎	×
	RCP6/RCP5	Motor/Encoder integrated cable	CB-CFA3-MPA	◎	◎	×
	RCP4/RCD	Motor/Encoder integrated cable	CB-CA-MPA	◎	◎	×
			CB-CA-MPA***-RB	◎	◎	×
	RCP3/RCP2/ RCA2/RCA/RCL	Motor/Encoder integrated cable	CB-APSEP-MPA	◎	◎	×
			CB-RCAPC-MPA	◎		×
			CB-RCAPC-MPA-RB	◎		×
	RCP3/RCP2	Motor/Encoder integrated cable	CB-PCS-MPA	◎	◎	×
	RCP/RCP2	Motor/Encoder integrated cable	CB-PSEP-MPA	◎	◎	×
		Motor/Encoder integrated cable (Small rotary type only)	CB-RPSEP-MPA	◎	◎	×
		Motor cable	CB-RCP2-MA	◎	◎	×
		Encoder cable	CB-RCP2-PA	◎	◎	×
			CB-RFA-PA	◎	◎	×
			CB-RCP2-PA***-RB	◎	◎	×
			CB-RFA-PA***-RB	◎	◎	×
	RCA2	Motor/Encoder integrated cable	CB-ACS-MPA	◎	◎	×
	RCA2/RCA/RCL	Motor/Encoder integrated cable	CB-ASEP-MPA	◎		×
			CB-ASEP2-MPA	◎	◎	×
		Motor cable	CB-ACS-MA	◎	◎	×
		Encoder cable	CB-ACS-PA	◎	◎	×
			CB-ACS-PA***-RB	◎	◎	×
	RCS3-RA15R/20R	Motor cable	CB-RCS3-MA***-RB	◎	◎	×
		Encoder cable	CB-RCS3-PLA***-RB	◎	◎	×
	RCS3/RCS2	Motor cable	CB-RCC-MA	◎	◎	×
			CB-RCC-MA***-RB	◎	◎	×
		Encoder cable	CB-RCS2-PA	◎	◎	×
			CB-RCS2-PLA	◎	◎	×
			CB-RCBC-PA	◎	◎	×
			CB-RCS2-PLLA (RA13R/with load cell)	◎	◎	×
			CB-RCBC-PA***-RB	◎	◎	×
	XSEL	Motor cable	CB-X-MA	◎	◎	×
			CB-XMC-MA	◎	◎	×
			CB-XEU-MA	◎	◎	×
		Encoder cable	CB-X-PA	◎	◎	×
			CB-X1-PA/PLA	◎	◎	×
			CB-X2-PA/PLA	◎	◎	×
			CB-X1-PA***-WC	◎	◎	×
			CB-X3-PA	◎	◎	×
		Limit switch cable	CB-X-LC	◎	◎	×
	XSEL-PCT/QCT	Motor cable	CB-CT4-MA	◎	◎	×
			CB-CT4R-MA	◎	◎	×
		Encoder cable	CB-CT4-PA	◎	◎	×
			CB-CT4R-PA	◎	◎	×
			CB-CT4PR-PA	◎	◎	×
Power supply - I/O cable	EC	PIO type power supply	CB-EC-PWBIO***-RB	◎	◎	×
			CB-EC2-PWBIO***-RB	◎	◎	×
I/O cable	MSEP	For standard	CB-MSEP-PIO	◎	◎	×
		For LC	CB-PAC-PIO	◎	◎	×
	PCON/ACON/ DCON	For standard (C/CA/CB/CG/CGB type)	CB-PAC-PIO	◎	◎	×
		For solenoid valve type (CY type)	CB-PACY-PIO	◎	◎	×
		For solenoid valve type (CYB type)	CB-PAD-PIO	◎	◎	×
		For pulse train control (PL/PO type)	CB-PACPU-PIO	◎	◎	×
		For pulse train control (PLB/POB type)	CB-PAD-PIOS	◎	◎	×
	SCON	For standard	TA4R/TA5R/TA6R/TA7R	◎	◎	×
	MSEL	Standard	CB-PAC-PIO	◎	◎	×
	PSEL/ASEL/SSEL	For standard	CB-DS-PIO	◎	◎	×

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE mark	UL standard
I/O cable	XSEL	For standard	CB-X-PIO	◎	◎	×
	ERC3	Power supply for PIO type	CB-ERC3P-PWBIO	◎	×	×
		Power supply for SIO type	CB-ERC3S-PWBIO	◎	×	×
	ERC/ERC2	Power supply for PIO type	CB-ERC-PWBIO***(-RB)	◎	◎	×
		Power supply/I/O cable	CB-ERC-PWBIO***-H6	◎	◎	×
			CB-ERC-PWBIO***-RB-H6	◎	◎	×
		Power supply for SIO type	CB-ERC2-PWBIO***(-RB)	◎	◎	×
Communication cable for SIO	ERC3	—	CB-PST-SIO050	◎	×	×
RCON-EC connection cable		Standard connector cable	CB-REC-PWBIO***-RB	◎	◎	×
		4-directional connector cable	CB-REC2-PWBIO***-RB	◎	◎	×
Others	RC system	Software for PC	RCM-101-MW	◎		
			RCM-101-USB	◎		
		External communication cable	CB-RCA-SIO***	◎		
		RS232C conversion cable	RCB-CV-MW	◎	◎	
		USB cable	CB-SEL-USB***	◎		
			CB-SEL-USB030	◎	×	◎
		USB conversion adapter	CB-CV-USB	◎	×	×
		Link cable	CB-RCB-CTL***	◎	◎	×
		Unit link cable	CB-REXT-SIO***	◎	◎	×
		Controller connection cable	CB-REXT-CTL***	◎	◎	×
		Conversion cable	CB-CAN-AJ002	◎		×
		Conversion connector	RCM-CV-APCS	◎		×
	SCON	Adapter for CON-TG	RCB-LB-TGS	◎	×	×
		Pulse train control cable	CB-SC-PIOS	◎	◎	
	RCP6S	Connection cable (between axis and GW)	CB-RCP6S-PWBIO□□□(-RB)	◎		×
		Connection cable (between GW and hub)	CB-RCP6S-PLY□□□(-RB)	◎		×
	ERC2	PC connection cable	CB-ERC2-SIO***	◎	◎	×
		Cable for network connection	CB-ERC2-CTL***	◎	◎	×
	MSEL (included with MSELABB)	Connection cable	CB-MSEL-AB***	◎	◎	×
	SEL system	Software for PC (Cable + EMG BOX)	IA-101-X-MW	◎	×	×
			IA-101-XA-MW	◎	×	×
			IA-101-X-USBS	◎	×	×
			IA-101-X-USBMW	◎	×	×
			EMG SW BOX	◎	×	×
		Insulated cable (single item)	CB-ST-E1MW***	◎	◎	×
			CB-ST-A2MW***	◎	◎	×
			CB-SEL-USB010	◎		
		USB conversion adapter	IA-CV-USB	◎	×	×
		Adapter for SEL-TG	IA-LB-TGS	◎	×	×
		Joint cable	CB-ST-232J001/CB-ST-422J010	◎	◎	×
		SEL-TG connection cable	CB-SEL25-LBS***	◎	◎	×
		Brake box - controller connection cable	CB-XBB-PA030/050-CS	◎	×	×
		Cable for brake box release switch	CB-XBB-SW020	◎	×	×
		Connection cable (included with EIOU - 4)	CB-RS-IAN020	◎	×	×
	A/P/SSEL	SEL-TG connection cable	CB-SEL26H-LBS***	◎	◎	×
	DDA	Brake box · Mechanical connection cable	CB-DDB-BK***	◎	×	×
	SEL	Panel unit	PU-1	◎		
		Connector conversion cable	CB-SEL-SJS***	◎	◎	
	TTA	Software for PC	IA-101-TTA-USB	◎		
Simple absolute unit	PCON/ACON	PCON-ABU ACON-ABU	—	×	×	×
Simple Absolute Battery Unit	ACON-CB/CGB	SEP-ABU/ABUS	—	*1	◎	×
Dc24V Power supply	—	PSA-24(L)	—	◎	◎	◎
		PS-241/PS-242	—	×	×	×
PLC connection unit	RCP6S	RCB-P6PLC	—	◎	◎	◎
Hub unit	RCP6S	RCM-P6HUB	—	◎	◎	◎
Gateway unit	RCP6S	RCM-P6GW	—	◎	◎	◎
	ERC3	RCM-EGW	—	◎	×	×
RC gateway (dedicated cable for communication port connection)	XSEL-P/Q	Communication cable	CB-RCB-SIO***	◎	◎	×
	XSEL-R/S	Controller link cable	CB-RCB-CTL***	◎	◎	×
Expansion I / O unit	SSEL	EIOU-1	—	◎	×	×
	MSEL					
	TTA					
	XSEL	EIOU-4	—	◎	×	×
Regenerative resistance unit	EC200V specification	Standard specification		◎	×	×
		DIN rail mount specification		◎	×	×
	SCON (for RCS3-RA20R)	RESU-35T	—	◎	◎	×

Compliant Product Table for Revised RoHS Directive/CE Mark/UL Standard

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
Regenerative resistance unit	MSCON	RESU-1/RESUD-1	—	◎	×	×
	XSEL-P/Q/R/S/RA/SA					
	SCON	RESU-2/RESUD-2	—	◎	×	×
	MSCON					
	SSEL					
	SCON	REU-2	—	◎	×	×
	SSEL				×	×
	MSEP	RER-1	—	◎	×	×
	MCON					
Absolute battery	IX Scalar (for 250-800)	AB-3	—	*1	×	×
	RCP2	AB-4	—		×	×
	XSEL-P/Q/R/S/RA/SA	AB-5	—		×	×
	ASEL					
	ACON					
	SCON					
	MSCON					
	SSEL					
	IX Scalar (for 120-180)	AB-6	—		×	×
	PCON-ABU	AB-7	—		×	×
	ACON-ABU					
	MCON					
	MSEL					
Absolute battery box	MSEP	MSEP-ABB	—	◎	◎	×
	MCON					
	MSEL	MSEL-ABB	—	◎	◎	×
Dummy plug	XSEL	DP-2	—	◎	×	×
	PSEL	DP-4S	—	◎		
	ASEL					
	SSEL					
	MSEL					
	MCON	DP-5	—	◎	×	×
	ACON-CGB					
	DCON-CGB					
	SCON-CGB/CGBL/CAL					
Brake box	RCS2-RA13R	RCB-110-RA13R-0	—	◎	×	×
	RCL	RCB-110-RCLB-0	—	×	×	×
	DDA	IA-110-DD-4	—	◎	×	×
Driver board	MSEP (for pulse motors)	MSEP-PPD1/PD1/PD2	—	◎	×	×
	MSEP (for AC Servomotor)	MSEP-AD1/AD2	—	◎	×	×
	MSEP (for DC brushless motor)	MSEP-DD1/DD2	—	◎	×	×
	MCON (for pulse motors)	MCON-PPD1/PD1/PD2	—	◎	×	×
	MCON (for AC Servomotor)	MCON-AD1/AD2	—	◎	×	×

◎ : Standard / ○ : Option / × : No plan

Product structure	Series name	Type	Model	RoHS Order	CE Marking	UL Standard
Driver board	MCON (for DC brushless motor)	MCON-DD1/DD2	—	◎	×	×
Fan unit	RCON	RCON-FU	—	◎	×	×
	MSEP	MSEP-FU	—	◎	×	×
	SCON	SCON-FU	—	◎	×	×
PIO converter	ERC3	RCB-CV	—	◎	×	×
PIO terminal block	—	RCB-TU-PIO-A/B	—	◎	×	×
SIO converter	—	RCB-TU-SIO-A/B	—	◎	×	×
RS232 conversion uni	RCS	New	RCB-CV-MW	◎		
	XSEL	RCB-CV-GW	—	◎		
Pulse converter	ACON/SCON	AK-04	—	◎	×	×
	SCON-CB	JM-08	—	◎	×	×
SIO isolator	—	—	—	×	×	×

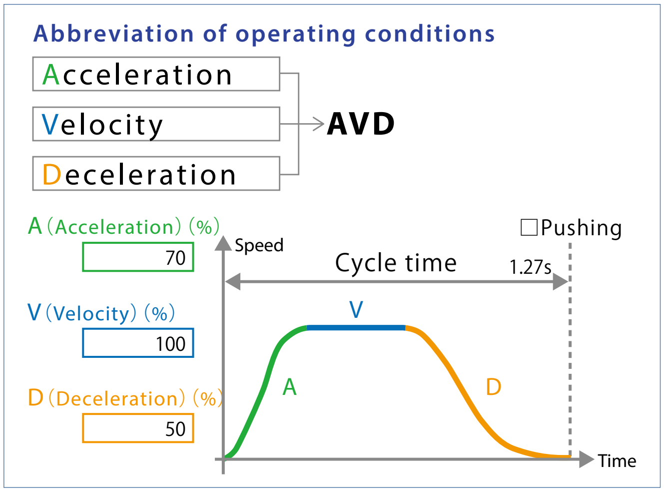
(*1) The EU Battery Directive is applied, and RoHS Order is not applicable.

Explanation of Terms

(This terminology is related to IAI products, and so the definitions are more limited than general meaning.)

AVD

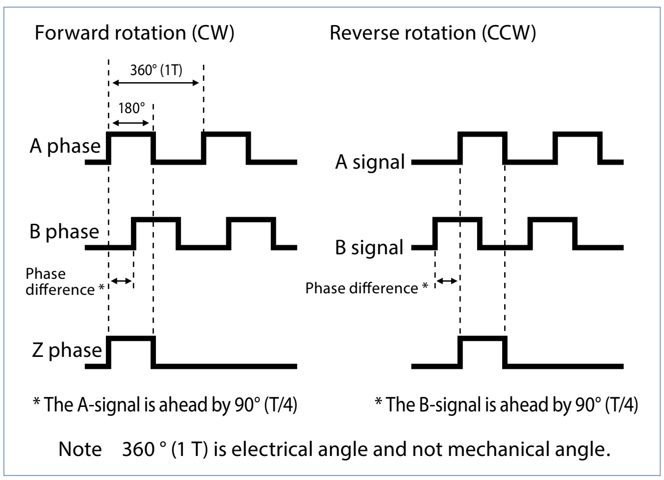
When moving an object, the object will accelerate from the stopped state, reach a constant speed, decelerate from that constant speed, and stop. The operating conditions of acceleration, speed, and deceleration at that time are abbreviated as AVD, with the initial letters of each English word. IAI uses it as an abbreviation of operating conditions. The IAI electric actuator can set the AVD individually to an arbitrary value.



A phase (signal) output · B phase (signal) output

The incremental type output judges the forward and reverse rotation of the axis with the phase difference between A phase and B phase. In the case of forward rotation (CW), the A phase precedes the B phase.

■ **Output mode diagram**



A transistor

When a small amount of current is passed through the base (B) part, current flows between the collector (C) and the emitter (E), and it functions as a switching element. There are two types, PNP type and NPN type.

Absolute battery

Battery to hold encoder information when power is cut off.

Absolute encoder

Encoder with absolute position detection function. Since absolute position can always be grasped, return to home is not required every time power is turned on.

Air purge

To ensure dust-proof and drip-proof properties in dust-proof and drip-proof type actuators, apply air pressure inside the actuator to prevent dust and other substances from entering the inside of the actuator.

Allowable Dynamic Moment

Indicator for guide life. In our company, the moment where the mileage is 5,000 km for ROBO Cylinder and 10,000 km for Single Axis Robot shall be the standard rated life.

Allowable Static Moment

Calculated based on the static load rating (N) * 1 that can be added to the slider while the slider is stopped.

*1 When a certain load is applied, a small indentation (the total permanent deformation amount of the guide ball becomes about 1/10000 times the ball diameter) remains on the contact surface between the guide and the ball (steel ball)).

AQ seal

Lubricating components obtained by solidifying lubricating oil with resin. Lubricating oil seeps out to the surface due to capillary phenomenon, the optimal amount of oil is secured on the raceway surface of the ball screw / linear guide, and lubricating performance is maintained.

Backlash

Gaps between the mechanical elements that move together.

Backup memory

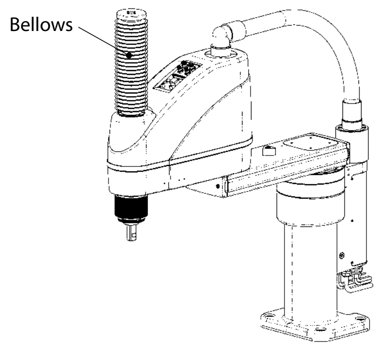
A storage device for storing information necessary for moving the actuator in the controller.

Ball screw

Machine parts where the screw shaft and nut operate through the ball.

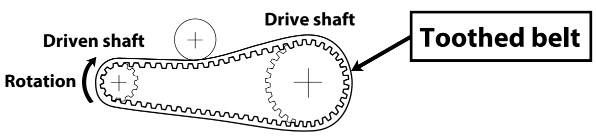
Bellows

A stretched sheet that is mounted for dust-proof or drip-proof purposes.



Belt drive

Drive system that transmits power from drive shaft to driven shaft (driven shaft) with belt. IAI mainly uses toothed belts.



Bit

Unit of information amount in the network. In addition, there are byte (word) and word (word).
The amount of information that can be handled in order of minimum bit, next byte, maximum word changes.
Concept: 8 bits = 1 byte 16 bits = 2 bytes = 1 word

Brake box

A device to be connected between the brake controller.

CCW

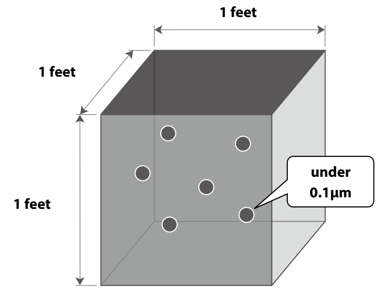
Counter clock wise.
It is used to indicate the direction of rotation of the motor.

Circuit

It is defined as "the one to operate the contact mechanism by using the electromagnetic suction force caused when the current more than the value in the electromagnet is flowed" composed of the electromagnet and the contact mechanism. The contacts are opened and closed by voltage and current (input signal) applied to the coil.

Cleanliness

An index showing the cleanliness in a clean room.



Coil

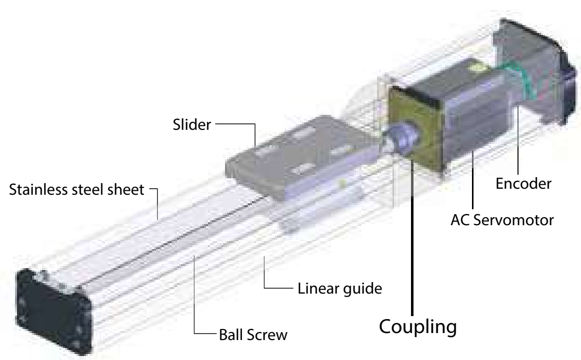
A component that generates an electromotive force proportional to a change in current per unit time when the flowing current changes. There is a property that only high-frequency electric signals are passed through, and only direct current or low-frequency alternating current is passed.

Condenser

Passive element that acts to store electric charge. Also referred to as electrostatic capacity or capacitor.

Coupling

Shaft coupling. Machine element for fastening shaft and shaft.



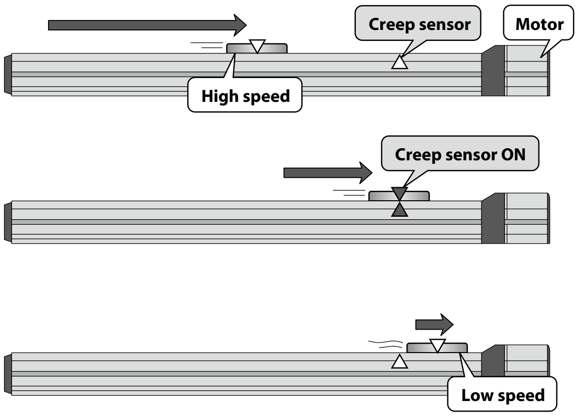
CP control

Control with all orbits or all routes specified. (Continuous Path)

Explanation of Terms

Creep sensor

Sensor for returning to home at high speed.



Critical speed

The speed of the slider where the ball screw resonates. (Ball screw rotation speed)

CT effect

By replacing the air cylinder of the facility with an electric actuator, it is possible to shorten the cycle time and reduce Choco Tei. As a result of improved productivity, capital investment and personnel expenses can be suppressed and the benefit of increasing customer profits. CT is an abbreviation for Cycle Time and Choco Tei.

CW

Clockwise (Clock Wise). It is used to indicate the direction of rotation of the motor.

Cycle time

The time taken for one process.

Differential line driver

It is one of the input / output method of the pulse train signal, and has the feature that it is more resistant to noise than the "open collector" method of the same input / output method. On the other hand, it is more expensive than the open collector type.

Diode

A part that makes the flow of electricity one way.

<Type of diode>

1. Switching diode

   It is used most frequently for small signal diodes.

   The shape is also small and it is sealed with glass.

2. Light emitting diode

   LED. It is used for display, infrared remote control etc.

Direct numerical designation control

A control method in which a numerical value is entered from a touch panel and is directly reflected on the target position even if the target position is not memorized in the controller in advance.

Dispenser

Equipment that restricts the flow of liquids. It is incorporated into adhesive and sealant coating equipment.

Double slider

A free slider (slider not connected to the ball screw/drive belt) is added separately from the drive slider.

Duty

The ratio between the time the actuator is operating and the elapsed time.

Earth

Connect the equipment casing, the reference potential wiring of the electronic equipment, etc. to the reference potential point. Or the reference potential point itself. It is connected for the purpose of noise countermeasure, electric shock prevention, etc. (Ground, ground)

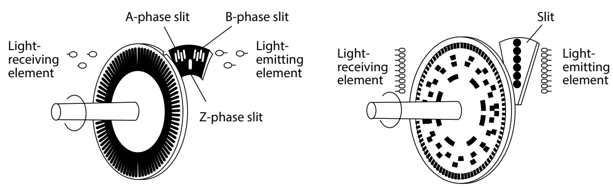
Emergency stop circuit

Circuit that stops the device either artificially or automatically if the device is in a hazardous state.

Encoder

Sensor that detects the position of the motor.

●Incremental ●Absolute



An incremental encoder

detects the rotational angle and the RPM of the axis from the number of output pulses. To detect the rotational angle and the RPM, a counter is needed to cumulatively add the number of output pulses. An incremental encoder allows you to electrically increase the resolution by using the rise and fall points on the pulse aveform to double or quadruple the pulse generation frequency.

An absolute encoder

detects the rotation angle of the axis from the state of the rotation slit, enabling you to know the absolute position at all times, even when the rotating slit is at rest. Consequently, the rotational position of the axis can always be checked even without a counter.

In addition, since the home position of the input rotation axis is determined at the time it is assembled into the machine, the number of rotations from home can always be accurately expressed, even when turning the power ON during startup or after a power outage or an emergency stop.

External operation mode

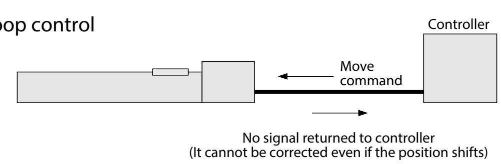
An operation mode activated by a start signal of an external device (PLC etc.). (self-driving)

Feedback control

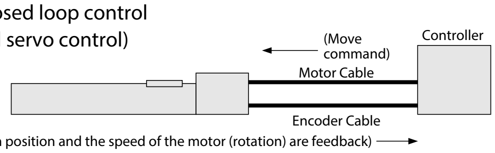
A mechanism to control so that the control results from the controller and the command from the encoder can match.

There are the following types of control of the actuator.

■ Open loop control

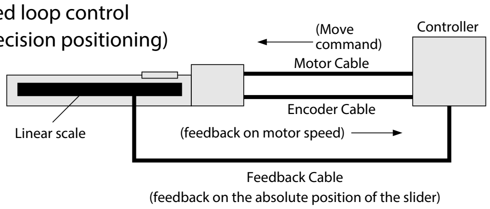


■ Semi-closed loop control (General servo control)



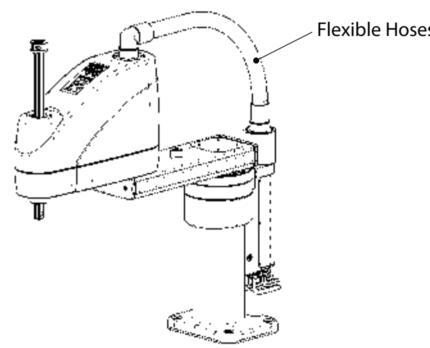
(The calculation position and the speed of the motor (rotation) are feedback)

■ Full closed loop control (High precision positioning)



Flexible Hoses

A pipe that is through the motor, encoder cables and user wiring of SCARA robot. Flexible hose, flexible tube and so on.



Frame ground

A place with a stable electric potential consisting of a large conductor such as the frame of the equipment.

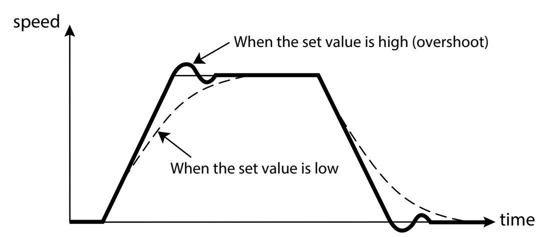
G

A unit representing the magnitude of acceleration. Non SI unit.

Acceleration is indicated based on standard gravity acceleration. 1 G = 9.807 m/s^2

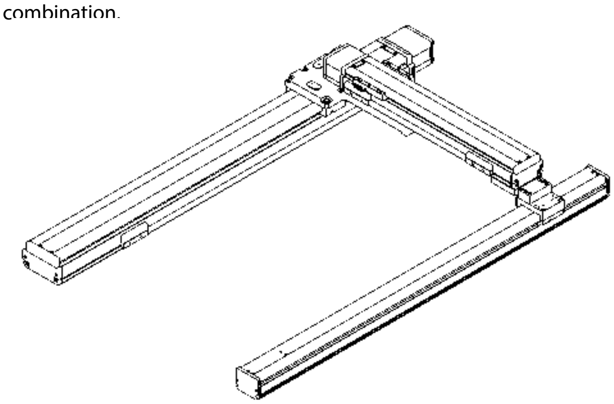
Gain

A numerical value that adjusts the response when the controller controls the servomotor. Generally, the higher the gain, the more quick response is improved.



Gantry

Combination type with a guide for Y axis support attached to XY 2 axis combination.



Explanation of Terms

Global specification

Type of controller and touch panel teaching pendant equipped with functions such as duplex emergency stop circuit and 3-position enable switch so that it can correspond to safety category.

Grease

Suspended thickener in lubricating oil to make it semisolid or solid.

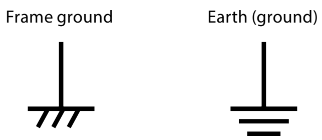
Grease up

Injecting and applying grease to sliding parts.

Ground

A place that becomes a reference potential that is installed in the earth and used for security.

<Ground sign>



Guide module

Guide mechanism with drive mechanism removed from direct acting actuator.

Home

Reference point of actuator operation.

Hunting

The phenomenon in which the response is vibrating near the target value.

I/O

Input / Output (Input / Output). An interface used for input and output information (signal) with devices connected to the outside of the device.

Incremental encoder

Encoder with the function to detect the relative position. Since only the relative position can be grasped, return to home is required every time the power is turned on.

Inertia

As long as no external force acts on the object, it is a property to sustain the current state.
(Inertia)

Inertia ratio

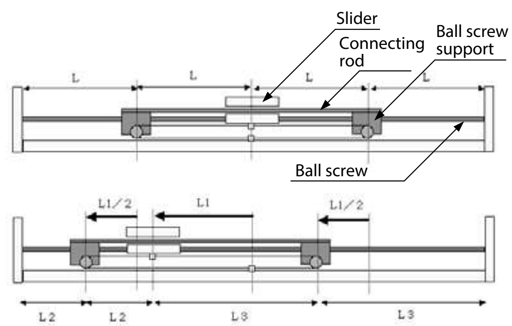
Ratio of load inertia moment to moment of inertia of motor shaft.

Inrush current

Current flowing to charge the capacitor at the moment of power-on. It is much larger than the steady state current.

Intermediate support mechanism

A ball screw support mechanism that moves in conjunction with a slider. A mechanism that greatly improves the maximum speed of the long stroke type, suppressing the runout of the ball screw in the case of long stroke, increasing the band of critical revolution number.



Jog feed

Send it manually at a predetermined feed speed.

Key Grooves

The grooves to be machined into the shaft or mounting parts for key mounting. (Key: The part to prevent the position shift in the rotation direction of the shaft and the mounting part.)

Lead

Distance at which the slider moves when the feed screw rotates once. When the lead is large, the speed of the slider is fast, but the thrust is small.

Leak current

It is a small current flowing from a part etc. used in a device using a high voltage power supply (AC 100 V etc.) to a surrounding conductor (mainly a frame).

Linear encoder

Encoder to detect linear distance.

Linear guide

Mechanism for guiding the slider of the actuator.

Linear motor

Motor that performs linear motion.

Load cell

Sensor that detects the magnitude of force.

Load Coefficient

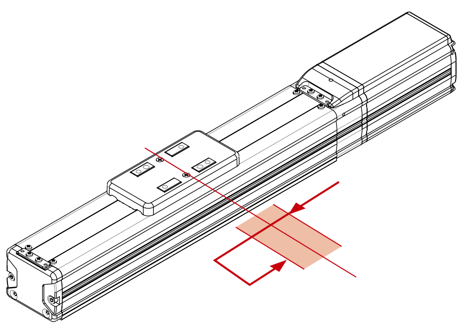
Coefficient to consider lifetime reduction due to operating conditions in lifetime calculation.

Load Rating

The ratio of the load to the rated output of the motor.

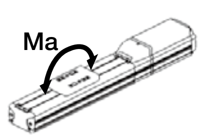
Lost motion

Difference between both stopping positions by positioning in a positive direction to a certain position and positioning in a negative direction. Repeat positioning from positive and negative directions seven times at an arbitrary point, measure the stop position, and find the average difference between the positive and negative measured values. This measurement is performed at the center of the moving distance and almost at both ends, and the largest one of the obtained average differences is taken as the measured value.



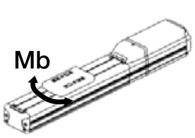
Ma direction

Front-to-rear direction with respect to the traveling direction.



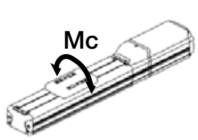
Mb direction

Horizontal direction with respect to the traveling direction.



Mc direction

Rotational direction with respect to the direction of travel.



Mechanical end

Mechanical movable limit position of the slider.

Moment

The power to try to rotate the object.

Moment of inertia

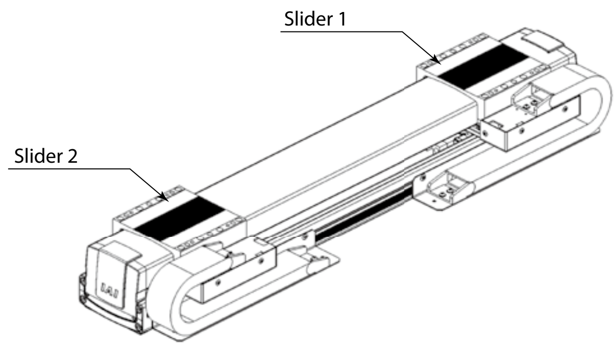
The amount that indicates the degree of difficulty of rotation (difficulty of stopping).

Motor / encoder cable

Cable connecting the actuator and the controller.

Multi Slider

Specifications equipped with multiple sliders that can be operated individually.



N

Unit of force in SI unit system. It shows the force to accelerate an object with a mass of 1 kg at 1 m/s^2. 1 kgf = 9.807 N

N·m

Unit of force moment (torque) in SI unit system. The moment of force around the center point is 1 N·m when 1 N force is applied in the direction perpendicular to the center point to the point 1 m away from the center point.

Noise

Distortion of electrical signal caused by unnecessary electromagnetic wave leaked from equipment.

Noise filter

Equipment that prevents leakage or intrusion of noise in power supplies, signals, etc.

Explanation of Terms

Open collector output

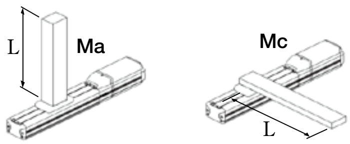
A system with no overload resistance in the voltage output circuit, that outputs signals by sinking the load current. Since this circuit can turn the load current ON/OFF regardless of voltage potential to which the current is connected, it is useful for switching an external load and is widely used as a relay or ramp circuit or the like for switching external loads, etc.

Open loop system

A type of control system. This system only outputs commands and does not take feedback.
A typical example of this is the stepping motor. Since it does not compare each actual value against the commanded value, even if a loss of synchronization (i.e signal error) occurs, the controller would
not be able to correct it.

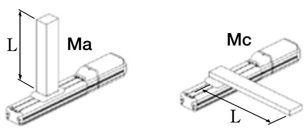
Overhang

The object to be mounted on the actuator protrudes in either front, back, left, right, up or down.



Overhang load length

Estimated maximum length that can be extended from the slider.



Overload check

Check overload. (One of protection functions)

Overshoot

The response goes over the target value too much.

Overvoltage

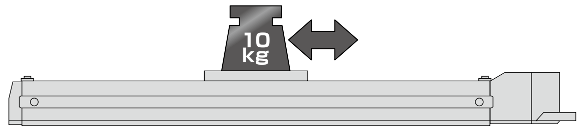
Voltage above the specified value will be applied to the motor.

Parameter

The data that the controller holds to operate the actuator, such as setting the input and output of the signal and how the voltage and current for rotating the motor are changed.

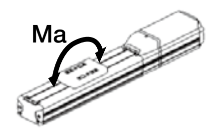
Payload quantity

Mass which can be conveyed by actuator slider / rod / table.



Pitching

It is an angle that shows how far it is inclined in the fore-and-aft direction (Ma direction) with respect to the traveling direction.

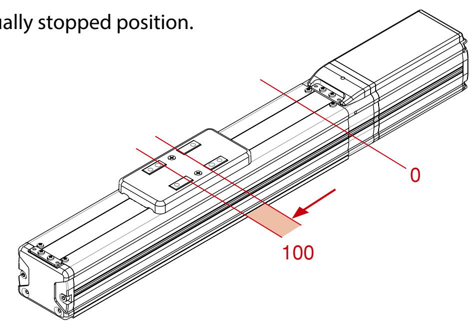


PLC

Abbreviation for Programmable Logic Controller. Programmable controller for controlling production facilities / equipment.

Positioning accuracy

The degree of coincidence between the commanded stop position and the actually stopped position.



Positioning complete width

Width regarded as positioning completion with respect to the coordinates to be positioned. (Pend Band)

Protective structure (IP□□□)

The degree of protection from water, human body and solid foreign matter.
It is based on the standards of IEC (International Electrotechnical Commission), JIS (Japan Industrial Standard) and JEMA (Japan Electric Industry Association).

Protocol

Conventions stipulated mainly when communicating. It decided how to arrange the data and give meaning.

PTP control

Control where pass points on the route are specified intermittently. (Point to Point)

Pulse Train Control

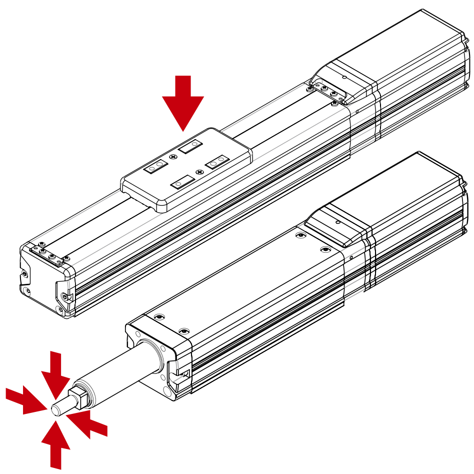
A method that controls the operation of the motor by modulating the pulse train output by the driver.

Push and return to origin

A method of determining the hime position by pushing against a stopper. Return to home is possible without using the home sensor.

Radial load

Load acting perpendicularly to the direction of motion of the direct acting actuator.



Rated thrust

Thrust that can be generated continuously.

Rated torque

Torque that can be generated continuously.

Reference rated life

Standard value of running life. We have set the standard rated life of ROBO Cylinder to 5,000 km and the standard rated life of single axis robot to 10,000 km. (Except some models)

Regenerative brake

It is a brake that uses the rotational resistance generated when the motor decelerates as a braking force.

Regenerative energy

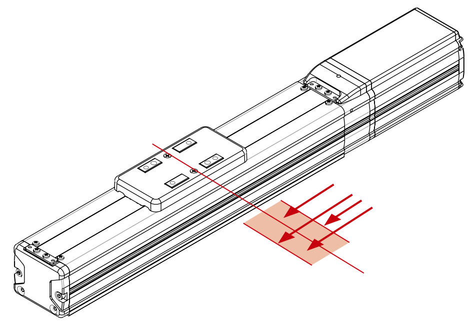
Energy generated by itself when the motor rotates.

Regenerative resistor

Resistance to discharge regenerative current.

Repetitive positioning accuracy

Reproducibility when repeatedly positioned by the same command under the same condition.
Repeat positioning from the same direction to an arbitrary point seven times, measure the stop position, and find the maximum difference in reading. This measurement is performed at the center of the moving distance and almost at both ends, and the maximum one of the obtained values is taken as the measured value, and 1/2 of the value is displayed with a sign of ±.



Return to home

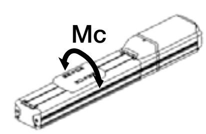
Go back to the point that is the basis of the movement of the actuator.

Robot cable

A cable excellent in resistance to bending and twisting.

Rolling

It is an angle that shows how tilted in the direction of rotation (Mc direction) with respect to the direction of travel.

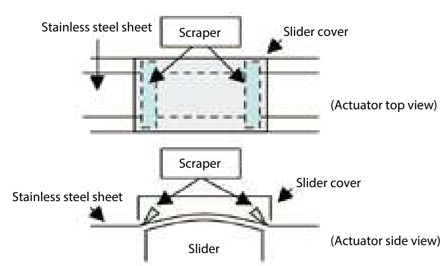


Safety category

It is prescribed by ISO 13849-1 of the international standard and classified as a function (safety function) to ensure safety. Classification is divided into 5 stages of B, 1, 2, 3, and 4 according to safety standards, and the standard (category) 4 indicates the standard with the highest safety.

Scraper

A part for removing foreign objects on the sliding surface and preventing intrusion into the inside of the main body.



Explanation of Terms

SEL language

Abbreviation for Shimizukiden Ecology Language. Our proprietary programming language.

Serial communication

Use one or two transmission lines to send and receive data.
1bit is a communication method that transmits and receives continuously.

Servo control

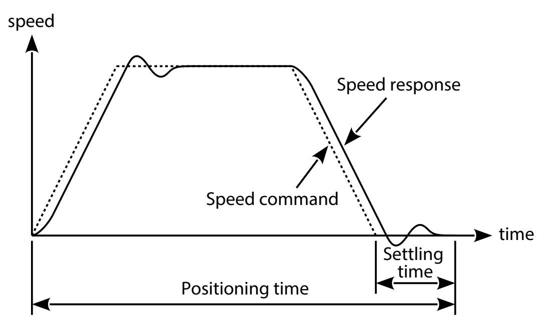
A control method that detects the current speed and position from the motor and compares the actual result against the command value by feeding back the result to the upper side to make the difference as small as possible.

Servomotor

Motor operated by giving feedback.

Settling time

In the positioning operation, it means the time until the speed command value becomes zero and then stops.



Shielded wire

An electric wire structured by covering the core wire with an electrostatic shield (aluminum tape, netting etc). It is less sensitive to noise.

Single phase AC

AC consisting of one phase. It is used for household power supply etc.

Software limit

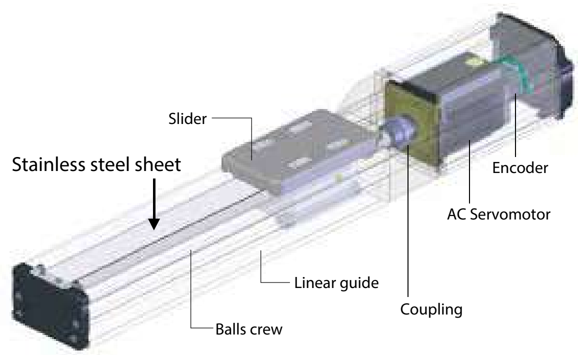
Limit of operating range set on software.

Solenoid valve type

The type of controller that made it possible to operate with the same signal as the signal operating the solenoid valve of the air cylinder.

Stainless steel sheet

Dust-proof sheet used for slider type.



Standard load factor

The standard value of the load factor set for each model.

Step-out

Synchronization between input pulse signal (command position) and motor rotation (position after movement) is lost due to shock, overload, etc. In the open-loop control, it is impossible to detect step-out, so the operation is continued with the position shift.

Stepping motor

Motor for angular positioning by input pulse signal. Also called a pulse motor.

Stroke

Operating range of the actuator.

Switch

It is made possible to connect and shut off the path of electricity by lever or push button.

<Types of representative switches>

1 Toggle switch (snap switch)
  Switch to turn ON / OFF by tilting the lever. There are 2P, 3P, 6P depending on the pin pin number.

2 Momentary switch
  A switch that turns ON when the operation part is pushed, and returns to the original when you release the hand.

3 Alternate switch
  A switch that holds the ON state even when you release your hand and turns it OFF when you press it again.

Tact time

In the production line, within a certain time, the working time per piece allocated to produce target production quantity. (Planned value)

Teaching

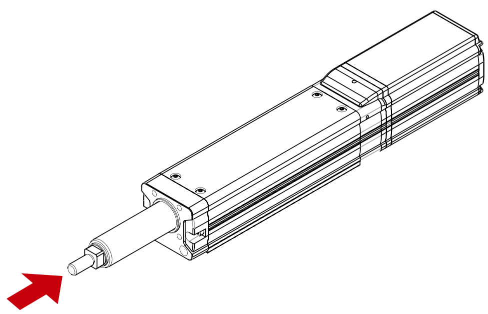
Make the controller store the information necessary for the required work. (Teaching)

Three phase AC

Exchange consisting of three phases. Since it can transmit with less current compared with single phase, it is widely used for power supply.

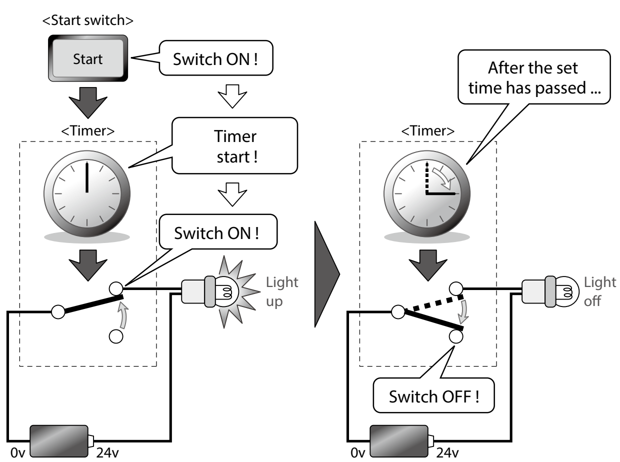
Thrust load

Load applied in the axial direction. (Axial load)



Timer

An electronic component that can be activated after an electrical start signal is given, and can switch circuits after a predetermined time has passed.

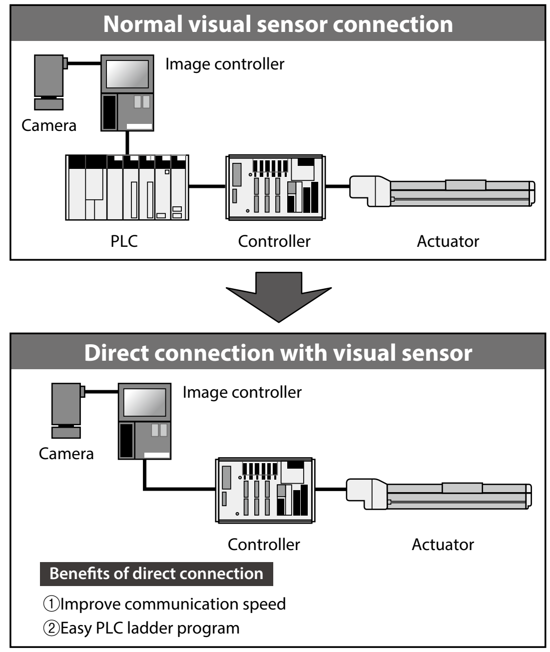


Trance

Electrical equipment or parts that convert AC voltage or current.

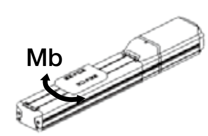
Vision Sensor

A device that uses a camera to capture an object (a workpiece), read a position or contour, and send data to a control device.



Yawing

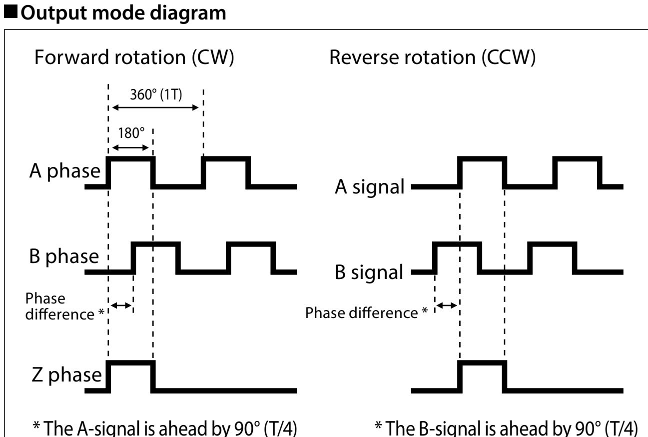
It is an angle that shows how much it tilts in the left-right direction (Mb direction) with respect to the traveling direction.



Z phase

It is a phase (signal) that detects the reference point of the incremental encoder and is used to detect the origin during home return operation. Searching the Z phase signal serving as a reference during the homing operation is called Z phase search.

■Output mode diagram

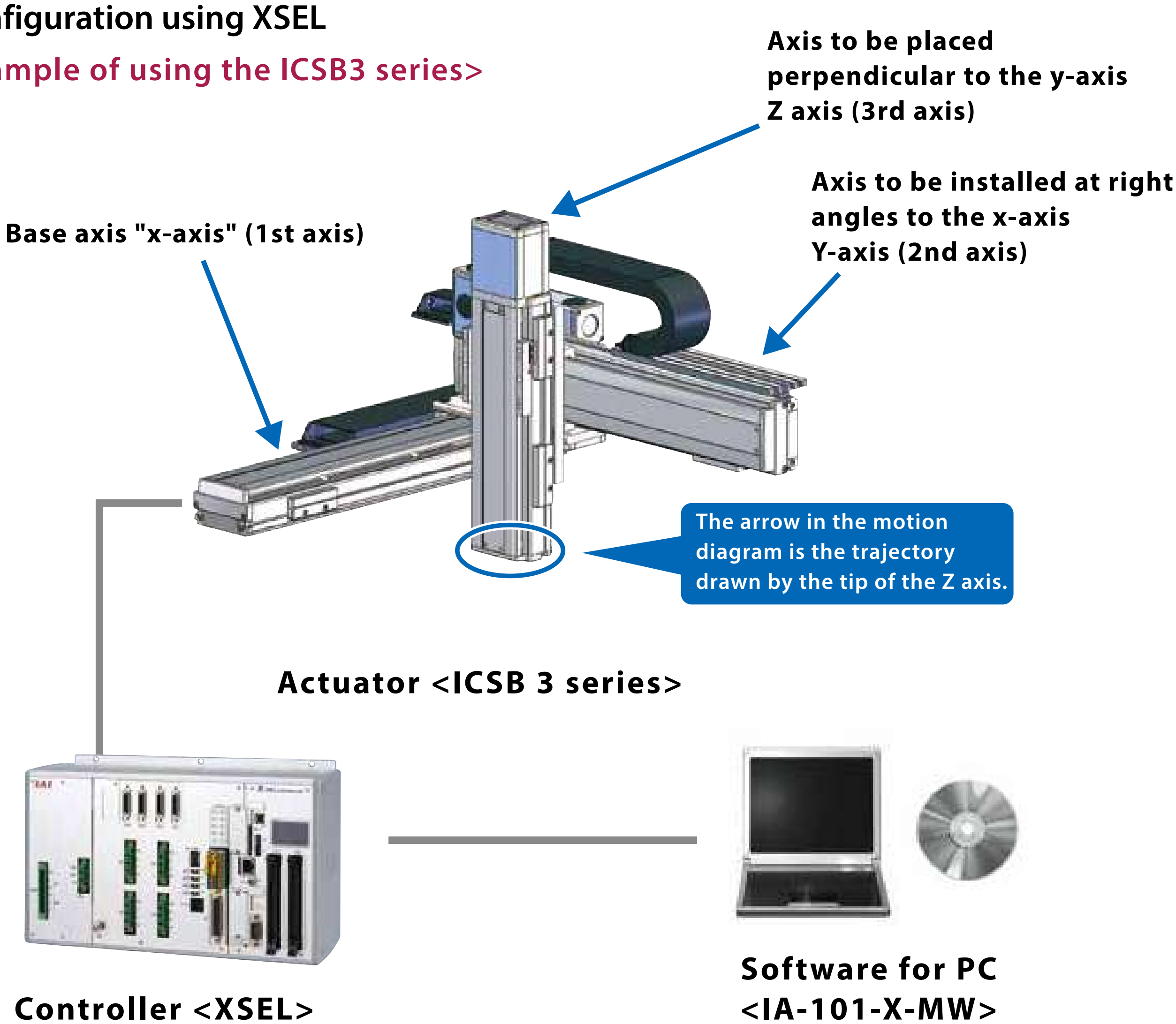


Note 360 ° (1 T) is electrical angle and not mechanical angle.

Introduction to SEL Language

Configuration using XSEL

<Example of using the ICSB3 series>



* SEL language is used in XSEL controller, PSEL controller, ASEL controller, SSEL controller, table top robot TTA series.

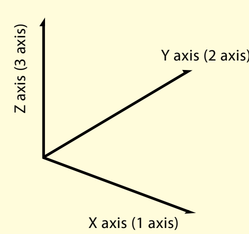
The above actuator combines three linear actuators.

❶ The three actuators are expressed as "1 axis, 2 axis, 3 axis", respectively.

❷ This actuator is called "3 axis orthogonal robot" which uses 3 axes in combination orthogonally.

❸ Each axis is classified into X axis, Y axis, Z axis from its installation status.

- Base axis → <X axis>
- Axis installed at right angles to the X axis → <Y axis>
- Axis installed perpendicular to the Y axis → <Z axis>

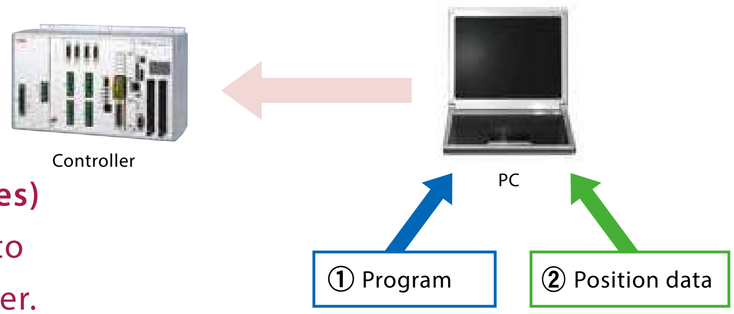


❹ In program data and position data, it is expressed as follows.

- X axis (first axis) = Axis 1
- Y axis (second axis) = Axis 2
- Z axis (third axis) = Axis 3

■ What is necessary for robot operation

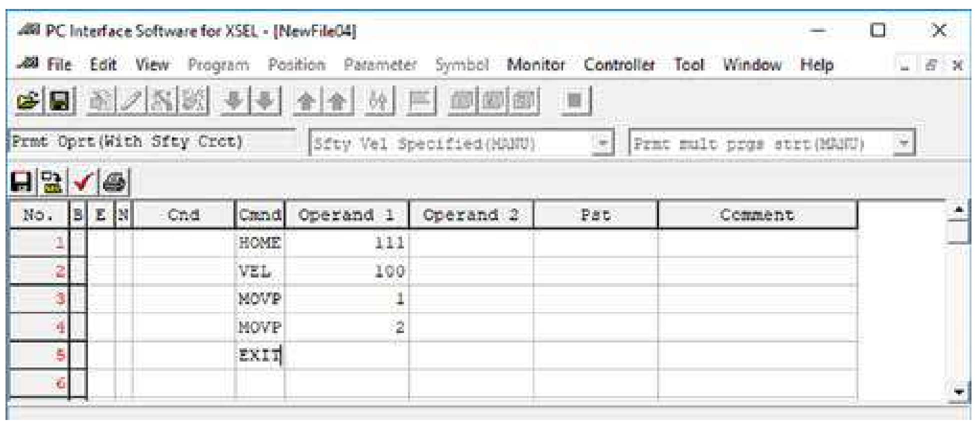
In order to operate the robot,
① **Program**
② **Position data**
(The position where the robot moves)
It is necessary to enter these two data to the controller using a personal computer.



① Program

Enter "SEL language" (our company's original language) which instructs the contents and order of action in the program data sheet in PC software.

* The program actually entered is displayed as follows.

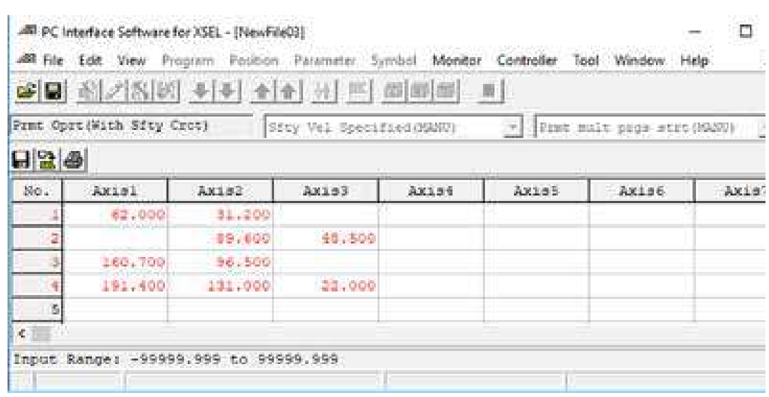


Software for PC IA-101-X-MW Program Input screen

② Position data (position where the robot moves)

The position to move the actuator is indicated by coordinates and entered in the position data sheet in the personal computer software.

* The position data actually entered is displayed as follows.
Data not transferred to the controller will be displayed in red and will be black after transfer.



Software for PC IA-101-X-MW Position Input screen

Introduction to SEL Language

■ Basics of program

Basics of program creation

① Use the instruction word "Super SEL language" (hereinafter "SEL language") to instruct the operation.
② "SEL language" basically executes instructions one by one in order from the top.
③ Enter the command word in the [Cmnd] field of the program data sheet.
 * [Cmnd] stands for Command.
④ In the [Operand 1] [Operand 2] field, enter various numerical values following the command word on the same line. Numeric values are various types, such as position number, axis number, axis pattern, speed, number of seconds.
 * [Operand] is a computer term and is "numerical value and variable to be calculated". In SEL language, Operand 1 is called "operation 1" and perand 2 is called "operation 2".
⑤ The basic program configurations are "move to reference point", "speed specification", "operation designation", and "end declaration".

- Move to reference point ... Return to origin and use the command word "HOME".
- Speed specification ... Specify the moving speed with the command word "VEL (abbreviation for speed translation English)".
  It will not work unless speed is specified. The maximum speed depends on the actuator used.
- Operation specification ... Set various actions.
- End declaration ... Ends the operation. At the end of the program, enter the instruction word "EXIT".
  If this is not entered, repeat the program.

<Example of program>

The following program shows
The X, Y and Z axes return to the reference point of motion and then move from the reference point to position No. 1 at a speed of 100 mm / s. After that, it moves to No. 2 and end the operation.

No.	B	E	N	Cnd	Cmnd	Operand 1	Operand 2	Pst	Comment
1					HOME	111			
2					VEL	100			
3					MOVL	1			
4					MOVL	2			
5					EXIT				
6									

Step No. Column for command Column for comment

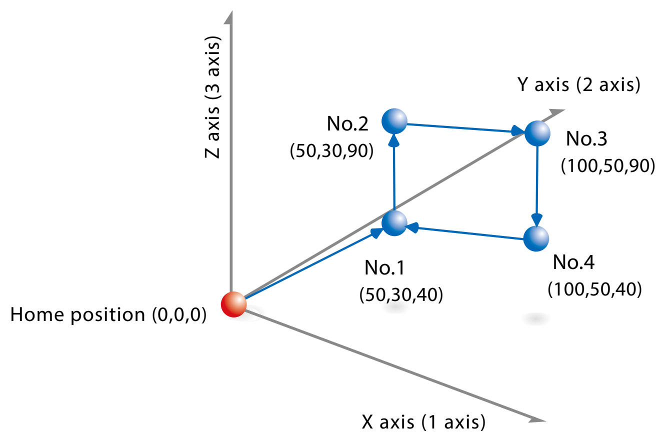
■ Basics of position data

Basics of creating position data

① In the position data sheet, enter the "coordinates" of the position to move.
② Axis is the axis, Axis 1 = first axis, Axis 2 = second axis, Axis 3 = third axis respectively.
In ICSB 3, Axis 1 = X axis, Axis 2 = Y axis, Axis 3 = Z axis.
③ Even if position data is entered, it will not operate unless a move is instructed by the program.
④ Since the order of moving is set by the program, the order of the position numbers is not related to the moving order.

<Example of Position Data>

Move from No. 1 to No. 4 by setting the target position to 4 points.



The four three-dimensional coordinates (distance from the origin) are set from position No. 1 to No. 4.

* The unit is mm.

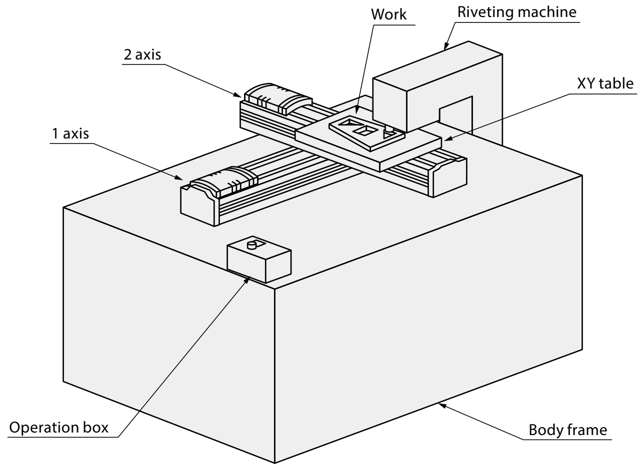
No.	Axis1	Axis2	Axis3
1	50.000	30.000	40.000
2	50.000	30.000	90.000
3	100.000	50.000	90.000
4	100.000	50.000	40.000
5			
6			

Position No.

Sample Program 1: Rivet Stopping Device

Device outline

This device consists of X Y table and riveting machine by 1 axis / 2 axis actuator. This is a rivet stop device that sets a work on the X Y table at the work home position and makes the rivet stop to the specified three points on the work by turning on the start switch.



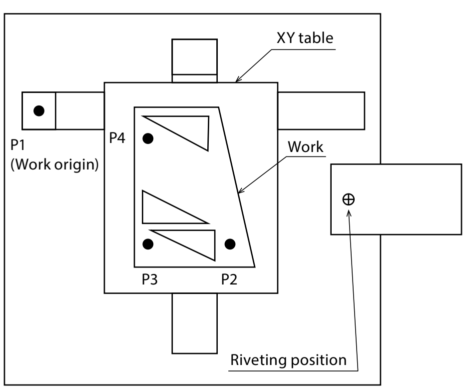
Operation explanation

Describe the operation of this device.

① The XY table moves to the work origin (P1) and waits.
② The operator sets the work on the XY table and turns on the start SW.
③ In the XY table, riveting position No.1 (P2) of the work moves to riveting position and riveting command is outputted to the riveting machine.
④ Riveting operation is completed, the rivet position No. 2 (P3), No. 3 (P4) is moved to the riveting position in the same operation after the completion signal is entered.
⑤ After returning to riveting on all 3 points, return to the work origin (P1).

Operation position, input / output allocation of external input / output, and operation flowchart are shown below.

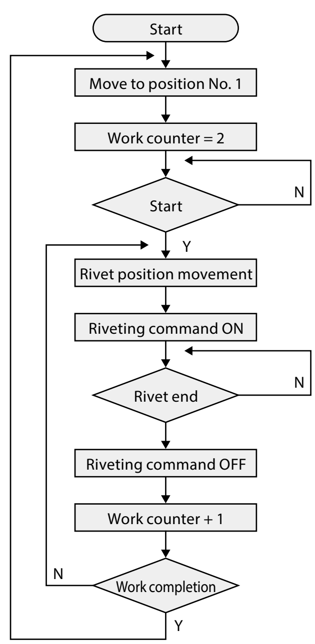
Operating position



I / O allocation

Classification		I / O No.	Signal name	Specification
XSEL	Enter	16	Start command	Pushbutton SW
		17	Riveting complete	Contact signal
	Output	309	Rivet Command	24v DC
	* Flag used more than 600			

Operation flowchart



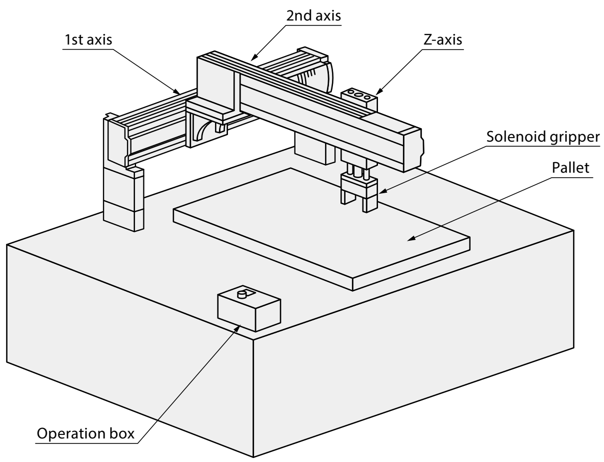
Application Program

Step	Extended condition	Input condition	Cnd	Command	Operation 1	Operation 2	Output condition	Comment
1				HOME	11			XY table home return (servo ON)
2				VEL	400			Speed 400 mm / s setting
3				TAG	1			
4				MOVL	1			Move to position No. 1 (work origin)
5				LET	1	2		Set 2 to work counter
6				BTOF	600			Clear completion flag
7				WTON	16			Waiting for start command
8				TAG	2			
9				MOVL	*1			Work counter position movement
10				BTON	309			Riveting command ON
11				WTON	17			Waiting for riveting completion
12				BTOF	309			Riveting command OFF
13				ADD	1	1		Work counter + 1
14				CPEQ	1	5	600	Flag ON when work is completed
15		N	600	GOTO	2			If it is not completed jump TAG 2
16				GOTO	1			If it is completed jump TAG 1
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								

Sample Program 2: Palletizing Device

Device outline

This device is a palletizing device that consists of 1st, 2nd and Z-axis actuators (controller: ACON-CYB) to grip workpieces from the part feeding point and transfer them sequentially on a pallet (using an offset instruction instead of the palletizing function).



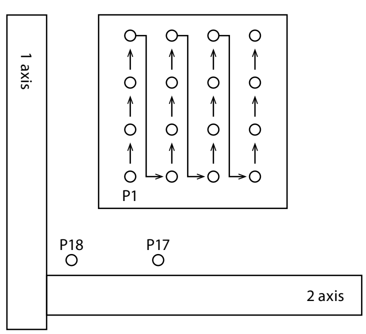
Operation explanation

Describe the operation of this device.

① Move to standby point and wait for start input.
② After starting input, move to the work supply point.
③ The Z-axis descends and the solenoid gripper grips the workpiece.
④ The Z-axis rises and moves onto the pallet.
⑤ The Z-axis descends and the solenoid gripper releases the workpiece.
⑥ The Z-axis rises and moves to the work supply point.
⑦ At the end of the pallet, the pallet completion indication is outputted, after waiting for restart after moving to P18.

Operation position, input / output allocation of external input / output, and operation flowchart are shown below.

Operating position

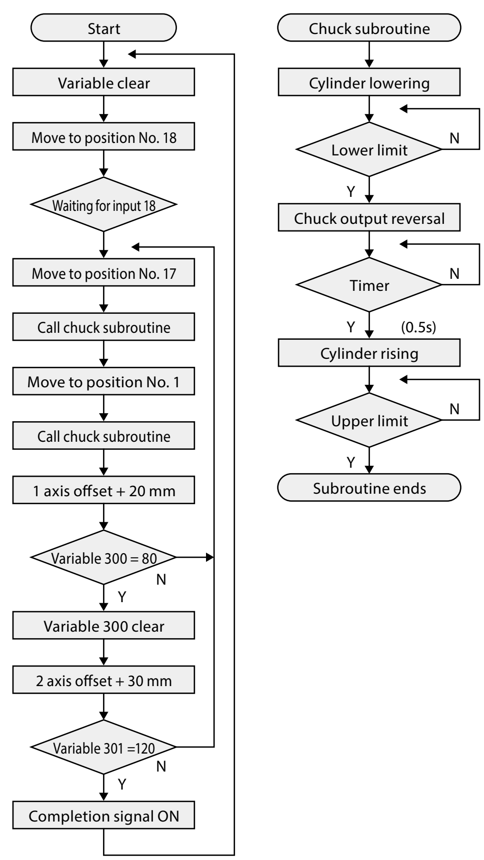


I / O allocation

Classification		I / O No.	Signal name	Specification
XSEL	Enter	16	Z-axis actuator upper limit	Controller complete signal
		17	Z-axis actuator lower limit	Controller complete signal
		18	Start	Pushbutton SW
	Output	309	Z axis actuator	DC24V
		310	Z axis chuck	DC24V
		311	Pallet completion	DC24V
	* Flag used more than 600			

Pallet specification 1 axis direction: 20 mm pitch 2 axial direction: 30 mm pitch

Operation flowchart



Application Program

Step	Extended condition	Input condition	Cnd	Command	Operation 1	Operation 2	Output condition	Comment
1				HOME	11			1 · 2 axes home return
2				VEL	100			2 VEL 100 speed 100 mm / s setting
3				ACC	0.2			3 ACC 0.2 Acceleration / Deceleration 0.2 G
4				TAG	1			
5				LET	300	0		Variable clear
6				LET	301	0		Variable clear
7				OFST	11	0		Offset value clear
8				MOVL	18			Move to position No. 18
9				WTON	18			Wait for start input
10				BTOF	311			Output 311 off
11				TAG	2			
12				OFST	11	0		Offset value clear
13				MOVL	17			Move to position No. 17
14				EXSR	1			Call chuck subroutine (chuck)
15				OFST	1	* 300		1 axis, value offset for variable 300
16				OFST	10	* 301		2 axis, value offset for variable 301
17				MOVL	1			Move to position No. 1 + offset value
18				EXSR	1			Call chuck subroutine (unchuck)
19				ADD	300	20		Add 20 to variable 300
20				CPEQ	300	80	600	If variable 300 = 80, flag 600 on
21		N	600	GOTO	2			If flag 600 is off, jump to TAG 2
22				LET	300	0		Variable 300 clear
23				ADD	301	30		Add 30 to variable 301
24				CPEQ	301	120	601	If variable 301 = 120, flag 601 is on
25		N	601	GOTO	2			If flag 601 is off, jump to TAG 2
26				BTON	311			Output 311 ON
27				GOTO	1			Jump to TAG 1
28				BGSR	1			Start of chuck subroutine
29				BTON	309			Z-axis actuator down
30				WTON	17			Wait for lower limit input
31				BTNT	310			Air chuck output reversal
32				TIMW	0.5			Timer 0.5 seconds
33				BTOF	309			Z-axis actuator up
34				WTON	16			Wait for upper limit input
35				EDSR				Chuck subroutine ends
36								
37								
38								
39								

Basic of Sequential Control

This chapter describes the basic of sequential control that controls actuators.

Contents

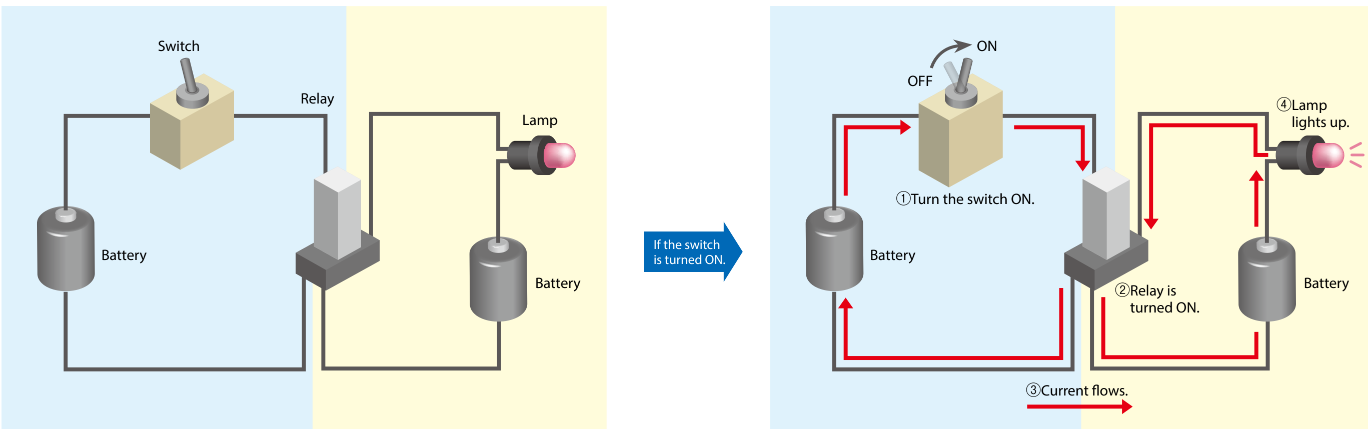
1. What is Sequential Control

The sequential control is a control according to the predetermined sequence.

A circuit using a switch to turn on and off a lamp is also a sequential control.

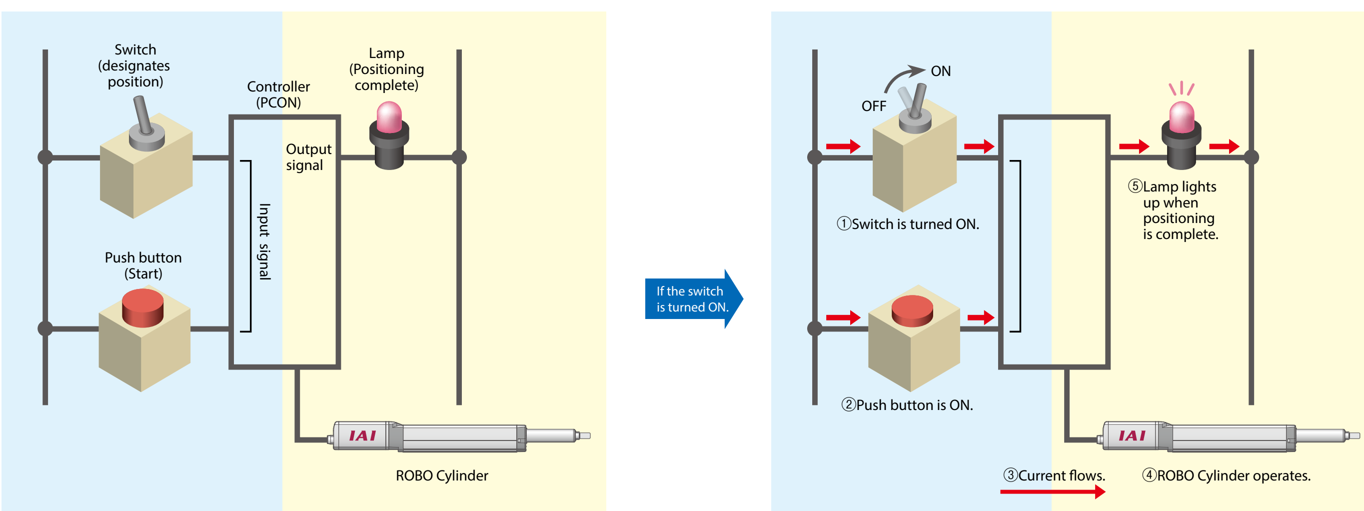
An example of control to turn on a lamp

(Wiring example)



Example of control for ROBO Cylinder

(Wiring example) If the switch is turned on and the push button is pressed, a positioning operation is performed to the designated position.



Basic of Sequential Control

2. A sequential control and PLC **A sequential control is performed mainly by PLC.**

Machinery is controlled by sequential control so that it can be operated according to the intended use.

A sequential control mainly uses a PLC that combines switches and sensor signals to turn on lamps, turn on/off solenoid valves and drive motors.

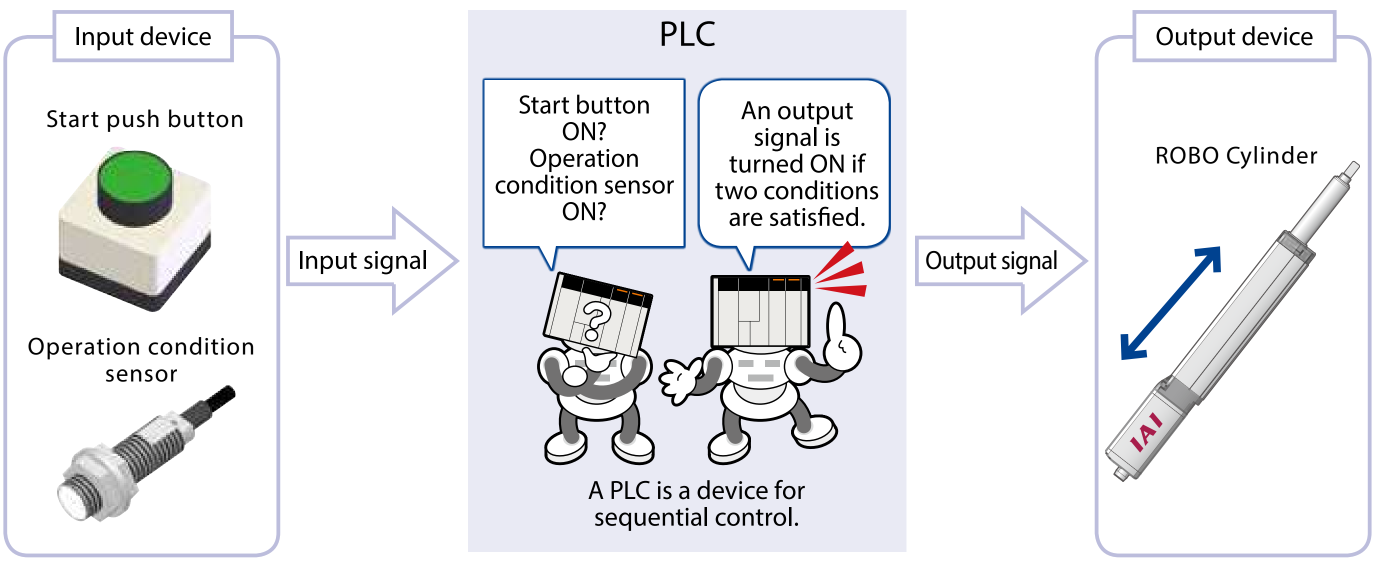
Method of sequential control by PLC

A sequential control is performed by the following three elements:

1 Input signal: Input signals entered into a control circuit, which are ON/OFF signals from input devices such as various switches attached to the control panel and sensors mounted on machinery. The output signals of a ROBO Cylinder controller are also input signals to a control circuit.

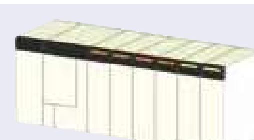
2 Control circuit: A control circuit to operate machinery.
In order to operate machinery using a PLC, operating conditions of the machine and a circuit to perform sequential operations (sequential control circuit) are stored in the memory.
The sequential control circuit turns output signals ON/OFF to perform predetermined operations according the input signals of push buttons and sensors.
It also monitors abnormal and safety states of the machine.

3 Output signal: Signals to turn ON/OFF by control signal, which turn ON/OFF of the output devices, such as motors to drive machinery and solenoid valves.
The ROBO Cylinder is also operated and controlled by these output signals.



PLC is an abbreviation of Programmable Logic Controller, which is generally called a sequencer(Note).

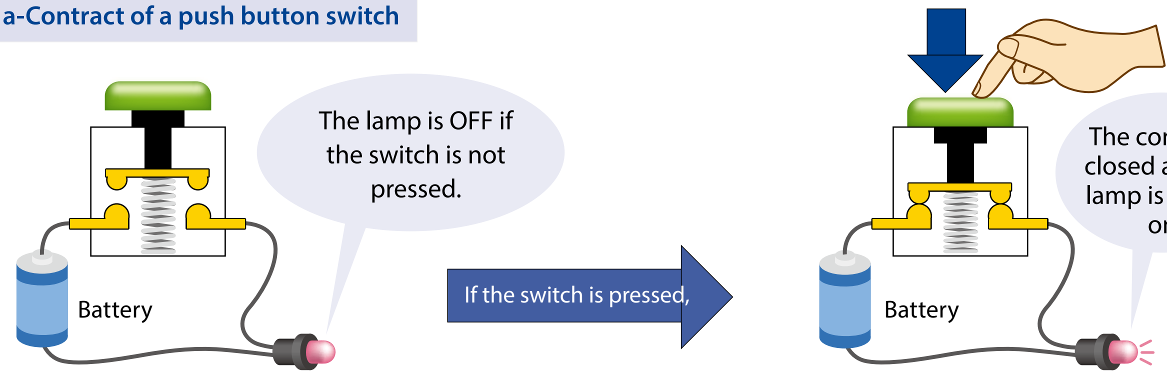
(Note) Sequencer is a trade name of Mitsubishi Electric Corporation.



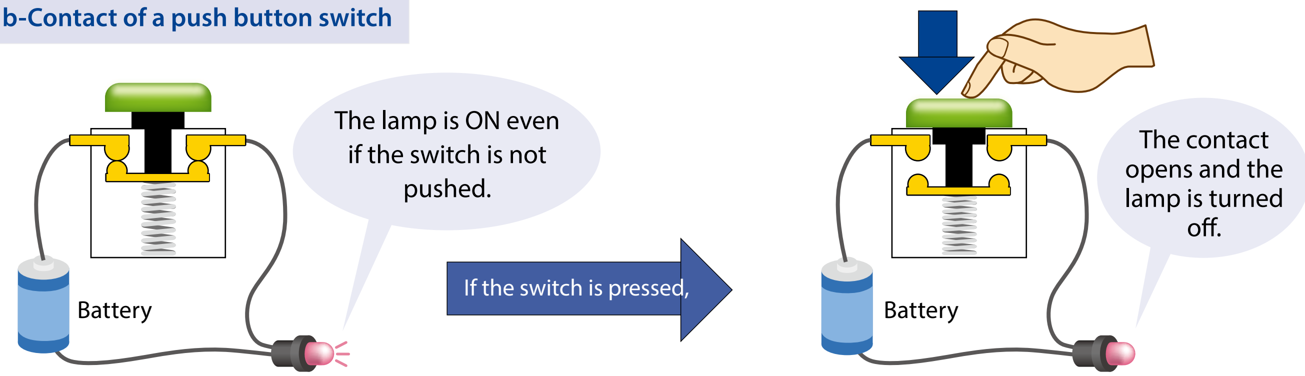
3. a-contact and b-contract

There are two kinds of contacts in switches: The a-contract is "Open" if it is not operated and "Close" if it is operated. Conversely, the b-contact is "Close" if it is not operated and "Open" if it is operated.

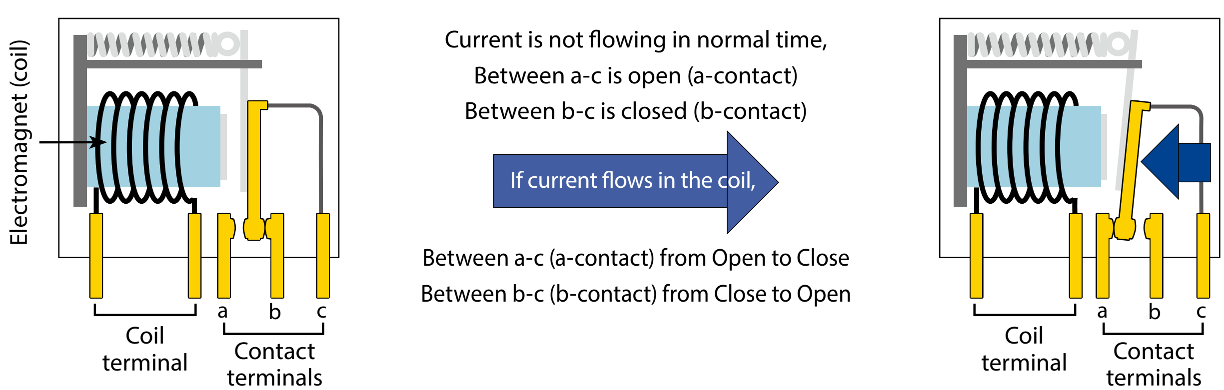
a-Contract of a push button switch



b-Contact of a push button switch



a-Contact and b-Contact of a relay



(Note) C is a common terminal.

As shown in the diagram above, the contact that has both the a-Contact and b-Contact is called a c-Contact.

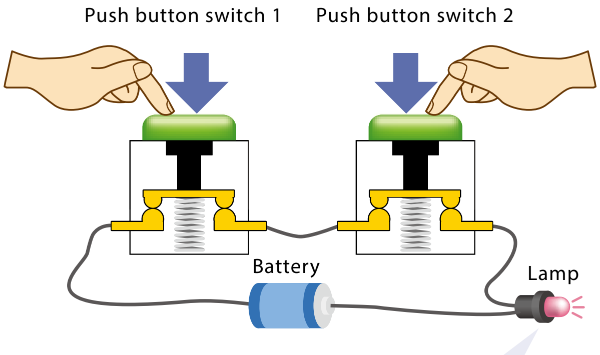
Basic of Sequential Control

4. AND and OR circuits

AND circuit

In a sequential control, the circuit that turns on in its output if more than two contacts connected in parallel are ON, is called an "AND circuit". The illustration below is an example of an "AND circuit" that turns on a lamp if two push buttons are pressed.

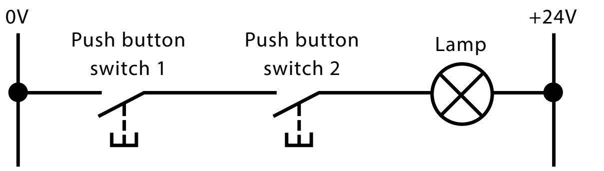
1 Wiring example



If either switch is not pressed, the lamp is turned OFF.
If both switches are pressed, the lamp is turned ON.

2 Circuit diagram

A typical control circuit using DC 24 V power supply(Note) of actual machinery is shown in a circuit diagram below. This circuit diagram is called an elementary wiring diagram.
Symbols are specified by JIS C 0617.

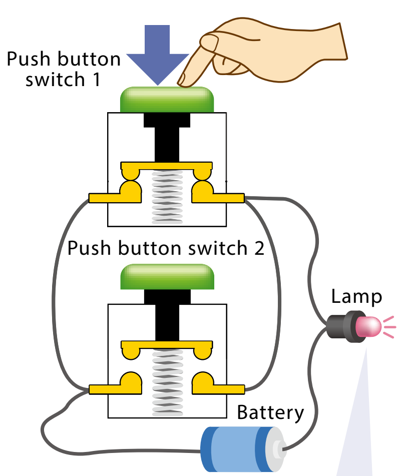


(Note) The power supply circuit is not shown here.

OR circuit

The circuit that turns on in its output if out of two or more contacts connected in parallel, either one or more contacts are turned ON, is called an "OR circuit".

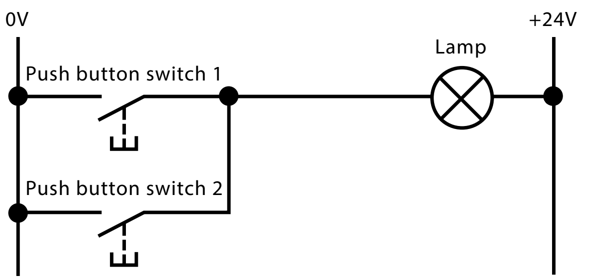
1 Wiring example



The lamp is turned OFF if either switch is not pressed.
It is turned ON if either switch is pressed.

2 Wiring diagram

The diagram below shows a DC 24 V power supply(Note).

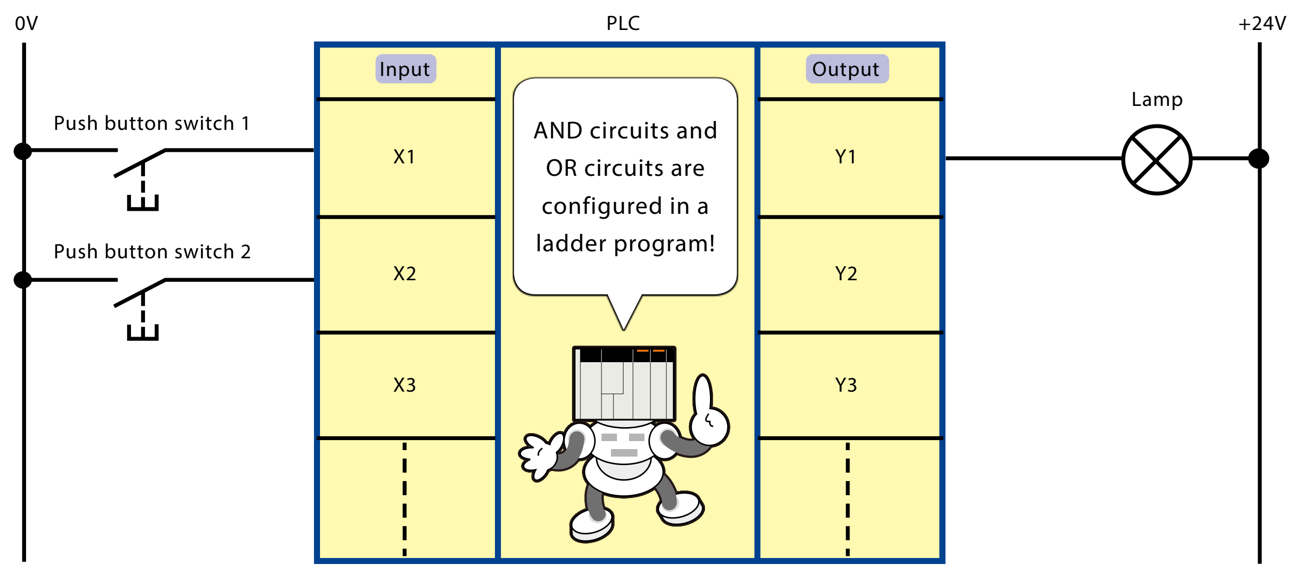


(Note) The power supply circuit is not shown here.

"AND circuit" and "OR circuit" using a PLC

When using a PLC, push buttons switches are connected to the input terminal, and a lamp is connected to the output terminal of the PLC. Since an "AND circuit" and an "OR circuit" are written in the PLC as a ladder program, the wiring is same.

1 Input/Output circuit diagram of a PLC



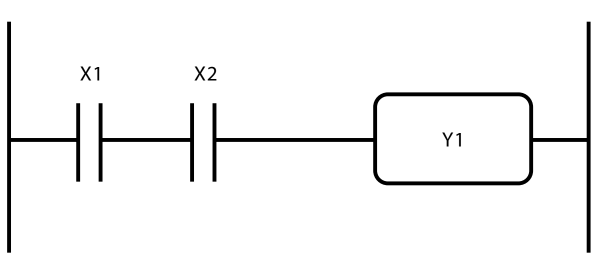
2 Ladder program

The PLC replaces circuits using relays with software.

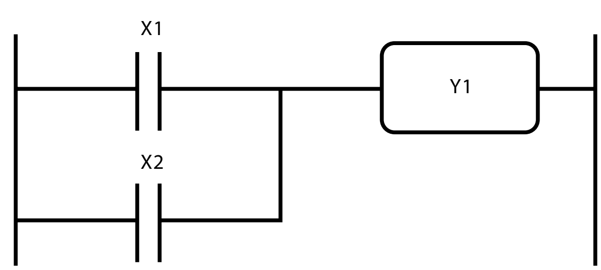
Relay circuits are configured in a program using dedicated software. It is called a ladder program.

In a ladder program, the push button switches 1 and 2 are replaced with contacts X1 and X2, and the lamp is replaced with the relay coil Y1. These X1, X2 and Y1 are called addresses.

(1) AND circuit



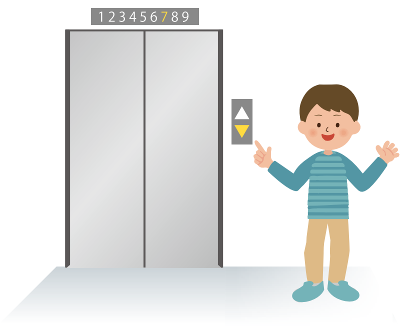
(2) OR circuit



Basic of Sequential Control

5. Self-holding circuit

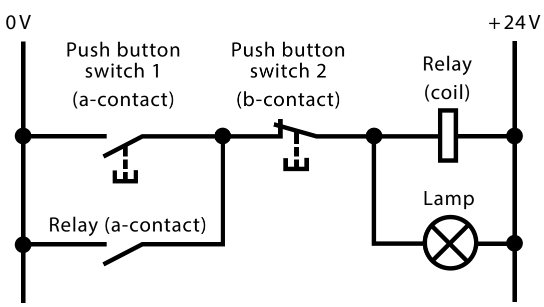
A self-holding circuit is a circuit that can retain memories.
For instance, when an elevator button is pressed, a push button lamp will light up.
Even if the switch button is released, the lamp continues to light up until the elevator arrives.
This is because until the elevator arrives, the push button holds the memory that the button was pressed.
A circuit like this is called a self-holding circuit.



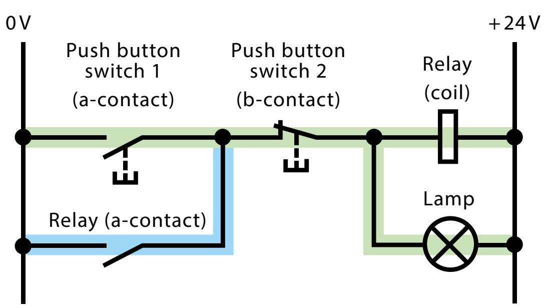
Current flow in the self-holding circuit that uses relays

Let's configure a circuit such that when pressing the push button switch 1 , the lamp is turned on and remains to light up until the push button 2 is pressed. Then try to see the current flow and the changes in the circuit.

1 Status before operation



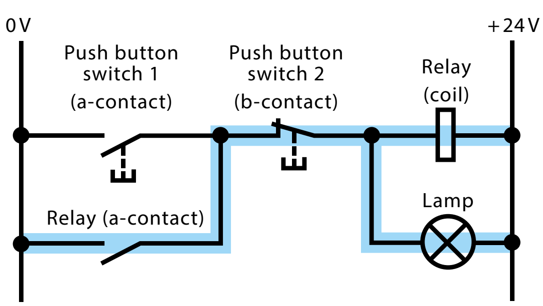
2 Current flow when the push button switch 1 is pressed



Current flows on the green circuit, the relay is closed, and the lamp is turned on.

When the relay is on, the contact is closed, and current also flows on the blue circuit.

3 Current flow when the push button switch 1 is released

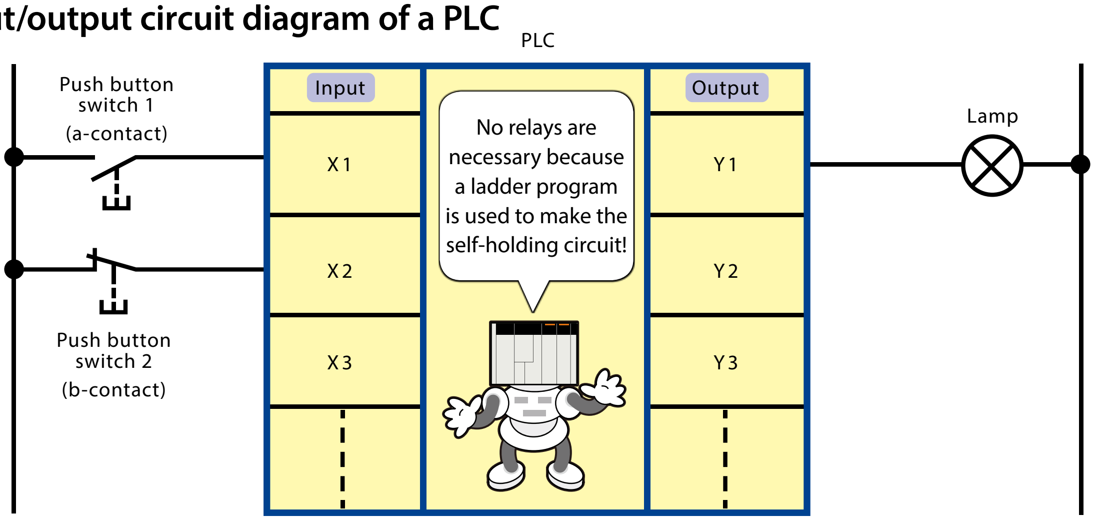


Even if the push button switch 1 is released, the current continues to flow through the blue circuit, the relay keeps ON, and the lamp also remains to light up.
This state is said that **the circuit is self-holding**.
When the push button switch 2 is pressed, the circuit is cut off and the self-holding circuit is released.

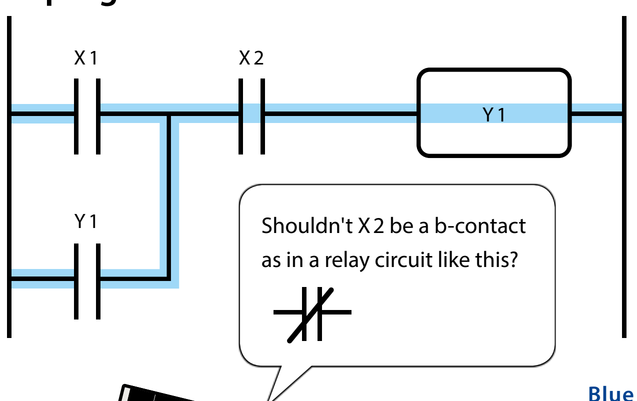
Self-holing circuit using a PLC

Let's consider a circuit using a PLC.

1 Input/output circuit diagram of a PLC



2 Ladder program



Blue letters represent processing by the ladder program.

The PLC controls ON/OFF of output signals by using a ladder program and combining input signals, doesn't it? (Refer to 2. Sequential Control and PLC.)

The push button switch 2 is connected to the input X2 of the PLC with a b-contact and current is always flowing, making the input signal X2 turned ON.
Therefore, X2 is always closed although it is an a-contact in the ladder program.

Conversely, although the push button switch is connected to the input X1 of the PLC with an a-contract, the a-contact of X1 is always open in the ladder program, because current is not flowing in a normal condition, which is an OFF state.

In this state, if the push button switch 1 is pressed, current flows in the input signal X1, the signal is turned ON, the contact X1 is closed in the ladder program, and all the blue lines are connected, enabling Y1 to self-hold.

If Y1 is turned ON, current flows in the lamp through output Y1 of PLC and makes the lamp turned on.

The contact X2 is turned off X2 only if the push button switch 2 is pressed, and opens contact X2 to function to release self-holding.

Basic of Sequential Control

6. Timer circuit

A timer circuit is used to change the ON/OFF timing of various signals in a sequential control.

To perform such controls, a timer is necessary.

A timer is a relay(Note 1) with a contact that activates after a predetermined time has elapsed.

A timer is not composed of electromagnets and relays, but is made of an electronic circuit that measures time.

(Note 1) Refer to the "3. a-contact and b-contact" (on P1-384) for the details of relay.

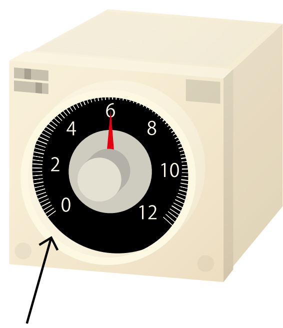
The self-timer of a camera releases the shutter after a certain time has elapsed subsequent to pressing the shutter button.
Such a timer delays activation and is called an "on-delay* timer".

An "on-delay" timer activates a relay after a specified time has elapsed subsequent to turning an input signal (power for timer) ON.

The "on-delay" is the most typical function of a timer, and is most frequently used in automation machinery.

*On-delay operation: A technical term that describes the operating function of a timer.
If the input signal (power of a timer) is turned ON, it starts counting time. After reaching at a specified counting value, it activates the relay.
If the input signal is turned OFF, the time counter is reset immediately, and the relay resumes the original state.

Timer



A lamp circuit using a timer

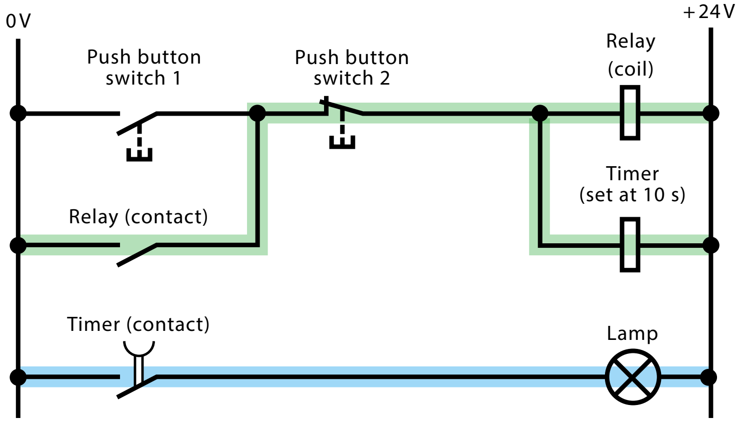
Let's configure a circuit such that the lamp is turned on 10 seconds after the push button switch 1 is pressed, and turned off when the push button switch 2 is pressed.
This circuit is configured in combination of a self-holding circuit(Note 2) and a timer.

If the push button switch 1 is pressed, the circuit self-holds by the green circuit.
Simultaneously the current flows to the timer, which starts counting.

When the count reaches the specified time, the timer's contact is closed, the current flows in the blue circuit and the lamp is turned on.

If the push button 2 is pressed, the self-hold is released, the timer is reset simultaneously, the contact is opened, and the lamp is turned off.

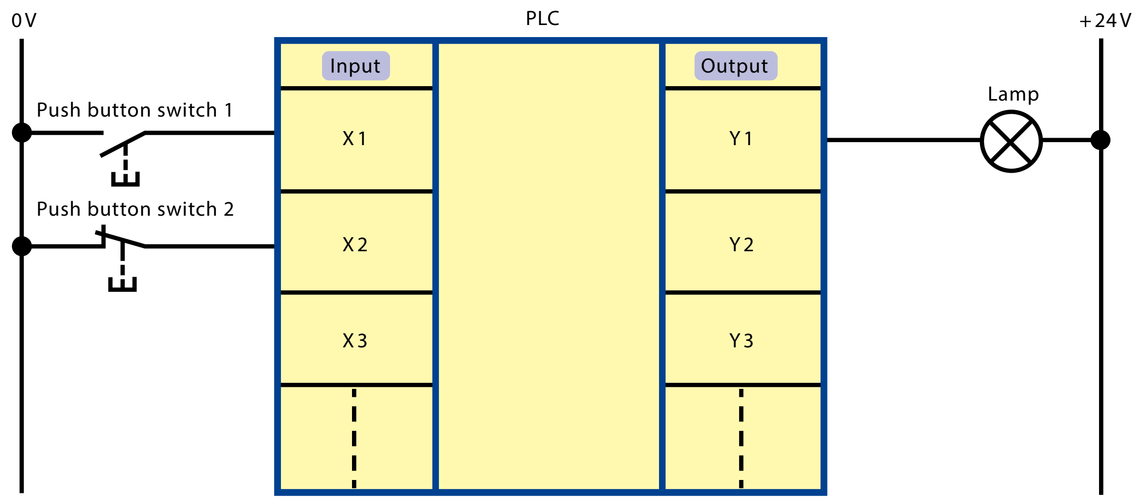
(Note 2) Refer to the "5. Self-Holding Circuit" on P1-387 for details.



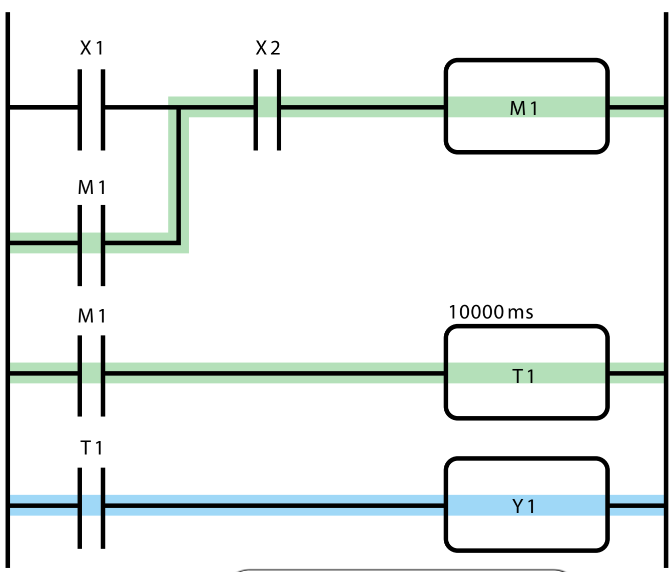
Timer circuit using a PLC

Let's configure a circuit of the preceding page by using a PLC.
The PLC has an on-delay timer as a ladder program function.

1 Input/output circuit of a PLC



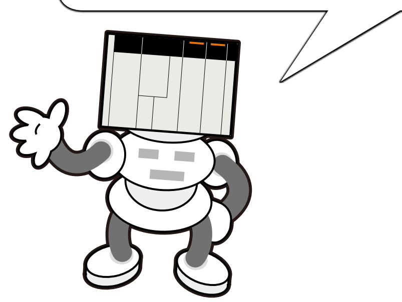
2 Ladder program

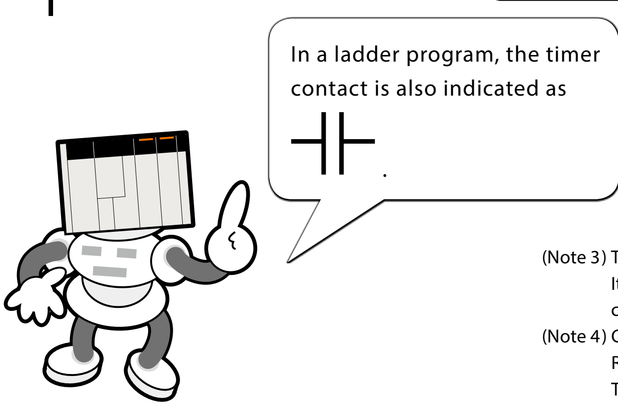


If the push button 1 is pressed, the input X 1 is turned on, the internal relay M 1 (Note 3) self-holds in the green circuit.
If the contact M 1 is closed, the timer T 1 activates and starts counting.

The "10000 ms (Note 4)" shown above T 1 is the specified value of the timer.
When the specified value of 10 seconds (10000 ms) has elapsed, the timer contact T 1 is closed, the output Y 1 is turned ON by the blue circuit, and the lamp is turned on.

The lamp is turned off if the self-holding of M 1 is released by the push button switch 2 and the timer is reset.





(Note 3) The Internal relay M1 is equivalent to an auxiliary relay of a sequential circuit using relays. It is not used to directly turn output signals ON/OFF, but used to configuring an auxiliary circuit within a PLC such as this circuit.
(Note 4) Commercially available PLC timers have minimum setting units of 10 ms and 100 ms. Refer to manufacturer's manual for the timer setting of the PLC. The diagrams and the minimum setting unit are those for the built-in PLC of IAI controllers.

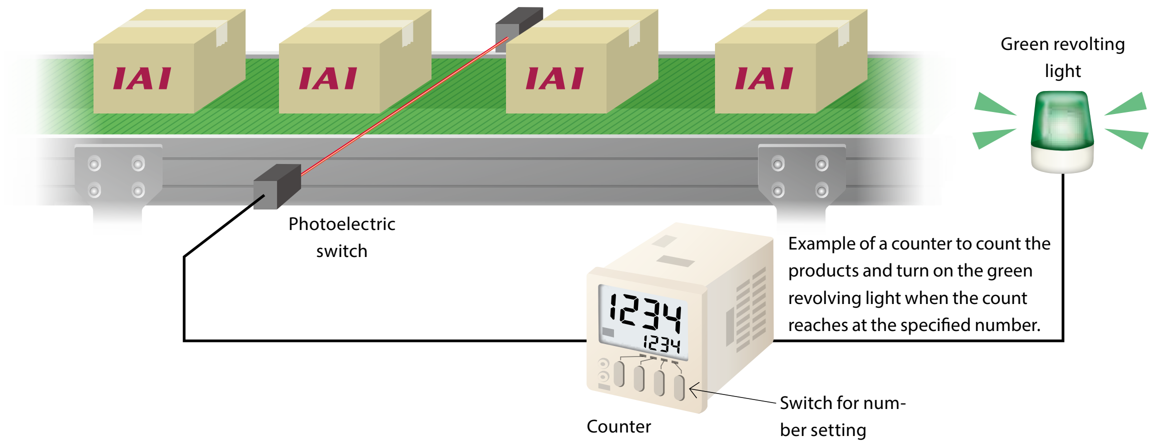
Basic of Sequential Control

7. Counter circuit

A counter circuit(Note 1) is used in a sequential circuit when counting is needed. For instance, it is used to count the number of products passed through or processed.

A counter outputs a signal when the counting reaches at a specified value.

Note 1: Some counters can perform not only addition, but also subtraction or both. Refer to counter manufacturer's catalog for details.



Circuit using a counter to turn on a lamp

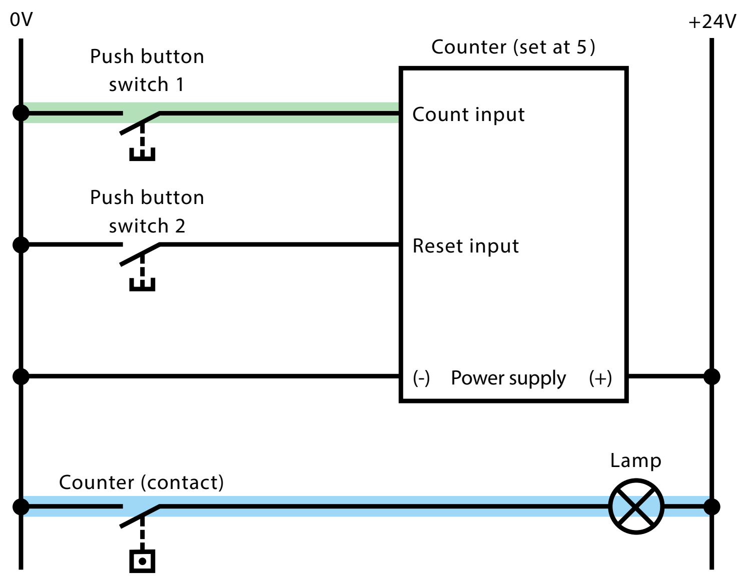
Let's configure a circuit such that the lamp is turned on if the push button switch 1 is pressed 5 times, and if the push button switch 2 is pressed, the counter is reset and lamp is turned off.

If the push button switch 1 is pressed, a count signal is entered through the green circuit.

The counter counts every time the input signal is turned on.

If the counting number reaches the specified number, the counter's contact is closed, the current flows on the blue circuit and the lamp is turned on.

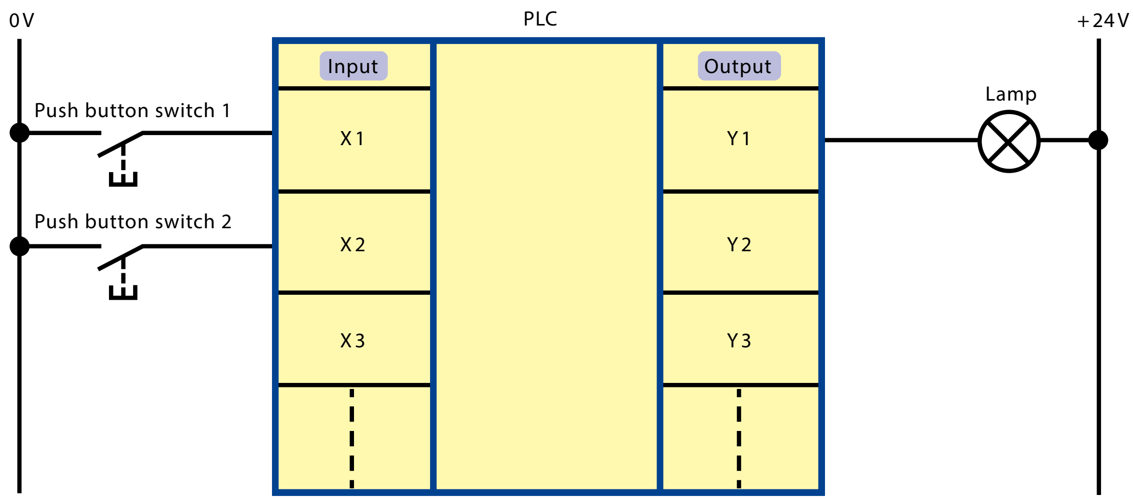
If the push button switch 2 is pressed, the counter is reset (the count value returns to 0), the contact is opened and the lamp is turned off.



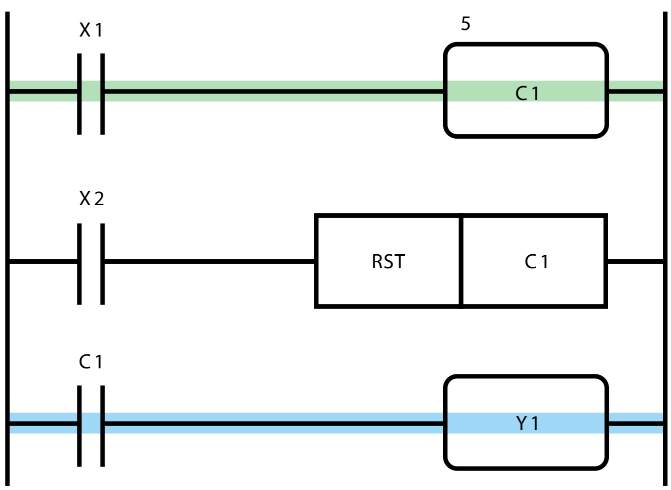
Counter circuit using a PLC

Let's configure a circuit using a counter.
The PLC has a counter as a ladder program function.

1 Input/output circuit of a PLC



2 Ladder program

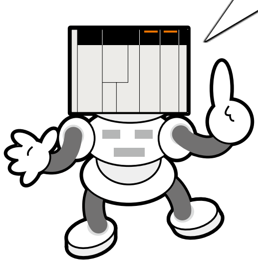


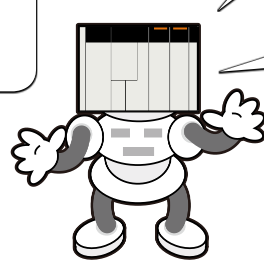
The circuit on the left is a ladder program using a counter.

The circuit in the first row is an input circuit for counting the counter C1. If the push button switch 1 is pressed, the input X1 is turned ON and the count signal is entered from the green circuit.
Counting is performed when the input signal is turned ON.(Note 2)
The number "5" on the upper left of C1 is the specified count number. If the number reaches the specified number, the counter closes the contact C1.

The circuit in the third row is a circuit using a counter output signal. If the counter contact C1 is closed, the output Y1 is turned ON and the lamp is turned on by the blue circuit.

In a ladder program, a counter relay is also indicated as ⊣⊢.





The second row shows a reset circuit for the counter.
To turn off the lamp, press the push button switch 2, reset the counter (count value returns to 0), open the contact C1 will turn off the output Y1.

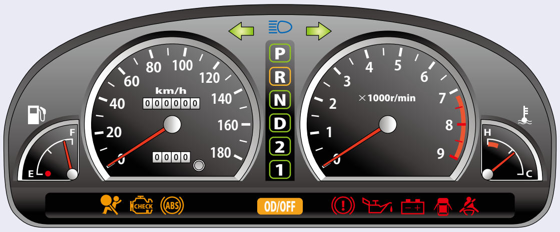
Note 2: Commercially available PLC counters could be a count-down counter.
It subtracts 1 at a time from the specified value by the count signal, and outputs a signal if the value becomes 0.
Refer to PLC manufacturer's manual for details. The above diagram shows those for the built-in PLC of the IAI controllers.

Basic of Sequential Control

8. Interlock

An interlock is an electronic circuit that makes an operation disabled unless certain conditions are satisfied.
In a sequential control, various interlocks are built in the circuit so that safe and correct operations are performed.
For instance,

①Operations are disabled if an incorrect manipulation is made.
②It determines the priority of the two operations that cannot be performed simultaneously.
③It determines the process to stop the operation in case of an emergency and the procedure to resume.

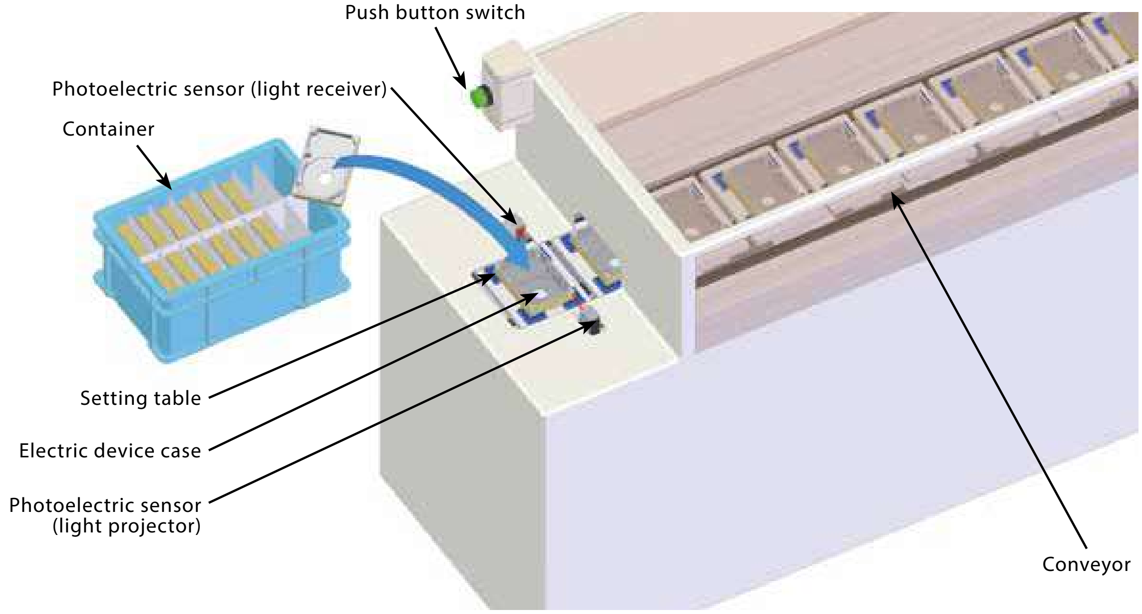


Unless the automobile gear is in the P (parking), the engine will not start or stop. This is also thanks to an interlock.

An interlock for loading electronic device cases (Example)

This is an example of loading electronic device cases.
An operator places an electronic device case on a setting table on the conveyor and pushes a push button switch. Then the conveyor moves to transfer one case at a time.

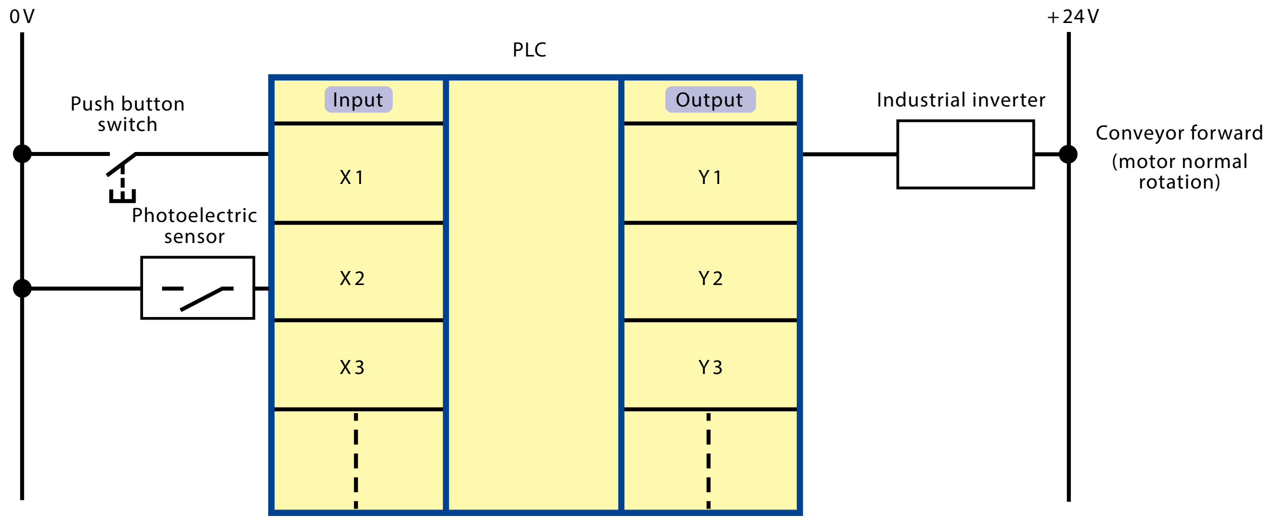
A photoelectric sensor[*1] detects when the electronic device case is placed on the setting table.
If the case is not placed, the conveyor cannot be operated even when the push button switch is pressed thanks to the interlock.
The conveyor, which is driven by an AC motor using an industrial inverter[*2], will stop 0.5 seconds after the case has passed and the photoelectric sensor[(Note 1)] is turned OFF.
(Note 1) This type of the photoelectric sensor turns ON its output signal if the case is placed and blocks the light.



*1 Photoelectric sensor: It consists of a light receiver and a light projector to detect objects by light transmission and reflection. Refer to manufacturer's catalog for detail specifications.
*2 Industrial inverter: An AC motor (3-phase induction motor) can change its speed by changing frequency. An industrial inverter is a power supply unit that changes frequency to change the rotational speed freely.
Refer to manufacturer's catalog for detail specifications and applicable motors.

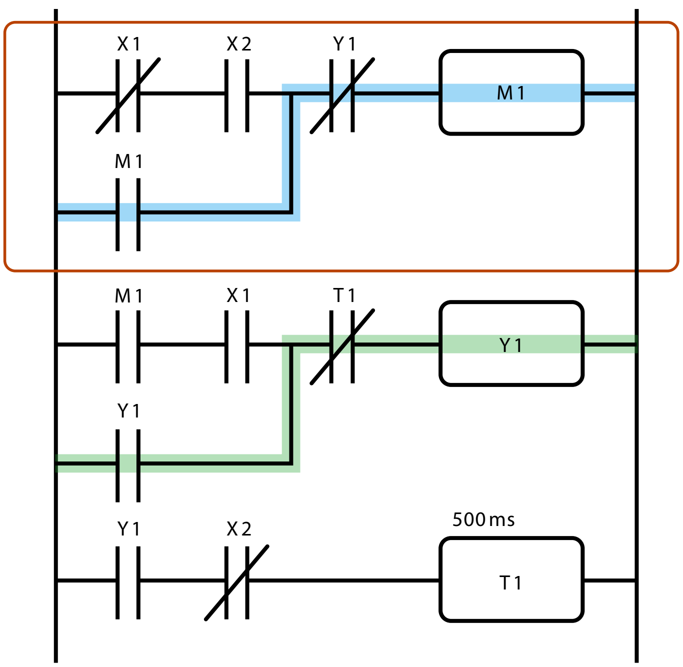
Example of sequential circuit for the loading electronic device cases

1 Input/Output circuit diagram of a PLC



Circuits other than input/output signals are not shown here because of a loading sequence.

2 Ladder program



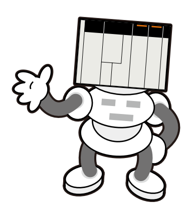
If the push button switches are not pressed and an electric device case is placed, the input X1 is OFF, the X2 is ON by the photoelectric sensor, and the internal relay M1 will self-hold through the blue circuit.

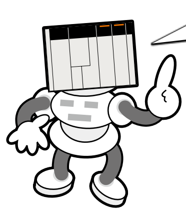
While the internal relay M1 is turned on, if the push button switch is pressed, the input X1 is turned ON, the output Y1 will self-hold through the green circuit, and the conveyor starts moving forward.

This means, the electronic device case must be placed before the push button switch is pressed.

Now, the internal relay M1 releases the self-holding of contact Y1 because the operations are performed in the proper manner.

Next, as the conveyor moves forward the photoelectric sensor detects the light and waits until the input X2 is turned OFF. Then, the Timer T1 is activated and output Y1 is turned OFF after 0.5 seconds(Note 2) to stop the conveyor.





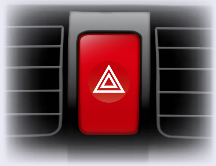
The circuit enclosed by the red square is an interlock circuit to detect that an electronic device case is placed before the push button switch is pressed.

(Note 2): Commercially available PLC timers have minimum units of 10ms and 100ms. Refer to manufacturer's manual for the timer setting of the PLC.
The diagrams and the minimum unit are those for the built-in PLC of IAI controllers.

Basic of Sequential Control

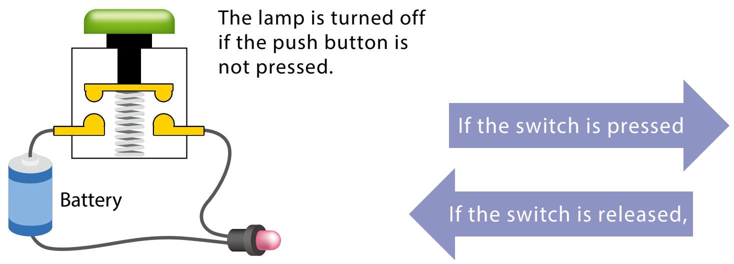
9. Alternate circuit

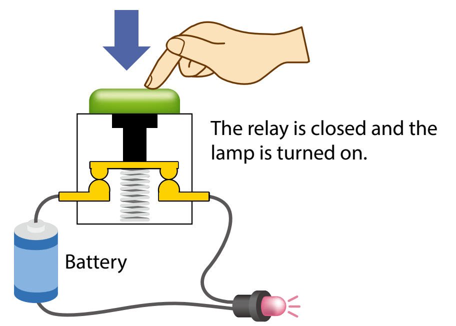
Switch operations are classified into two categories: the momentary and alternate operations.
In push button switches, a momentary operation is such that the switch is ON while the push button is being pressed, and it is OFF if the push button is released. In contrast, an alternate operation is such that even if the switch is released it remains ON until the button is pressed again. For instance, it is used for an automobile hazard lamp.
An alternate operation switch can be used only if such an operation does not cause a dangerous situation(Note 1).
It cannot generally be used to start the operation of machinery.



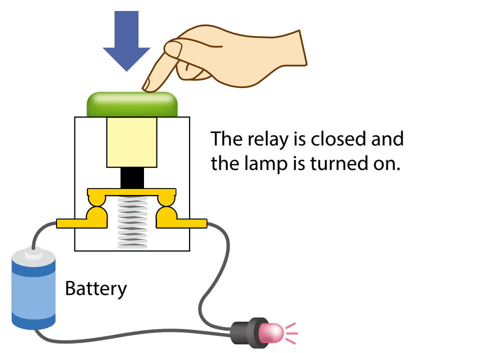
Note 1: Refer to the "JIS B9960-1 Safety of machinery-electrical equipment of machines-Part 1: General requirements".

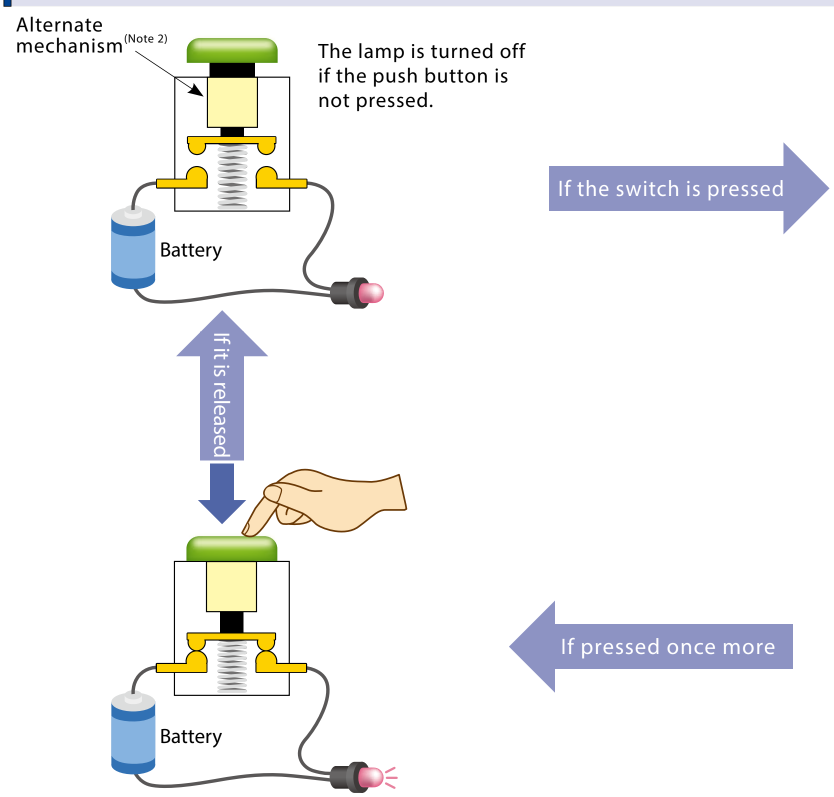
Lamp switch-on circuit using a push button with a momentary operation

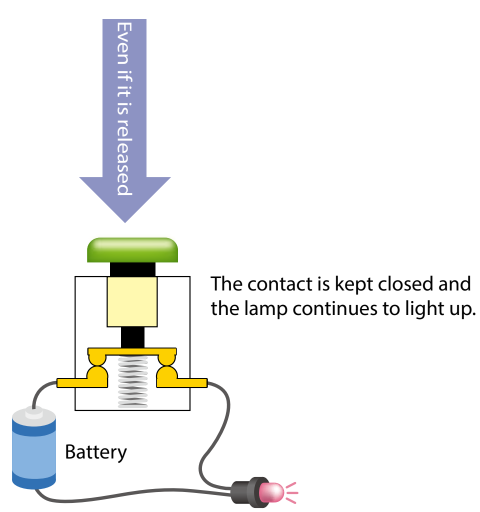




Lamp switch-on circuit using a push button with an alternate operation





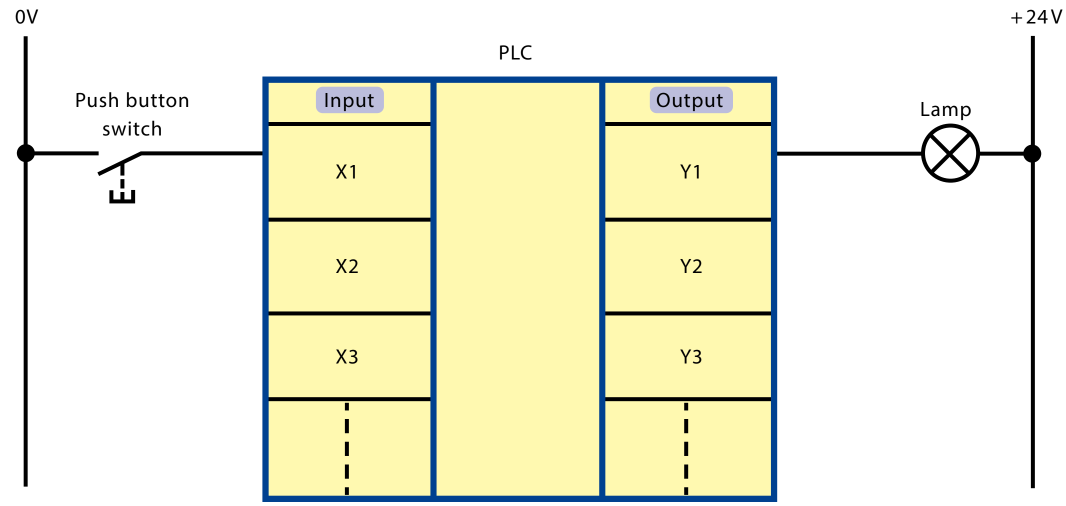


Note 2: An alternate mechanism generally employs a cam system, in which the cam rotates every time the button is pressed and the contact repeats ON and OFF alternately.

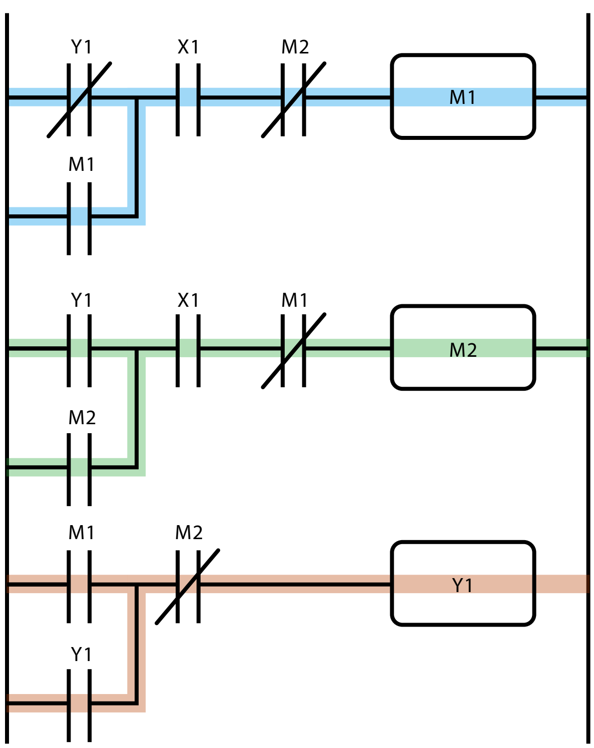
Alternate circuit using a PLC

Let's configure a lamp circuit of an alternate operation using a push button switch of a momentary operation.
This circuit can output ON/OFF using an input signal from the contact of a push button switch.
However, unless the state of a selected operation is displayed, it is not possible to see whether it is ON or OFF although the push button switch is visible.

1 Input/output of a PLC



2 Ladder program

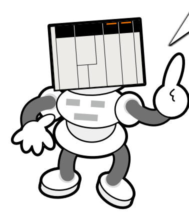


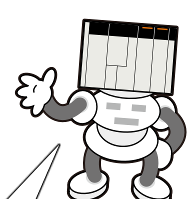
An auxiliary circuit is in blue color is such that while the output Y1 is OFF (the lamp is turned off), if the push button switch is pressed, the input X1 is turned ON and keeps self-holding as long as the button is being pressed.

Likewise, the auxiliary relay M2 in green color is such that while the output Y1 is ON (the lamp is turned on), if the push button switch is pressed, the Input X1 is ON and keeps self-holding.

The circuit is interlocked so that the auxiliary relays M1 and M2 are not turned on at the same time.

The circuit of the output Y1 in orange color that turns on the lamp performs self-holding by the auxiliary relay M1, and is released by M2.





In other words, while the output Y1 is OFF (the lamp is turned off), if the push button is pressed, then Y1 is turned ON by the auxiliary relay M1. If the push button is pressed while Y1 is ON, then Y1 is turned OFF (lamp is turned off) by the auxiliary relay M2.
This is an alternate circuit that the lamp is turned on and off by pressing a push button.

Basic of Sequential Control

10. ROBO Cylinder PIO Control (Solenoid valve mode)

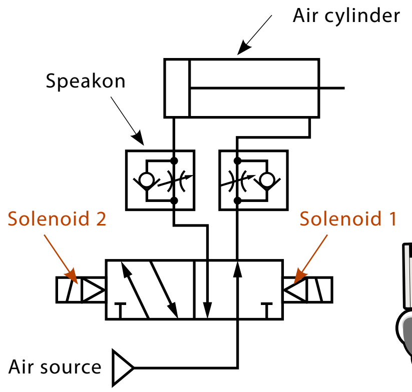
There are two methods in the ROBO Cylinder PIO control: One is such that the start signal is turned on by specifying the position No. is in binary code*1. The other, is such that the signal of the position No. is directly turned ON. The latter method using the signal of the position No. directly is called the solenoid valve mode.

An air cylinder changes the direction of motions using a solenoid valve. A solenoid valve operates an internal valve by current flow in the solenoid (electromagnetic coil) to change the air flow and the direction of the air cylinder motion.

There are various types of solenoid valves. The ROBO Cylinder in the solenoid valve mode can be operated using a ladder program equivalent to so-called the double solenoid valve*2 that has 2 positions and 5 ports and is frequently used.

*1 Binary code :	Values in binary digits. Position Nos. are entered into a ROBO Cylinder controller in binary digits. (Refer to the controller operation manual for details.)
*2 Double solenoid valve with 2 positions and 5 ports :	It is equipped with two solenoids to change the air flow direction by switching these solenoids. The internal valve does not change its state even if the current is cut off. In contrast, a single solenoid changes the air cylinder motions if current is cut off because the internal valve returns to the original position by spring. (See the pneumatic circuit diagram of an air cylinder shown below.)

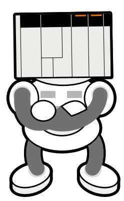
A pneumatic circuit diagram of an air cylinder using a double solenoid valve

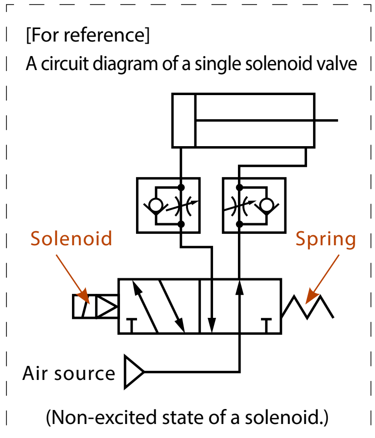


(Excited state of a solenoid.)

This diagram is called a pneumatic circuit that shows air cylinder motions of a double solenoid valve.

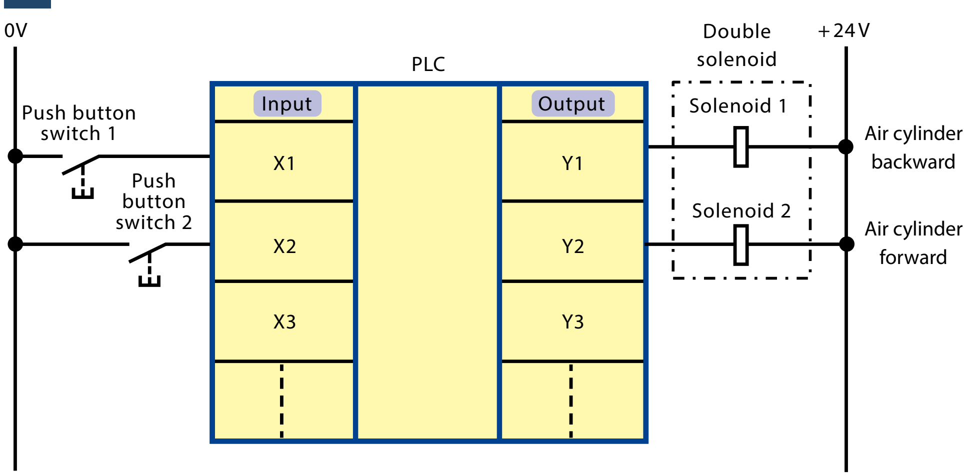
The air cylinder moves backwards if the current flows in solenoid 1, and moves forward if the current flows in the solenoid 2.





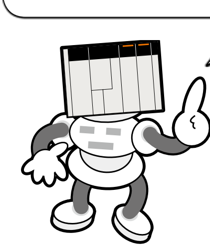
Inpupt/Output of a PLC

1 Double solenoid valve

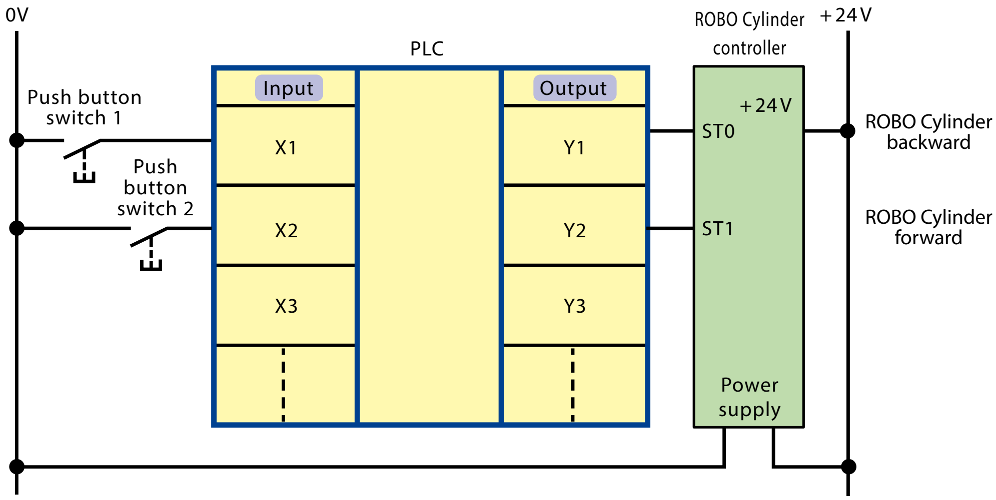


Let's compare the PIO between a double solenoid valve and a PLC connected to a ROBO Cylinder controller.

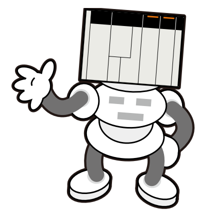
The operating condition is that the push button switch 1 is to move backwards, and push button switch 2 is to move forwards.



2 In case of a ROBO Cylinder controller

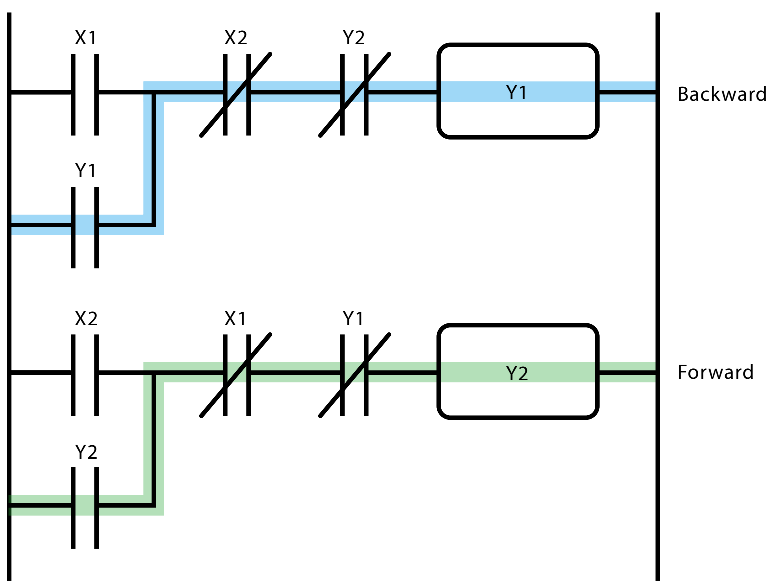


Except for the power supply to the ROBO Cylinder controller, the number of signals is same as for the double solenoid valve.(Note)

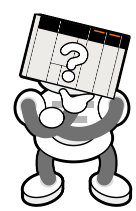


(Note) The PIO wiring of the ROBO Cylinder uses flat cables.
Refer to the "ROBO Cylinder Operation Manual" for the details of the signal assignments and the connection method of power supply.

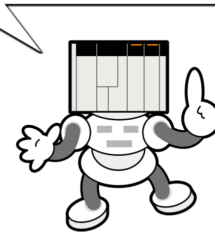
Ladder program



Oh!
There is only one ladder program. Is it common in the ROBO Cylinder and air cylinder?

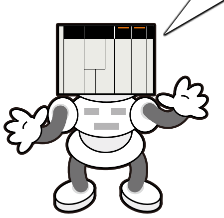


Yes, it's correct!
The ladder program is common in a ROBO Cylinder and air cylinder.
That's why there is no need to change the program when replacing an air cylinder with a ROBO Cylinder.



The circuit is common in a ROBO Cylinder and in an air cylinder. If the push button switch 1 is pressed, the input X1 is turned ON and the output Y2 is turned OFF. After that, the output Y1 will self-hold through the blue circuit and the ROBO Cylinder (air cylinder) moves backward.

Likewise, if the push button switch 2 is pressed, the input X2 is turned ON, the output Y1 is turned OFF, and after that the output Y2 will self-hold through the green circuit and the ROBO Cylinder (air cylinder) moves forward.



International System of Unit SI Excerpt from JIS Z 8203 (2000)

■International unit system (SI) and its usage

1. Scope This standard specifies how to use units in the International System of Units (SI) and international unit systems, as well as units used in conjunction with international unit systems and units that may be used together.

2. Terms and Definitions The main terms used in this standard and their definitions shall be as follows.

(1) International System of Units (SI) Consistent unit system adopted and recommended at the International Association of Measurement and Measurement. It consists of basic units, ancillary units and assembly units assembled from them and their integer multiplier of ten.
SI is an abbreviation for the international unit system.

(2) SI unit A general term for basic units, auxiliary units and assembly units in the International Unit System (SI).
- Basic unit The one shown in Table 1 is the basic unit.
- Auxiliary unit The one shown in Table 2 shall be an auxiliary unit.
- Assembled Unit The unit represented by an algebraic method (using multiplicative / divisional mathematical symbols) using the basic unit and auxiliary unit is an assembly unit. Assembly units with unique names are given in Table 4.

Table 1. Basic unit

Amount	Name of unit	Unit symbol	Definition
Length	meters	m	The meter is the length of travel that the light travels through the vacuum in the time of 299,792,458 minutes.
Mass	kilogram	kg	Kilogram is a unit of mass (neither weight nor force), which is equal to the mass of the international kilogram prototype.
Time	Seconds	s	Seconds is the duration of 9, 192, 631, 770 cycles of radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.
Current	Ampere	A	Ampere , a constant current that flows through each of the infinitely long two straight conductors that have an infinitely small circular cross-sectional area, placed parallel at a distance of 1 meter in a vacuum, and each of these conductors exert a power of 2 × 10-7 newton per meter long.
Thermodynamic temperature	Kelvin	K	Kelvin is a 273.16 of the thermodynamic temperature of the triple point of water.
Substance quantity	Mol	mol	Mol is the amount of substance in a system composed of a number of element particles or aggregates of element particles (limited to compositions whose composition is clarified) equal to the number of atoms present in 0.012 kilograms of carbon 12. Element particles are used by specifying an aggregate of element particles.
Luminous	candela	cd	Candela emits monochromatic radiation with a frequency of 540 × 10 12 Hertz and the intensity in that direction of the light source whose radiation intensity in a given direction is 683 watts per steradian.

Table 2. Auxiliary unit

Amount	Name of unit	Unit symbol	Definition
Plane angle	radian	rad	Radian is a plane angle included between two radii cutting off an arc of a length equal to the length of its radius on the circumference of the circle.
Solid angle	steradian	sr	A steradian is a solid angle in which the center of the sphere is the vertex, and the area equal to the square area of the sphere is cut off on the surface of the sphere.

Table 3. Examples of assembly units

Amount	Name of unit	Unit symbol
Area	square meters	m^2
Volume	cubic meter	m^3
Speed	meter per second	m/s
Acceleration	meter per second per second	m/s^2
Wave number	per meter	m^{-1}
Density	kilogram per cubic meter	kg/m^3
Current density	amperes per square meter	A/m^2
Magnetic field strength	ampere meter per meter	A/m
(amount of substance) Concentration of substance	Mole per cubic meter	mol/m^3
Specific volume	Cubic meters per kilogram	m^3/kg
Luminance	Candela per square meter	cd/m^2

Table 4. Assembly unit with unique name

Amount	Name of unit	Unit symbol	A pair of cubic cubic or other assembly units with basic or supplementary units
frequency	Hertz	Hz	$1Hz=1s^{-1}$
Power	Newton	N	$1N=1kg\cdot m/s^2$
Pressure, stress	Pascal	Pa	$1Pa=1N/m^2$
Energy Work, calorie	Joule	J	$1J=1N\cdot m$
Power factor, power factor, power	Watt	W	1W=1J/s
Electric charge	Coulomb	C	$1C=1A\cdot s$
Potential Voltage	Bolt	V	1V=1J/C
Capacitance capacitance	Farad	F	1F=1C/V
Electric resistance	Ohm	Ω	1Ω=1V/A
Conductance	Siemens	S	$1S=1\Omega^{-1}$
Magnetic flux	Weber	Wb	$1Wb=1V\cdot s$
Magnetic flux density Magnetic induction	Tesla	T	$1T=1Wb/m^2$
Inductance	Henry	H	1H=1Wb/A
Celsius temperature	Celsius degree or degrees C	℃	1t=T-To
Luminous flux	Lumen	lm	$1lm=1cd\cdot sr$
Illuminance	lux	lx	$1lx=1lm/m^2$

3. Integer multiplication of 10 in SI unit

(1) Prefix The multiples and the prefix names and the prefix symbols for constituting the integer multiple of 10 in the SI unit are shown in Table 5.

Table 5. Prefixes

multiple	prefix	symbol	multiple	prefix	symbol	multiple	prefix	symbol
10^{18}	Exa	E	10^{2}	Hecto	h	10^{-9}	Nano	n
10^{15}	Peta	P	10^{1}	Deca	da	10^{-12}	Pico	p
10^{12}	Peta	T	10^{-1}	Digi	d	10^{-15}	Femto	f
10^{9}	Giga	G	10^{-2}	Centimeter	c	10^{-18}	Atto	a
10^{6}	Mega	M	10^{-3}	Milli	m			
10^{3}	Km	k	10^{-6}	Micro	μ			

4. Handling of units not included in SI unit

Units not included in SI are practically important, so the units shown in Table 6 are used in conjunction with SI units.

Table 6. Units used in conjunction with SI units

Amount	Name of unit	Unit symbol	Definition	Amount	Name of unit	Unit symbol	Definition
Time	Minute	min	1min=60s	Plane angle	Degree	°	1°=(π/180)rad
	Hour	h	1h=60min		Minute	′	1′=(1/60)°
	Day	d	1d=24h		Second	″	1″=(1/60)′
Volume	Liter	l、L	1l=7dm³	Mass	Ton	t	1t=10³kg

5. Other

Table 7. Conversion table of main SI unit

Amount	SI unit	Weight unit (Units previously used)	Weight unit → SI unit	SI unit → dynamic unit
Mass	kg	Weight (tons)	1t=10³kg	1kg=10⁻³t
Power	N (Newton) 〔kg･m/s²〕	kgf (weight kilogram) dyn (dyne)	1kgf=9.806 65 N 1dyn=10⁻⁵N	1N=0.101 972 kgf 1N=10⁵dyn
Torque	N · m (Newton meters)	kgf･m	1kgf･m=9.806 65 N･m	1N･m=0.101 972 kgf･m
Pressure	Pa (Pascal) 〔N/m²〕	kgf/cm² mmAq(mmH₂O) mmHg(Torr) bar (bar)	1kgf/cm²=9.806 65 × 10⁴Pa 1mmAq=9.806 65 Pa 1mmHg=133.322 Pa 1bar=10⁵Pa	1Pa=1.019 72 × 10⁻⁵kgf/cm² 1Pa=0.101 972mmAq 1Pa=7.500 6 × 10⁻² mmHg 1Pa=10⁻⁵bar
Stress	Pa (Pascal) 〔N/m²〕	kgf/mm²	1kgf/mm²=9.806 65 × 10⁴Pa	1Pa=1.019 72 × 10⁻⁷kgf/mm²
Work, Thermal energy, Heat quantity, enthalpy, Electric energy	J(Joule) 〔N･m〕	kcal kgf・m kW・h	1kcal=4.186 05 kJ 1kgf・m=9.806 65J 1kW・h=3.6 × 10⁴J	1kJ=0.239 kcal 1J=0.101 972 × kgf・m 1J=(1/3.6) × 10⁻⁵kW・h
Heat flow, power, electricity	W (Watt) 〔J/s〕	kcal/h kgf・m/s Ps (French horsepower, metric horsepower)	1kcal/h=1.163W 1kgf・m/s=9.806 65W 1Ps=7.355 × 10²W	1W=0.859 8 kcal/h 1W=0.101 972kgf・m/s 1W=1.359 6 × 10⁻²Ps
Heat flow density	W/m²	kcal/h・m²	1kcal/h・m²=1.163W/m²	1W/m²=0.859 8 kcal/h・m²
Heat capacity	J/K	kcal/℃	1kcal/℃ =4.186 05kJ/K	1kJ/K=0.239 kcal/℃
Specific heat	J/(kg･K)	kcal/kg・℃	1kcal/kg・℃ =4.186 05 kJ/(kg・K)	1kJ/(kg・K)=0.239 kcal/kg・℃
Thermal conductivity	J/kg	kcal/kg	1kcal/kg=4.186 05 kJ/kg	1kJ/kg=0.239 kcal/kg
Heat passage rate	W/(m･K)	kcal/・h・℃	1kcal/m・h・℃ =1.163W/(m・K)	1W/(m・K)=0.859 8 kcal/m・h・℃
Thermal conductivity	W/(m²･K)	kcal/m²・h・℃	1kcal/m²・h・℃ =1.163W/(m²・K)	1W/(m²・K)=0.859 8 kcal/m²・h・℃
Temperature	K(Kelvin)	℃ (Celsius degree)	T〔K〕=t〔℃〕+273.15	t〔℃〕=T〔K〕-273.15

[Remarks] (1) In this table, kcal may adopt the calorie method of weighing method. For international calories 1 kcal = 4.186 8 kJ.

(2) Weight: 1 kg (SI unit) = 1 / 9.806 65 kgf · s 2 / m (unit of gravity)

Weight: 1 kg (f gravity unit) = 9.806 65 kg · m = s (2 SI units)

Standard atmospheric pressure: 760 mmHg (gravity unit) = 101 325 Pa (SI unit)

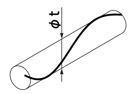
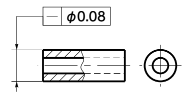
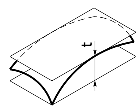
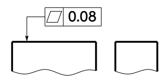
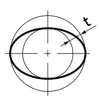
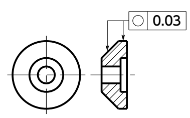
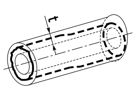
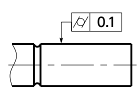
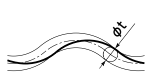
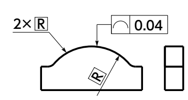
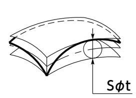
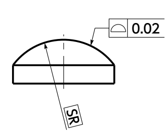
1 Japan frozen tones: 3 320 kcal / h (gravity unit) = 3.816 kW (SI unit)

1 USA (country system) frozen tons: 3 024 kcal / h (gravity unit) = 3.157 kW (SI unit)

(3) In this manual, as a conventional unit, weighing [kgf] instead of weight [kg] is displayed.

Illustration Method of Geometric Tolerances Excerpt from JIS b0021 (1998)

■Types of geometric tolerances and their symbols

Types of tolerance		Characteristic symbol	Definition of tolerance zone	Illustration and interpretation
Shape tolerance	Straightness tolerance	—	 If the symbol φ is added before the tolerance value, the tolerance zone is regulated by the cylinder of the diameter t.	 The actual (reproduced) axis of the cylinder to which the tolerance is applied must be within the cylindrical tolerance range of diameter 0.08.
	Flatness tolerance	▱	 The tolerance zone is regulated by parallel two planes that are separated by a distance t.	 The actual (reproduced) surface must be between two parallel planes separated by 0.08.
	Roundness tolerance	○	 In the symmetrical cross section, the tolerance zone is regulated by two coaxial circles.	 In any cross section of the cylinder and the surface of the cone, the actual (reproduced) radial line must be between two coaxial circles on the common plane, separated by a radius distance of 0.03.
	Cylindrical tolerance	⌭	 The tolerance zone is regulated by two coaxial cylinders that are separated by a distance t.	 The actual (reproduced) cylindrical surface must be between two coaxial cylinders which are separated by a radius distance of 0.1.
	Line Contour Tolerance: Line contour tolerance not related to datum (ISO 1660)	⌒	 The tolerance zone is regulated by the two envelopes of each circle of diameter t and the centers of these circles lie on the line with theoretically exact geometric shape.	 In each section that is parallel to the projection plane in the direction indicated, the actual (reproduced) contour line is 0.04 in diameter, and the center of those circles must be between the two envelopes of the circle located on the line with the ideal geometric shape.
	Surface Contour Tolerance: Surface contour tolerance not related to datum (ISO 1660)	⌓	 The tolerance zone is regulated by the two envelopes of each circle of diameter t and the centers of these circles lie on the line with theoretically exact geometric shape.	 The actual (reproduced) surface must be between the enveloping surfaces of each sphere with a diameter of 0.02, the centers of which spheres lie on a surface with a theoretical exact geometric shape.

The lines used in the definition column of the tolerance zone represent the following meanings.
Thick solid line or broken line: Form
Thick dash-dotted line: Datum
Thin solid line or broken line: Tolerance area
Thin dotted line: center line
Thin two-dot chain line: Supplementary projection plane or section
Thick, two-dot chain line: projection of feature on supplemental projection plane or section

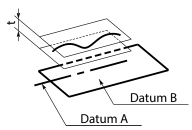
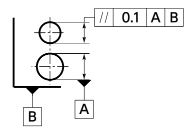
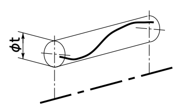
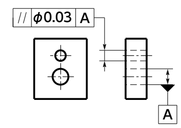
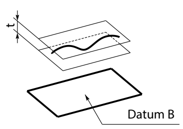
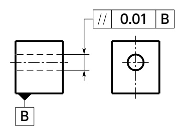
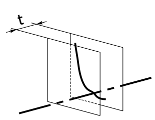
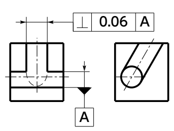
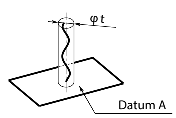
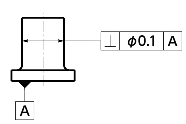
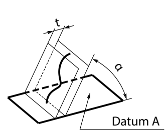
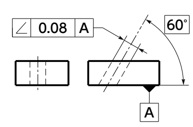
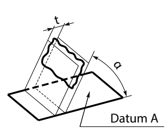
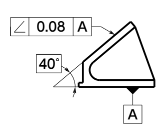
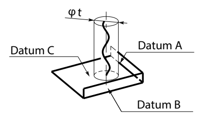
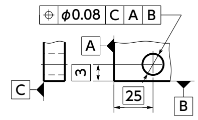
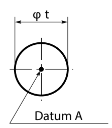
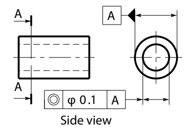
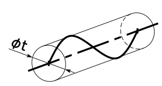
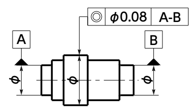
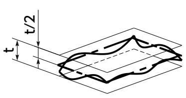
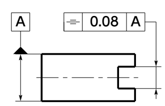
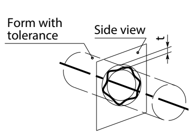
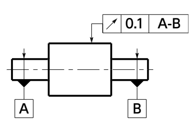
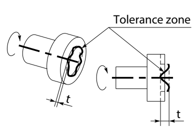
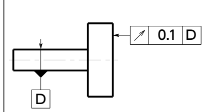
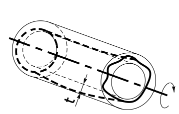
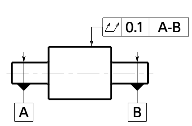
Types of tolerance		Characteristic symbol	Definition of tolerance zone	Illustration and interpretation
Attitude tolerance	Parallelism tolerance	//	1. Parallelism tolerance of lines related to Datum straight line	
			 The tolerance zone is regulated by parallel two planes that are separated by a distance t. The planes are parallel to the datum and are in the indicated direction.	 The actual (reconstructed) axes must be separated by 0.1, parallel to datum axis A and between parallel two planes in the indicated direction.
			 If the symbol φ is added before the tolerance value, the tolerance zone is regulated by a cylinder of diameter t parallel to the datum.	 The actual (reproduced) axis must be within the cylindrical tolerance range 0.03 in diameter parallel to the datum axis straight line A.
			2. Parallelism tolerance of the line associated with the datum plane	
			 The tolerance zone is separated by a distance t and regulated by parallel two planes parallel to datum plane B.	 The actual (reproduced) axes must be 0.01apart and be between parallel two planes parallel to datum plane B.
	Square tolerance	⊥	1. Right angle tolerance of line related to datum axis line	
			 The tolerance zone is separated by a distance t and regulated by parallel two planes parallel to datum plane B.	 The actual (reproduced) axis must be 0.06 apart and be between parallel two planes perpendicular to datum axis line A.
			2. Linear angle tolerance of the line relative to the datum plane	
			 If the symbol φ is added before the tolerance value, the tolerance zone is regulated by a cylinder of diameter t perpendicular to the datum.	 The actual (reproduced) axis of the cylinder must be within the cylindrical tolerance area of diameter 0.1 perpendicular to datum axis line A.
	Slope tolerance	∠	1. Linear slope tolerance relative to datum plane	
			 The tolerance zone is separated by a distance t and regulated by parallel two planes inclined at a specified angle with respect to the datum.	 The actual (reproduced) axis should be perpendicular to datum A and datum B perpendicular to each other, theoretically exactly 60 ° tilted with respect to datum plane A, and parallel two planes separated by 0.08 .
			2. Slope tolerance of the plane relative to datum plane	
			 The tolerance zone is separated by a distance t and regulated by parallel two planes inclined at a specified angle with respect to the datum.	 The actual (reproduced) surface should be 0.08 apart and be between parallel two planes which are theoretically exactly 40 ° inclined with respect to datum plane A.

Illustration Method of Geometric Tolerances Excerpt from JIS b0021 (1998)

■Types of geometric tolerances and their symbols

Types of tolerance		Characteristic symbol	Definition of tolerance zone	Illustration and interpretation
Position tolerance	Position angle tolerance	⌖	1. Line position angle tolerance	
			 When the tolerance value is marked with the symbol φ, the tolerance zone is regulated by the cylinder of diameter t. Its axis is positioned with theoretically exact dimensions with respect to datum C, A and B.	 The actual (reconstructed) axis must be within the cylindrical tolerance area with a diameter of 0.08 whose axis is at theoretically exact position with respect to datum planes C, A and B.
	Concentricity tolerance and coaxiality toleranc	◎	 When the tolerance value is marked with the symbol φ, the tolerance zone is regulated by a circle of diameter t. The center of the circular tolerance zone matches Datum A	 The actual (reproduced) center of the outer circle must be in a circle with diameter 0.1 concentric with datum circle A.
			 When the tolerance value is marked with the symbol φ, the tolerance zone is regulated by a cylinder of diameter t. The axis of the cylindrical tolerance zone coincides with datum A.	 The actual (reproduced) axis of the inner cylinder must be within the cylindrical tolerance range 0.08 in diameter coaxial to the common datum axis line A-B.
	Symmetry tolerance (Symmetry tolerance of center plane)	⌯	 Tolerance zones are separated by t and are regulated by parallel two planes symmetrical about the datum with respect to the center plane.	 The actual (reproduced) center plane must be between two parallel planes that are 0.08 symmetrical to the datum center plane A.
Runout tolerance	Circumferential deflection tolerance	↗	1. Circumferential runout tolerance - radial direction	
			 The tolerance zone is restricted within an arbitrary transverse plane perpendicular to the axis of two coaxial circles whose radius is t and coincides with the datum axis straight line.	 The actual (reproduced) circumferential deflection should be less than 0.1 in any cross section while making one revolution around the common datum axis line A - B.
			2. Circumferential runout tolerance - axis direction	
			 The tolerance zone is restricted within an arbitrary transverse plane perpendicular to the axis of two coaxial circles whose radius is t and coincides with the datum axis straight line.	 On the cylindrical axis coinciding with the datum axis straight line D, the actual (reproduced) line in the axial direction must be between two circles 0.1 away.
	Full runout tolerance: Total runout tolerance in the circumferential direction	⌰	 The tolerance zone is separated by t and its axis is regulated by two coaxial cylinders matching the datum.	 The actual (reproduced) surface must be between the coaxial two cylinders with a radius difference of 0.1, whose axis coincides with the common datum axis line A-B.

Normal Tolerance of Processing Dimensions Excerpt from JIS B 0405, B 0419 (1991)

■Normal tolerance

1. Tolerance to length dimension excluding chamfer

Unit: mm

Tolerance grade		Classification of reference dimensions							
Symbol	Description	0.5 or more* and less than 3	3 or more and less than 6	6 or more and less than 30	30 or more and less than 120	120 or more and less than 400	400 or more and less than 1000	1000 or more and less than 2000	2000 or more and less than 4000
		tolerance							
f	Precision	±0.05	±0.05	±0.1	±0.15	±0.2	±0.3	±0.5	-
m	Intermediate level	±0.1	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2
c	Coarse level	±0.2	±0.3	±0.5	±0.8	±1.2	±2	±3	±4
v	Extremely coarse level	-	±0.5	±1	±1.5	±2.5	±4	±6	±8

* For reference dimensions less than 0.5 mm, tolerance is individually indicated following the reference dimension.

2. Tolerance to length dimension of chamfered portion (Roundness of corner and chamfered dimension of corner)

Unit: mm

Tolerance grade		Classification of reference dimensions		
Symbol	Description	0.5 or more* and less than 3	3 or more and less than 6	more than 6
		tolerance		
f	Precision	±0.2	±0.5	±1
m	Intermediate level			
c	Coarse level	±0.4	±1	±2
v	Extremely coarse level			

* For reference dimensions less than 0.5 mm, tolerance is individually indicated following the reference dimension.

3. Angular dimension tolerance

Tolerance grade		The division of the length (mm)of the shorter side of the target angle				
Symbol	Description	less than 10	10 or more and less than 50	50 or more and less than 120	120 or more and less than 400	more than 400
		tolerance				
f	Precision	±1°	±30'	±20'	±10'	±5'
m	Intermediate level					
c	Coarse level	±1° 30'	±1°	±30'	±15'	±10'
v	Extremely coarse level	±3°	±2°	±1°	±30'	±20'

4. Normal tolerance of straight angle

Unit: mm

Tolerance grade	Classification of shorter side nominal length			
	less than 100	100 or more and less than 300	300 or more and less than 1000	1000 or more and less than 3000
	Straight angle tolerance			
H	0.2	0.3	0.4	0.5
K	0.4	0.6	0.8	1
L	0.6	1	1.5	2

5. Normal tolerance of circumferential deflection

Unit: mm

Tolerance grade	Tolerance of circumferential deflection
H	0.1
K	0.2
L	0.5

6. Normal tolerance of straightness and flatness

Unit: mm

Tolerance grade	Classification of nominal length					
	less than 10	10 or more and less than 30	30 or more and less than 100	100 or more and less than 300	300 or more and less than 1000	1000 or more and less than 3000
	Straightness tolerance and flatness tolerance					
H	0.02	0.05	0.1	0.2	0.3	0.4
K	0.05	0.1	0.2	0.4	0.6	0.8
L	0.1	0.2	0.4	0.8	1.2	1.6

Symbol of Quantity and Unit : Name and Symbol of Chemical Element Excerpt from JIS Z8202

■Name and symbol of chemical element

Atomic number	Element name	Element symbol	Atomic number	Element name	Element symbol	Atomic number	Element name	Element symbol
1	Hydrogen	H	36	Krypton	Kr	71	Lutetium	Lu
2	Helium	He	37	Rubidium	Rb	72	Hafnium	Hf
3	Lithium	Li	38	Strontium	Sr	73	Tantalum	Ta
4	Beryllium	Be	39	Yttrium	Y	74	Tungsten	W
5	Boron	B	40	Zirconium	Zr	75	Rhenium	Re
6	Carbon	C	41	Niobium	Nb	76	Osmium	Os
7	Nitrogen	N	42	Molybdenum	Mo	77	Iridium	Ir
8	Oxygen	O	43	technetium	Tc	78	Platinum	Pt
9	Fluorine	F	44	ruthenium	R	79	Gold	Au
10	Neon	Ne	45	rhodium	Rh	80	Mercury	Hg
11	Sodium	Na	46	palladium	Pd	81	Thallium	Tl
12	Magnesium	Mg	47	Silver	Ag	82	Lead	Pb
13	Aluminum	Al	48	Cadmium	Cd	83	Bismuth	Bi
14	Silicon	Si	49	indium	In	84	rhenium	Po
15	Rin	P	50	tin	Sn	85	astatine	At
16	Sulfur	S	51	Antimony	Sb	86	Radon	Rn
17	Chlorine	Cl	52	Tellurium	T	87	francium	Fr
18	Argon	Ar	53	Iodine	I	88	Radium	Ra
19	Potassium	K	54	Xenon	Xe	89	Actinium	Ac
20	Calcium	Ca	55	Cesium	Cs	90	Thorium	Th
21	Scandium	Sc	56	Barium	Ba	91	Protactinium	Pa
22	Titanium	Ti	57	Lanthanum	La	92	Uranium	U
23	Pana	V	58	Cerium	Ce	93	Neptunium	Np
24	Chromium	Cr	59	Praseodymium	Pr	94	Plutonium	Pu
25	Manganese	Mn	60	Neodymium	Nd	95	Americium	Am
26	Iron	Fe	61	Promethium	Pm	96	Curium	Cm
27	Cobalt	Co	62	Samarium	Sm	97	Berklium	Bk
28	Nickel	Ni	63	Eurobium	Eu	98	Californium	Cf
29	Copper	Cu	64	Gadolinium	Gd	99	Einsteinium	Es
30	Zinc	Zn	65	Terbium	Tb	100	Fermium	Fm
31	Gallium	Ga	66	Dysprosium	Dy	101	Mendelebium	Md
32	Germanium	Ge	67	Holmium	Ho	102	Nobelium	No
33	Arsenic	As	68	Erbium	Er	103	Laurenzium	Lr
34	Selenium	Se	69	Thulium	Tm			
35	Bromine	Br	70	Ytterbium	Yb			

[Remarks] This table shows Appendix A (element names and symbols) of ISO 31 / 8-1980 (Amount and unit of physicochemical and molecular physics) and Annex C (radioactivity (quantity and unit of atomic physics and nuclear physics) of ISO 31 / 9-1980 Nuclide name and symbol).

■Quantity symbol · Unit symbol

uppercase letter	Lower case	How to Read	Usual use
Α	α	Alpha	angle, coefficient
Β	β	Beta	Angle, factor
Γ	γ	Gamma	angle, unit area weight (capital letters) product sign
Δ	δ	Delta	Micro change, density, displacement
Ε	ε	Epsilon	Small amount, strain
Ζ	ζ	Geeta	Variable
Η	η	Eta	Variable
Θ	θ	Theta	Angle, temperature, time
Ι	ι	Eota	
Κ	κ	Kappa	Turning radius
Λ	λ	Lambda	Wavelength, Eigenvalue
Μ	μ	Mu	coefficient of friction 10^{-6} (micro)
Ν	ν	New	frequency
Ξ	ξ	Qsai	Variable

uppercase letter	Lower case	How to Read	Usual use
Ο	ο	Omicron	
Π	π	pie	Pi pi (3.14159 ...), Angle (uppercase) product sign
Ρ	ρ	Low	Radius, density
Σ	σ	Sigma	Stress, standard deviation, (uppercase) Sum of the number
Τ	τ	Tau	Time constant, time, torque
Υ	υ	Epsilon	
Φ	φ	File	Angle, function, diameter
Χ	χ	Kai	
Ψ	ψ	Psi	Angle, relationship
Ω	ω	Omega	angular velocity = 2 π f (capital letters) Ohm = electrical resistance unit

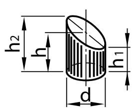
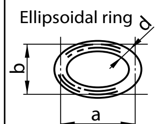
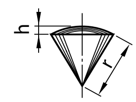
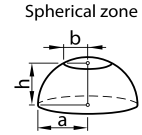
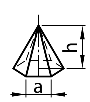
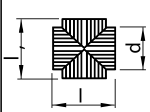
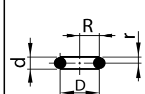
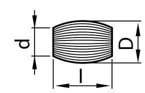
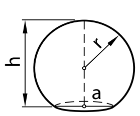
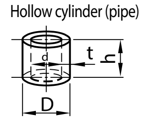
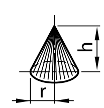
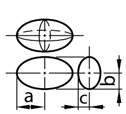
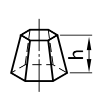
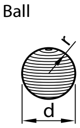
[Remarks] Lowercase letters except upper case letters

Method of Calculating Properties / Volume / Weight of Metal Material

■Properties of metallic materials

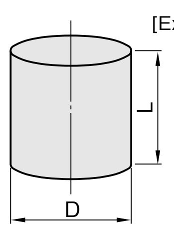
Material	Specific gravity	Coefficient of thermal expansion	Longitudinal elastic modulus	
		× 10^{-6}/℃	N/mm²	{kgf/mm²}
Mild steel	7.85	11.7	205800	{21000}
NAK80	7.8	12.5	200900	{20500}
SKD11	7.85	11.7	205800	{21000}
SKD61	7.75	10.8	205800	{21000}
SKH51	8.2	10.1	218540	{22300}
Carbide V30	14.1	6	548800	{56000}
Carbide V40	13.9	6	529200	{54000}
Cast iron	7.3	9.2 ～ 11.8	73500 ～ 102900	{7500 ～ 10500}
SUS304	8	17.3	193060	{19700}
SUS440C	7.78	10.2	199920	{20400}
Oxygen free copper C1020	8.9	17.6	114660	{11700}
6/4 brass	8.4	20.8	100940	{10300}
Beryllium copper C1720	8.3	17.1	127400	{13000}
Aluminum A1100	2.7	23.6	67620	{6900}
Duralumin A7075	2.8	23.6	70560	{7200}
Titanium	4.5	8.4	103880	{10600}

■How to calculate volume

Solid	Volume V	Solid	Volume V	Solid	Volume V	Solid	Volume V
Truncated cylinder 	$V=\frac{\pi}{4}d^2h$ $=\frac{\pi}{4}d^2\left(\frac{h_1+h_2}{2}\right)$	Ellipsoidal ring 	$V=\frac{\pi^2}{4}d^2\frac{\sqrt{a^2+b^2}}{2}$	Sphere 	$V=\frac{2}{3}\pi r^2h$ $=2.0944r^2h$	Spherical zone 	$V=\frac{\pi h}{6}(3a^2+3b^2+h^2)$
Pyramid 	$V=\frac{h}{3}A=\frac{h}{6}arn$ A=Base area r=Radius of inscribed circle a=Length of side of regular polygon n=Number of sides of a regular polygon	Crossover Cylinder 	$V=\frac{\pi}{4}d^2(l+l'-\frac{d}{3})$	Torus 	$V=2\pi^2Rr^2$ $=19.739Rr^2$ $=\frac{\pi^2}{4}Dd^2$ $=2.4674Dd^2$	Barrel shape 	When the circumference forms a curvature equal to an arc $V=\frac{\pi L}{12}(2D^2+d^2)$ When the circumference forms a curvature equal to a parabola $V=0.209L(2D^2Dd+1/4d^2)$
Ball crown 	$V=\frac{\pi h^2}{3}(3r-h)$ $=\frac{\pi h}{6}(3a^2+h^2)$ a is the radius	Hollow cylinder (pipe) 	$V=\frac{\pi}{4}h(D^2-d^2)$ $=\pi th(D-t)$ $=\pi th(d+t)$	Conical 	$V=\frac{\pi}{3}r^2h$ $=1.0472r^2h$		
Ellipsoid 	$V=\frac{4}{3}\pi abc$ Spheroid $V=\frac{4}{3}\pi ab^2$	Truncated pyramid 	$V=\frac{h}{3}(A+a+\sqrt{Aa})$ A,a=Area of both end faces	Ball 	$V=\frac{4}{3}\pi r^3=4.1888r^3$ $=\frac{\pi}{6}d^3=0.5236d^3$		

■Weight calculation method

Weight W [g] = Volume [cm³] × Specific Gravity



[Example] Material: mild steel

D = ϕ 16 Weight of 50 mm is

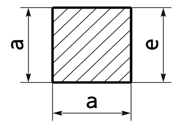
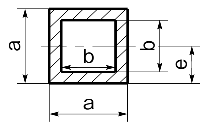
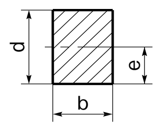
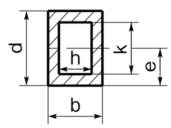
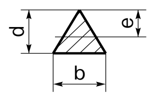
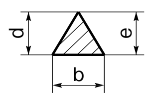
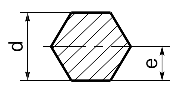
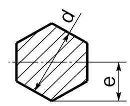
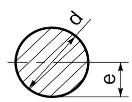
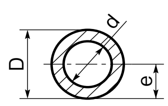
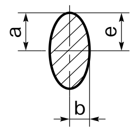
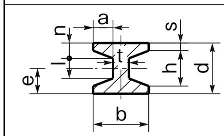
$W=\frac{\pi}{4}D^2\times L\times$ specific gravity

$=\frac{\pi}{4}\times 1.6^2\times 5\times 7.85$

≈ 79 [g]

Second Moment of Cross-Section, Other Calculation Method

■Correlation table of Cross-sectional shape and cross-sectional area, Secondary moment of area, Section modulus and rotational radius.

Shape area of cross section	Cross section A	Distance from the neutral axis to the farthest position e	Sectional moment of inertia I	Section modulus $Z=\frac{I}{e}$	Turning radius $p=\frac{\sqrt{I}}{A}$
	a^2	a	$\frac{a^4}{3}$	$\frac{a^3}{3}$	$\frac{a}{\sqrt{3}}=0.577a$
	a^2-b^2	$\frac{1}{2}a$	$\frac{a^4-b^4}{12}$	$\frac{a^4-b^4}{6a}$	$\sqrt{\frac{a^2+b^2}{12}}$ $=0.289\sqrt{a^2+b^2}$
	bd	$\frac{1}{2}d$	$\frac{bd^3}{12}$	$\frac{bd^2}{6}$	$\frac{d}{\sqrt{12}}=0.289d$
	bd −hk	$\frac{1}{2}d$	$\frac{bd^3-hk^3}{12}$	$\frac{bd^3-hk^3}{6d}$	$\sqrt{\frac{bd^3-hk^3}{12(bd-hk)}}$ $=0.289\sqrt{\frac{bd^3-hk^3}{bd-hk}}$
	$\frac{1}{2}bd$	$\frac{2}{3}d$	$\frac{bd^3}{36}$	$\frac{bd^2}{24}$	$\frac{d}{\sqrt{18}}=0.236d$
	$\frac{1}{2}bd$	d	$\frac{bd^3}{12}$	$\frac{bd^2}{12}$	$\frac{a}{\sqrt{6}}=0.408d$
	$\frac{3d^2\tan30^\circ}{2}=0.866d^2$	$\frac{d}{2}$	$\frac{A}{12}\left[\frac{d^2(1+2\cos^2 30^\circ)}{4\cos^2 30^\circ}\right]$ $=0.6d^4$		$\sqrt{\frac{d^2(1+2\cos^2 30^\circ)}{48\cos^2 30^\circ}}$ $=0.264d$
	$\frac{3d^2\tan30^\circ}{2}=0.866d^2$	$\frac{d}{2\cos30^\circ}=0.577d$	$\frac{A}{12}\left[\frac{d^2(1+2\cos^2 30^\circ)}{4\cos^2 30^\circ}\right]$ $=0.6d^4$	$\frac{A}{6}\left[\frac{d(1+2\cos^2 30^\circ)}{4\cos^2 30^\circ}\right]$ $=0.104d3$	$\sqrt{\frac{d^2(1+2\cos^2 30^\circ)}{48\cos^2 30^\circ}}$ $=0.264d$
	$\frac{\pi d^2}{4}=0.7854d^2$	$\frac{d}{2}$	$\frac{\pi d^4}{64}=0.049d^4$	$\frac{\pi d^3}{32}=0.098d^3$	$\frac{d}{4}$
	$\frac{\pi(D^2-d^2)}{4}$ $=0.7854(D^2-d^2)$	$\frac{d}{2}$	$\frac{\pi(D^4-d^4)}{64}$ $=0.049(D^4-d^4)$	$\frac{\pi(D^4-d^4)}{32D}$ $=0.098\frac{D^4-d^4}{D}$	$\frac{\sqrt{D^4-d^4}}{4}$
	$\pi ab=3.1416ab$	a	$\frac{\pi a^3 b}{4}=0.7854a^3b$	$\frac{\pi a^2 b}{4}=0.7854a^2b$	$\frac{a}{2}$
	dt+2a(s+n)	$\frac{d}{2}$	$I=\frac{1}{12}\left[bd^3-\frac{1}{4g}(h^4-l^4)\right]$ ただしg=つばのこう配	$\frac{1}{6d}\left[bd^3-\frac{1}{4g}(h^4-l^4)\right]$	$\sqrt{\frac{\frac{1}{12}\left[bd^3-\frac{1}{4g}(h^4\right.}{dt+2a(s+n)}}$

Foundation of Fit Selection Extract of JIS usage series drafting manual (Accuracy)

■Standard of Fit selection

			H6	H7	H8	H9	Applicable part	Functional classification		Application example
Parts are moved relatively	Clearance	Relaxation				c9	Especially, there may be a large gap, or a moving part that needs a gap. A part that can increase the gap to make assembly easier. A part that needs an appropriate gap even at high temperature.	A part requiring a large gap in terms of function. (Expands, position error is large.) (The fitting length is long.) Try to lower the cost. (Production cost) (Maintenance cost)		Fitting of piston ring and ring groove loose stop pin
		Light rotation			d9	d9	There is a large clearance, or a part that needs a gap.			Crank web and pin bearing (side) Exhaust valve casing and splash ring slide piston ring and ring groove
				e7	e8	e9	There is a slightly large gap, or a moving part that needs a gap. Slightly large clearance, bearing part with good lubrication. High temperature, high speed, high load bearing part (advanced forced lubrication).	General rotation or sliding parts. (Good lubrication is required) A normal fit part. (Often decomposed)		Fitting of exhaust valve seat Main bearing for crankshaft General sliding section
		Rotation	f6	f7	f7 f8		There is a suitable clearance and fit can be exercised (fine fit). General temperature room bearing part for grease and oil lubrication.			Cooling type exhaust valve valve box insertion part General axis and bush Link device lever and bushing
		Rerotation	g5	g6			Continuous rotating part of light load precision equipment. A fit that allows for small gap movement (spikot, positioning). Precise sliding part.	Part that requires precise exercise without rattling.		Link device pin and lever Key and key groove Precise control valve stem
Parts cannot be moved relatively	Intermediate fit	Sliding	h5	h6	h7 h8	h9	If you use a lubricant you can move by hand (fitting in fine quality). Particularly precise sliding parts. A static part that is not important.	It can disassemble and assemble without damaging parts.	It is impossible to transmit force only by the fitting force of fitting.	Fits the rim and the boss Fitting of a gear of a precise gear device
		Driving	h5 h6	js6			There is a slight interference in the mounting part. High precision positioning that prevents mutual movement during use. Fit to the extent that it can stand and disassemble with trees and lead hammers.			Fitting between joint flanges Governor way and pin Fitting of gear rim and boss
		Driving	js5	k6			Fitting to the extent of using iron hammer / hand press for assembly / disassembly (keys and others are necessary to prevent rotation axis between parts). High precision positioning.			Fastening of gear pump shaft and casing Reamer bolt
			k5	m6			Assembly / disassembly is the same as above. High precision positioning where little clearance is not allowed.			Reamer bolt Hydraulic equipment Piston and shaft fixing Fitting of fitting flange and shaft
		Light press fitting	m5	n6			It requires considerable force to assemble and disassemble. High precision fixed mounting (Key and others are necessary for transmission of large torque).		It can be transmitted by the coupling force of small fitting force.	Flexible coupling and gear (passive side) High accuracy fit Intake valve, valve guide insertion
	Interference fit	Press fitting	n5 n6	p6			Fitting that requires a large force for assembly / disassembly (key and others are required for transmission of large torque). However, in the case of non-ferrous components, the press-fitting force is lightly pressed. Standard press fitting fixation of iron and iron, bronze and copper.	It is difficult to disassemble without damaging parts.		Intake valve, valve guide insertion Fixing the gear and shaft (small torque) Flexible joint shaft and gear (drive side)
			p5	r6			Assembly / disassembly is the same as above. For large-size parts, sintering, cold fitting, strong press fitting.		A considerable force can be transmitted by the fitting force of the fitting.	Fitting and shaft
		Strong press fitting, sintering fitting, cold fitting	r5	s6 t6 u6 x6			It is firmly fixed to each other, and the assembly requires sintering, cold fitting, and strong press fitting. It will be a permanent assembly without disassembly. In the case of a light alloy, it is press fit.			Inserting and fixing of bearing bush Inlet valve, insertion of valve seat Fitting flange and shaft fixing (large torque) Fastening of drive gear rim and boss Bearing bush fixed in

Dimensional Tolerance of Used for Most Fit Holes Extracted from JIS B0401 (1998)

■Correlation table of standard dimension classification and hole tolerance area class

Classification of reference dimensions (mm)		Tolerance range class of holes																		
Over	Below	B10	C9	C10	D8	D9	D10	E7	E8	E9	F6	F7	F8	G6	G7	H6	H7	H8	H9	H10
-	3	+180 +140	+85 +60	+100 +60	+34 +20	+45 +20	+60 +20	+24 +14	+28 +14	+39 +14	+12 +6	+16 +6	+20 +6	+8 +2	+12 +2	+6 0	+10 0	+14 0	+25 0	+40 0
3	6	+188 +140	+100 +70	+118 +70	+48 +30	+60 +30	+78 +30	+32 +20	+38 +20	+50 +20	+18 +10	+22 +10	+28 +10	+12 +4	+16 +4	+8 0	+12 0	+18 0	+30 0	+48 0
6	10	+208 +150	+116 +80	+138 +80	+62 +40	+76 +40	+98 +40	+40 +25	+47 +25	+61 +25	+22 +13	+28 +13	+35 +13	+14 +5	+20 +5	+9 0	+15 0	+22 0	+36 0	+58 0
10	14	+220 +150	+138 +95	+165 +95	+77 +50	+93 +50	+120 +50	+50 +32	+59 +32	+75 +32	+27 +16	+34 +16	+43 +16	+17 +6	+24 +6	+11 0	+18 0	+27 0	+43 0	+70 0
14	18																			
18	24	+244 +160	+162 +110	+194 +110	+98 +65	+117 +65	+149 +65	+61 +40	+73 +40	+92 +40	+33 +20	+41 +20	+53 +20	+20 +7	+28 +7	+13 0	+21 0	+33 0	+52 0	+84 0
24	30																			
30	40	+270 +170	+182 +120	+220 +120	+119 +80	+142 +80	+180 +80	+75 +50	+89 +50	+112 +50	+41 +25	+50 +25	+64 +25	+25 +9	+34 +9	+16 0	+25 0	+39 0	+62 0	+100 0
40	50	+280 +180	+192 +130	+230 +130																
50	65	+310 +190	+214 +140	+260 +140	+146 +100	+174 +100	+220 +100	+90 +60	+106 +60	+134 +60	+49 +30	+60 +30	+76 +30	+29 +10	+40 +10	+19 0	+30 0	+46 0	+74 0	+120 0
65	80	+320 +200	+224 +150	+270 +150																
80	100	+360 +220	+257 +170	+310 +170	+174 +120	+207 +120	+260 +120	+107 +72	+126 +72	+159 +72	+58 +36	+71 +36	+90 +36	+34 +12	+47 +12	+22 0	+35 0	+54 0	+87 0	+140 0
100	120	+380 +240	+267 +180	+320 +180																
120	140	+420 +260	+300 +200	+360 +200	+208 +145	+245 +145	+305 +145	+125 +85	+148 +85	+185 +85	+68 +43	+83 +43	+106 +43	+39 +14	+54 +14	+25 0	+40 0	+63 0	+100 0	+160 0
140	160	+440 +280	+310 +210	+370 +210																
160	180	+470 +310	+330 +230	+390 +230																
180	200	+525 +340	+355 +240	+425 +240	+242 +170	+285 +170	+355 +170	+146 +100	+172 +100	+215 +100	+79 +50	+96 +50	+122 +50	+44 +15	+61 +15	+29 0	+46 0	+72 0	+115 0	+185 0
200	225	+565 +380	+375 +260	+445 +260																
225	250	+605 +420	+395 +280	+465 +280																
250	280	+690 +480	+430 +300	+510 +300	+271 +190	+320 +190	+400 +190	+162 +110	+191 +110	+240 +110	+88 +56	+108 +56	+137 +56	+49 +17	+69 +17	+32 0	+52 0	+81 0	+130 0	+210 0
280	315	+750 +540	+460 +330	+540 +330																
315	355	+830 +600	+500 +360	+590 +360	+299 +210	+350 +210	+440 +210	+182 +125	+214 +125	+265 +125	+98 +62	+119 +62	+151 +62	+54 +18	+75 +18	+36 0	+57 0	+89 0	+140 0	+230 0
355	400	+910 +680	+540 +400	+630 +400																
400	450	+1010 +760	+595 +440	+690 +440	+327 +230	+385 +230	+480 +230	+198 +135	+232 +135	+290 +135	+108 +68	+131 +68	+165 +68	+60 +20	+83 +20	+40 0	+63 0	+97 0	+155 0	+250 0
450	500	+1090 +840	+635 +480	+730 +480																

Remarks For each table, the upper side shows the upper dimensional tolerance and the lower side shows the lower dimensional tolerance.

Units: μm

Classification of reference dimensions (mm)		Tolerance range class of holes														
Over	Below	JS6	JS7	K6	K7	M6	M7	N6	N7	P6	P7	R7	S7	T7	U7	X7
-	3	±3	±5	0 -6	0 -10	-2 -8	-2 -12	-4 -10	-4 -14	-6 -12	-6 -16	-10 -20	-14 -24	-	-18 -28	-20 -30
3	6	±4	±6	+2 -6	+3 -9	-1 -9	0 -12	-5 -13	-4 -16	-9 -17	-8 -20	-11 -23	-15 -27	-	-19 -31	-24 -36
6	10	±4.5	±7	+2 -7	+5 -10	-3 -12	0 -15	-7 -16	-4 -19	-12 -21	-9 -24	-13 -28	-17 -32	-	-22 -37	-28 -43
10	14	±5.5	±9	+2 -9	+6 -12	-4 -15	0 -18	-9 -20	-5 -23	-15 -26	-11 -29	-16 -34	-21 -39	-	-26 -44	-33 -51
14	18															-38 -56
18	24	±6.5	±10	+2 -11	+6 -15	-4 -17	0 -21	-11 -24	-7 -28	-18 -31	-14 -35	-20 -41	-27 -48	-	-33 -54	-46 -67
24	30													-33 -54	-40 -61	-56 -77
30	40	±8	±12	+3 -13	+7 -18	-4 -20	0 -25	-12 -28	-8 -33	-21 -37	-17 -42	-25 -50	-34 -59	-39 -64	-51 -76	-
40	50													-45 -70	-61 -86	
50	65	±9.5	±15	+4 -15	+9 -21	-5 -24	0 -30	-14 -33	-9 -39	-26 -45	-21 -51	-30 -60	-42 -72	-55 -85	-76 -106	-
65	80											-32 -62	-48 -78	-64 -94	-91 -121	
80	100	±11	±17	+4 -18	+10 -25	-6 -28	0 -35	-16 -38	-10 -45	-30 -52	-24 -59	-38 -73	-58 -93	-78 -113	-111 -146	-
100	120											-41 -76	-66 -101	-91 -126	-131 -166	
120	140	±12.5	±20	+4 -21	+12 -28	-8 -33	0 -40	-20 -45	-12 -52	-36 -61	-28 -68	-48 -88	-77 -117	-107 -147	-	-
140	160											-50 -90	-85 -125	-119 -159		
160	180											-53 -93	-93 -133	-131 -171		
180	200	±14.5	±23	+5 -24	+13 -33	-8 -37	0 -46	-22 -51	-14 -60	-41 -70	-33 -79	-60 -106	-105 -151	-	-	-
200	225											-63 -109	-113 -159			
225	250											-67 -113	-123 -169			
250	280	±16	±26	+5 -27	+16 -36	-9 -41	0 -52	-25 -57	-14 -66	-47 -79	-36 -88	-74 -126	-	-	-	-
280	315											-78 -130				
315	355	±18	±28	+7 -29	+17 -40	-10 -46	0 -57	-26 -62	-16 -73	-51 -87	-41 -98	-87 -144	-	-	-	-
355	400											-93 -150				
400	450	±20	±31	+8 -32	+18 -45	-10 -50	0 -63	-27 -67	-17 -80	-55 -95	-45 -108	-103 -166	-	-	-	-
450	500											-109 -172				

Dimensional Tolerance of Used for Most Fit Holes Extracted from JIS B0401 (1998)

■Correlation table of standard dimension classification and hole tolerance area class

Classification of reference dimensions (mm)		Tolerance range class of holes																
Over	Below	b9	c9	d8	d9	e7	e8	e9	f6	f7	f8	g5	g6	h5	h6	h7	h8	h9
-	3	-140 -165	-60 -85	-20 -34	-20 -45	-14 -24	-14 -28	-14 -39	-6 -12	-6 -16	-6 -20	-2 -6	-2 -8	0 -4	0 -6	0 -10	0 -14	0 -25
3	6	-140 -170	-70 -100	-30 -48	-30 -60	-20 -32	-20 -38	-20 -50	-10 -18	-10 -22	-10 -28	-4 -9	-4 -12	0 -5	0 -8	0 -12	0 -18	0 -30
6	10	-150 -186	-80 -116	-40 -62	-40 -76	-25 -40	-25 -47	-25 -61	-13 -22	-13 -28	-13 -35	-5 -11	-5 -14	0 -6	0 -9	0 -15	0 -22	0 -36
10	14	-150 -193	-95 -138	-50 -77	-50 -93	-32 -50	-32 -59	-32 -75	-16 -27	-16 -34	-16 -43	-6 -14	-6 -17	0 -8	0 -11	0 -18	0 -27	0 -43
14	18																	
18	24	-160 -212	-110 -162	-65 -98	-65 -117	-40 -61	-40 -73	-40 -92	-20 -33	-20 -41	-20 -53	-7 -16	-7 -20	0 -9	0 -13	0 -21	0 -33	0 -52
24	30																	
30	40	-170 -232	-120 -182	-80 -119	-80 -142	-50 -75	-50 -89	-50 -112	-25 -41	-25 -50	-25 -64	-9 -20	-9 -25	0 -11	0 -16	0 -25	0 -39	0 -62
40	50	-180 -242	-130 -192															
50	65	-190 -264	-140 -214	-100 -146	-100 -174	-60 -90	-60 -106	-60 -134	-30 -49	-30 -60	-30 -76	-10 -23	-10 -29	0 -13	0 -19	0 -30	0 -46	0 -74
65	80	-200 -274	-150 -224															
80	100	-220 -307	-170 -257	-120 -174	-120 -207	-72 -107	-72 -126	-72 -159	-36 -58	-36 -71	-36 -90	-12 -27	-12 -34	0 -15	0 -22	0 -35	0 -54	0 -87
100	120	-240 -327	-180 -267															
120	140	-260 -360	-200 -300															
140	160	-280 -380	-210 -310	-145 -208	-145 -245	-85 -125	-85 -148	-85 -185	-43 -68	-43 -83	-43 -106	-14 -32	-14 -39	0 -18	0 -25	0 -40	0 -63	0 -100
160	180	-310 -410	-230 -330															
180	200	-340 -455	-240 -355															
200	225	-380 -495	-260 -375	-170 -242	-170 -285	-100 -146	-100 -172	-100 -215	-50 -79	-50 -96	-50 -122	-15 -35	-15 -44	0 -20	0 -29	0 -46	0 -72	0 -115
225	250	-420 -535	-280 -395															
250	280	-480 -610	-300 -430	-190 -271	-190 -320	-110 -162	-110 -191	-110 -240	-56 -88	-56 -108	-56 -137	-17 -40	-17 -49	0 -23	0 -32	0 -52	0 -81	0 -130
280	315	-540 -670	-330 -460															
315	355	-600 -740	-360 -500	-210 -299	-210 -350	-125 -182	-125 -214	-125 -265	-62 -98	-62 -119	-62 -151	-18 -43	-18 -54	0 -25	0 -36	0 -57	0 -89	0 -140
355	400	-680 -820	-400 -540															
400	450	-760 -915	-440 -595	-230 -327	-230 -385	-135 -198	-135 -232	-135 -290	-68 -108	-68 -131	-68 -165	-20 -47	-20 -60	0 -27	0 -40	0 -63	0 -97	0 -155
450	500	-840 -995	-480 -635															

Remarks For each table, the upper side shows the upper dimensional tolerance and the lower side shows the lower dimensional tolerance.

Units: μm

<table>
<tr><th colspan="2">Classification of reference dimensions (mm)</th><th colspan="14">Tolerance range class of holes</th></tr>
<tr><th>Over</th><th>Below</th><th>js5</th><th>js6</th><th>js7</th><th>k5</th><th>k6</th><th>m5</th><th>m6</th><th>n6</th><th>p6</th><th>r6</th><th>s6</th><th>t6</th><th>u6</th><th>x6</th></tr>
<tr><td>-</td><td>3</td><td>±2</td><td>±3</td><td>±5</td><td>+4
0</td><td>+6
0</td><td>+6
+2</td><td>+8
+2</td><td>+10
+4</td><td>+12
+6</td><td>+16
+10</td><td>+20
+14</td><td>-</td><td>+24
+18</td><td>+26
+20</td></tr>
<tr><td>3</td><td>6</td><td>±2.5</td><td>±4</td><td>±6</td><td>+6
+1</td><td>+9
+1</td><td>+9
+4</td><td>+12
+4</td><td>+16
+8</td><td>+20
+12</td><td>+23
+15</td><td>+27
+19</td><td>-</td><td>+31
+23</td><td>+36
+28</td></tr>
<tr><td>6</td><td>10</td><td>±3</td><td>±4.5</td><td>±7</td><td>+7
+1</td><td>+10
+1</td><td>+12
+6</td><td>+15
+6</td><td>+19
+10</td><td>+24
+15</td><td>+28
+19</td><td>+32
+23</td><td>-</td><td>+37
+28</td><td>+43
+34</td></tr>
<tr><td>10</td><td>14</td><td rowspan="2">±4</td><td rowspan="2">±5.5</td><td rowspan="2">±9</td><td rowspan="2">+9
+1</td><td rowspan="2">+12
+1</td><td rowspan="2">+15
+7</td><td rowspan="2">+18
+7</td><td rowspan="2">+23
+12</td><td rowspan="2">+29
+18</td><td rowspan="2">+34
+23</td><td rowspan="2">+39
+28</td><td rowspan="2">-</td><td rowspan="2">+44
+33</td><td>+51
+40</td></tr>
<tr><td>14</td><td>18</td><td>+56
+45</td></tr>
<tr><td>18</td><td>24</td><td rowspan="2">±4.5</td><td rowspan="2">±6.5</td><td rowspan="2">±10</td><td rowspan="2">+11
+2</td><td rowspan="2">+15
+2</td><td rowspan="2">+17
+8</td><td rowspan="2">+21
+8</td><td rowspan="2">+28
+15</td><td rowspan="2">+35
+22</td><td rowspan="2">+41
+28</td><td rowspan="2">+48
+35</td><td>-</td><td>+54
+41</td><td>+67
+54</td></tr>
<tr><td>24</td><td>30</td><td>+54
+41</td><td>+61
+48</td><td>+77
+64</td></tr>
<tr><td>30</td><td>40</td><td rowspan="2">±5.5</td><td rowspan="2">±8</td><td rowspan="2">±12</td><td rowspan="2">+13
+2</td><td rowspan="2">+18
+2</td><td rowspan="2">+20
+9</td><td rowspan="2">+25
+9</td><td rowspan="2">+33
+17</td><td rowspan="2">+42
+26</td><td rowspan="2">+50
+34</td><td rowspan="2">+59
+43</td><td>+64
+48</td><td>+76
+60</td><td rowspan="2">-</td></tr>
<tr><td>40</td><td>50</td><td>+70
+54</td><td>+86
+70</td></tr>
<tr><td>50</td><td>65</td><td rowspan="2">±6.5</td><td rowspan="2">±9.5</td><td rowspan="2">±15</td><td rowspan="2">+15
+2</td><td rowspan="2">+21
+2</td><td rowspan="2">+24
+11</td><td rowspan="2">+30
+11</td><td rowspan="2">+39
+20</td><td rowspan="2">+51
+32</td><td>+60
+41</td><td>+72
+53</td><td>+85
+66</td><td>+106
+87</td><td rowspan="2">-</td></tr>
<tr><td>65</td><td>80</td><td>+62
+43</td><td>+78
+59</td><td>+94
+75</td><td>+121
+102</td></tr>
<tr><td>80</td><td>100</td><td rowspan="2">±7.5</td><td rowspan="2">±11</td><td rowspan="2">±17</td><td rowspan="2">+18
+3</td><td rowspan="2">+25
+3</td><td rowspan="2">+28
+13</td><td rowspan="2">+35
+13</td><td rowspan="2">+45
+23</td><td rowspan="2">+59
+37</td><td>+73
+51</td><td>+93
+71</td><td>+113
+91</td><td>+146
+124</td><td rowspan="2">-</td></tr>
<tr><td>100</td><td>120</td><td>+76
+54</td><td>+101
+79</td><td>+126
+104</td><td>+166
+144</td></tr>
<tr><td>120</td><td>140</td><td rowspan="3">±9</td><td rowspan="3">±12.5</td><td rowspan="3">±20</td><td rowspan="3">+21
+3</td><td rowspan="3">+28
+3</td><td rowspan="3">+33
+15</td><td rowspan="3">+40
+15</td><td rowspan="3">+52
+27</td><td rowspan="3">+68
+43</td><td>+88
+63</td><td>+117
+92</td><td>+147
+122</td><td rowspan="3">-</td><td rowspan="3">-</td></tr>
<tr><td>140</td><td>160</td><td>+90
+65</td><td>+125
+100</td><td>+159
+134</td></tr>
<tr><td>160</td><td>180</td><td>+93
+68</td><td>+133
+108</td><td>+171
+146</td></tr>
<tr><td>180</td><td>200</td><td rowspan="3">±10</td><td rowspan="3">±14.5</td><td rowspan="3">±23</td><td rowspan="3">+24
+4</td><td rowspan="3">+33
+4</td><td rowspan="3">+37
+17</td><td rowspan="3">+46
+17</td><td rowspan="3">+60
+31</td><td rowspan="3">+79
+50</td><td>+106
+77</td><td>+151
+122</td><td rowspan="3">-</td><td rowspan="3">-</td><td rowspan="3">-</td></tr>
<tr><td>200</td><td>225</td><td>+109
+80</td><td>+159
+130</td></tr>
<tr><td>225</td><td>250</td><td>+113
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+140</td></tr>
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+4</td><td rowspan="2">+36
+4</td><td rowspan="2">+43
+20</td><td rowspan="2">+52
+20</td><td rowspan="2">+66
+34</td><td rowspan="2">+88
+56</td><td>+126
+94</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>280</td><td>315</td><td>+130
+98</td></tr>
<tr><td>315</td><td>355</td><td rowspan="2">±12.5</td><td rowspan="2">±18</td><td rowspan="2">±28</td><td rowspan="2">+29
+4</td><td rowspan="2">+40
+4</td><td rowspan="2">+46
+21</td><td rowspan="2">+57
+21</td><td rowspan="2">+73
+37</td><td rowspan="2">+98
+62</td><td>+144
+108</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>355</td><td>400</td><td>+150
+114</td></tr>
<tr><td>400</td><td>450</td><td rowspan="2">±13.5</td><td rowspan="2">±20</td><td rowspan="2">±31</td><td rowspan="2">+32
+5</td><td rowspan="2">+45
+5</td><td rowspan="2">+50
+23</td><td rowspan="2">+63
+23</td><td rowspan="2">+80
+40</td><td rowspan="2">+108
+68</td><td>+166
+126</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>450</td><td>500</td><td>+172
+132</td></tr>
</table>

Surface Roughness Extracted from JIS B0601 (1994), JIS B0031 (1994)

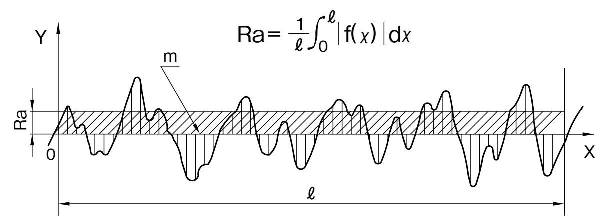
■Types of Surface Roughness

Parameters representing the surface roughness of industrial products are defined as arithmetic average roughness (Ra), maximum height (Ry), ten-point mean roughness (Rz), average irregularities spacing (Sm), mean spacing of local peaks (S), and load length rate (tp). The surface roughness is the arithmetic mean value of each part randomly extracted from the surface of the object.
[Center line average roughness (Ra_{75}) is defined in the appendix of JIS B 0031 · JIS B 0601.]

How to obtain representative surface roughness

Arithmetic average roughness Ra

Extract only the reference length from the roughness curve in the direction of the average line and set the X axis in the direction of the average line of the extracted portion and the Y axis in the direction of the longitudinal magnification. Refers to a value obtained by the following equation expressed in micrometers (μm) when a roughness curve is expressed by y = f (χ).

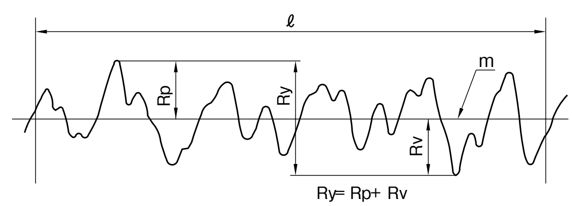


$$Ra = \frac{1}{\ell}\int_0^{\ell} |f(x)|\,dx$$

Maximum height Ry

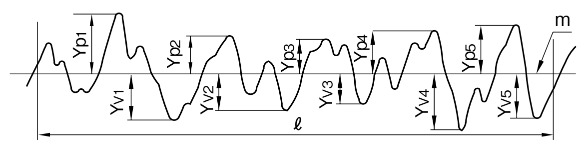
From the roughness curve, extract only the reference length in the direction of the average line, measure the interval between the summit line and the valley line of this extracted portion in the direction of the longitudinal magnification of the roughness curve.

Remarks In the case of obtaining Ry, it extracts the reference length only from the portion which is out of the ordinary and which has no high mountain and low valley which is regarded as a flaw.



Ten point average roughness Rz

Extract only the reference length from the roughness curve in the direction of the average line. The average value of the absolute values of the altitudes (Yp) of the mountain peaks from the highest peak to the fifth highest measured from the average line of the extracted portion in the direction of the longitudinal magnification and the average value of the altitudes of the valleys at the lowest valley bottom (Yv), and the average of the absolute values of the absolute values. This value is expressed in micrometers (μm).



$$Rz = \frac{|Y_{p1}+Y_{p2}+Y_{p3}+Y_{p4}+Y_{p5}| + |Y_{v1}+Y_{v2}+Y_{v3}+Y_{v4}+Y_{v5}|}{5}$$

'p1 Yp2 Yp3 Yp4 Yp5 The elevation of the summit from the highest mountain peak to the fifth highest peak in the sampling length with respect to the reference length ℓ

'v1 Yv2 Yv3 Yv4 Yv5 The elevation of the summit from the lowest mountain peak to the fifth lowest peak in the sampling length with respect to the reference length ℓ

Reference Relation between arithmetic average roughness (Ra) and conventional notation

Arithmetic average roughness Ra			Maximum height Ry	Ten point average roughness Rz	Reference length of Ry · Rz ℓ (mm)	Conventional standard sequence
Standard sequence	Cutoff value entered c (mm)	Illustration of surface skin	Standard sequence			
0.012 a	0.08	0.012√ ~ 0.2√	0.05 s	0.05 z	0.08	▽▽▽▽
0.025 a	0.25		0.1 s	0.1 z	0.25	
0.05 a			0.2 s	0.2 z		
0.1 a	0.8		0.4 s	0.4 z	0.8	
0.2 a			0.8 s	0.8 z		
0.4 a		0.4√ ~ 1.6√	1.6 s	1.6 z		▽▽▽
0.8 a			3.2 s	3.2 z		
1.6 a			6.3 s	6.3 z		
3.2 a	2.5	3.2√ ~ 6.3√	12.5 s	12.5 z	2.5	▽▽
6.3 a			25 s	25 z		
12.5 a	8	12.5√ ~ 25√	50 s	50 z		▽
25 a			100 s	100 z	8	
50 a	-	50√ ~ 100√	200 s	200 z		～
100 a			400 s	400 z	-	

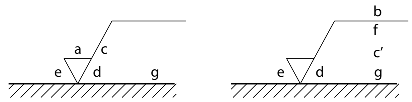
* The three kinds of mutual relations represent relationships for convenience and are not strict.
* Ra: The evaluation length of Ry, Rz is a value obtained by multiplying the cutoff value and the reference length by 5 respectively.

Diagrammatic Representation of Plane Surface Extracted from JIS B0031 (1994)

■The position of each instruction symbol with respect to the instruction symbol in the figure

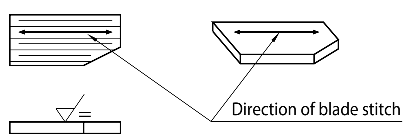
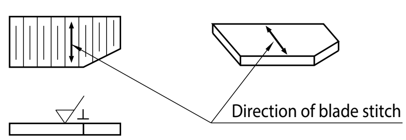
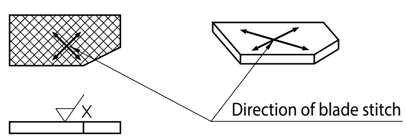
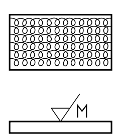
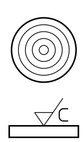
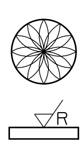
Instruction marks related to the skin of the face are obtained by placing the value of the surface roughness, the cutoff value or the reference length, the processing method, the mark of the line direction, the surface waviness and the like at the position shown in FIG. 1 Represent

Fig. 1 Input position of each instruction symbol



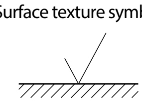
a: Value of Ra
b: Processing method
c: cutoff value · evaluation length
c ': Reference length / evaluation length
d: Symbol of line direction
f: Parameters other than Ra (parameter / disconnection level when tp)
g: Surface waviness (according to JIS B 0610)
Remarks Please fill in as necessary except for a or f.

Reference In the reference e in Fig. 1, the finishing fee is to be filled in ISO 1302.

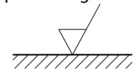
Symbol	Description	Illustration drawing
=	The direction of the stitch of the cutter by processing is parallel to the projection plane of the figure filled with the symbol Example Shaped surface	
⊥	The direction of the stitch of the cutter by machining is perpendicular to the projection plane of the drawing in which the symbol is written Example Shaped surface (state viewed from the side) Turning, cylindrical grinding surface	
X	The direction of the stitch of the knife by machining diagonally crosses in two directions on the projection plane of the figure in which the symbol is written Example Honing surface	
M	Cutting stitch of the cutter by processing intersects or diverges in many directions Example Lapped surface, superfinished surface, Front-face milling with cross-feed, or end mill cutting surface	
C	The stitch of the cutter by machining is almost concentric with the center of the face on which the symbol is written Example Surface ground surface	
R	Approximately radial shape of the blade stitch by machining against the center of the face on which the symbol is written	

■Illustrated example of skin of the face

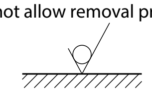
Surface texture symbol



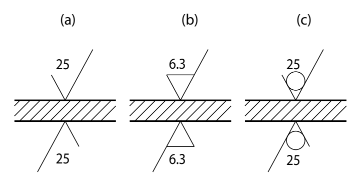
Texture symbol for surface requiring removal processing texture symbol



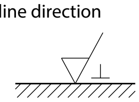
Texture symbol for surface that does not allow removal processing



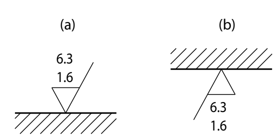
An example indicating the upper limit of Ra



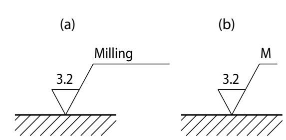
An example of instructing the line direction



An example showing the upper and lower limits of Ra

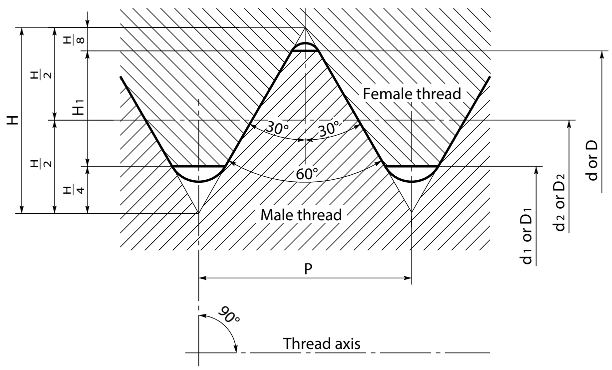


Example of instructing processing method



Metric Coarse Thread Extracted from JIS B0205 (1997) (Previous standard)

■Metric coarse thread reference chevron, official and standard dimensions



$H = 0.866025P$ $\quad d_2 = d - 0.649519P$ $\quad D = d$

$H_1 = 0.541266P$ $\quad d_1 = d - 1.082532P$ $\quad D_2 = d_2$

$D_1 = d_1$

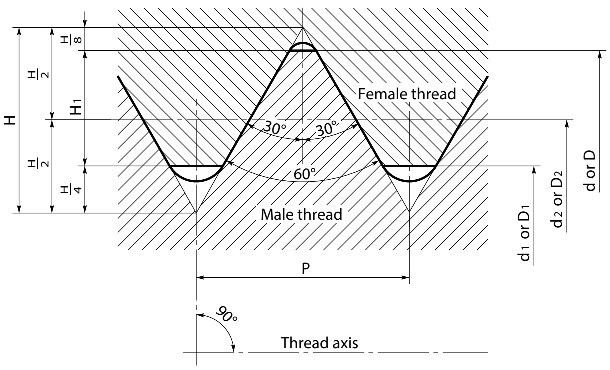
Unit: mm

Thread type*			Pitch P	Height of snag H1	Female thread: Diameter of valley D / Male thread: Outer diameter d	Female thread: Effective diameter D_2 / Male thread: Effective diameter D_2	Female thread: Inner diameter D_1 / Male thread: Diameter of valley d_1
1 column	2 column	3 column					
M1			0.25	0.135	1.000	0.838	0.729
	M1.1		0.25	0.135	1.100	0.938	0.829
M1.2			0.25	0.135	1.200	1.038	0.929
	M1.4		0.3	0.162	1.400	1.205	1.075
M1.6			0.35	0.189	1.600	1.373	1.221
	M1.8		0.35	0.189	1.800	1.573	1.421
M2			0.4	0.217	2.000	1.740	1.567
	M2.2		0.45	0.244	2.200	1.908	1.713
M2.5			0.45	0.244	2.500	2.208	2.013
M3			0.5	0.271	3.000	2.675	2.459
	M3.5		0.6	0.325	3.500	3.110	2.850
M4			0.7	0.379	4.000	3.545	3.242
	M4.5		0.75	0.406	4.500	4.013	3.688
M5			0.8	0.433	5.000	4.480	4.134
M6			1	0.541	6.000	5.350	4.917
		M7	1	0.541	7.000	6.350	5.917
M8			1.25	0.677	8.000	7.188	6.647
		M9	1.25	0.677	9.000	8.188	7.647
M10			1.5	0.812	10.000	9.026	8.376
		M11	1.5	0.812	11.000	10.026	9.376
M12			1.75	0.947	12.000	10.863	10.106
	M14		2	1.083	14.000	12.701	11.835
M16			2	1.083	16.000	14.701	13.835
	M18		2.5	1.353	18.000	16.376	15.294
M20			2.5	1.353	20.000	18.376	17.294
	M22		2.5	1.353	22.000	20.376	19.294
M24			3	1.624	24.000	22.051	20.752
	M27		3	1.624	27.000	25.051	23.752
M30			3.5	1.894	30.000	27.727	26.211
	M33		3.5	1.894	33.000	30.727	29.211
M36			4	2.165	36.000	33.402	31.670
	M39		4	2.165	39.000	36.402	34.670
M42			4.5	2.436	42.000	39.077	37.129
	M45		4.5	2.436	45.000	42.077	40.129
M48			5	2.706	48.000	44.752	42.587
	M52		5	2.706	52.000	48.752	46.587
M56			5.5	2.977	56.000	52.428	50.046
	M60		5.5	2.977	60.000	56.428	54.046
M64			6	3.248	64.000	60.103	57.505
	M68		6	3.248	68.000	64.103	61.505

* Select the 1 column preferentially, if necessary, in the 2nd and 3rd columns.

Metric Fine Thread Extracted from JIS B0207 (1982) (Previous standard)

■Metric fine thread standard chevron, official and standard dimensions



$H = 0.866025P$ $d_2 = d - 0.649519P$ $D = d$

$H_1 = 0.541266P$ $d_1 = d - 1.082532P$ $D_2 = d_2$

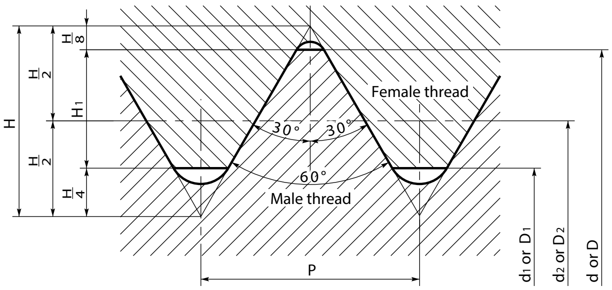
$D_1 = d_1$

Unit: mm

Thread type	Pitch P	Height of snag H1	Female thread		
			Diameter of valley D	Effective diameter D_2	Inner diameter D_1
			Male thread		
			Outer diameter d	Effective diameter d_2	Diameter of valley d_1
M1×0.2	0.2	0.108	1.000	0.870	0.783
M1.1×0.2	0.2	0.108	1.100	0.970	0.883
M1.2×0.2	0.2	0.108	1.200	1.070	0.983
M1.4×0.2	0.2	0.108	1.400	1.270	1.183
M1.6×0.2	0.2	0.108	1.600	1.470	1.383
M1.8×0.2	0.2	0.108	1.800	1.670	1.583
M2×0.25	0.25	0.135	2.000	1.838	1.729
M2.2×0.25	0.25	0.135	2.200	2.038	1.929
M2.5×0.35	0.35	0.189	2.500	2.273	2.121
M3×0.35	0.35	0.189	3.000	2.773	2.621
M3.5×0.35	0.35	0.189	3.500	3.273	3.121
M4×0.5	0.5	0.271	4.000	3.675	3.459
M4.5×0.5	0.5	0.271	4.500	4.175	3.959
M5×0.5	0.5	0.271	5.000	4.675	4.459
M5.5×0.5	0.5	0.271	5.500	5.175	4.959
M6×0.75	0.75	0.406	6.000	5.513	5.188
M7×0.75	0.75	0.406	7.000	6.513	6.188
M8×1	1	0.541	8.000	7.350	6.917
M8×0.75	0.75	0.406	8.000	7.513	7.188
M9×1	1	0.541	9.000	8.350	7.917
M9×0.75	0.75	0.406	9.000	8.513	8.188
M10×1.25	1.25	0.677	10.000	9.188	8.647
M10×1	1	0.541	10.000	9.350	8.917
M10×0.75	0.75	0.406	10.000	9.513	9.188
M11×1	1	0.541	11.000	10.350	9.917
M11×0.75	0.75	0.406	11.000	10.513	10.188
M12×1.5	1.5	0.812	12.000	11.026	10.376
M12×1.25	1.25	0.677	12.000	11.188	10.647
M12×1	1	0.541	12.000	11.350	10.917
M14×1.5	1.5	0.812	14.000	13.026	12.376
M14×1.25	1.25	0.677	14.000	13.188	12.647
M14×1	1	0.541	14.000	13.350	12.917
M15×1.5	1.5	0.812	15.000	14.026	13.376
M15×1	1	0.541	15.000	14.350	13.917
M16×1.5	1.5	0.812	16.000	15.026	14.376
M16×1	1	0.541	16.000	15.350	14.917
M17×1.5	1.5	0.812	17.000	16.026	15.376
M17×1	1	0.541	17.000	16.350	15.917
M18×2	2	1.083	18.000	16.701	15.835
M18×1.5	1.5	0.812	18.000	17.026	16.376
M18×1	1	0.541	18.000	17.350	16.917
M20×2	2	1.083	20.000	18.701	17.835
M20×1.5	1.5	0.812	20.000	19.026	18.376
M20×1	1	0.541	20.000	19.350	18.917
M22×2	2	1.083	22.000	20.701	19.835
M22×1.5	1.5	0.812	22.000	21.026	20.376
M22×1	1	0.541	22.000	21.350	20.917
M24×2	2	1.083	24.000	22.701	21.835
M24×1.5	1.5	0.812	24.000	23.026	22.376
M24×1	1	0.541	24.000	23.350	22.917

Unified Coarse Thread/Fine Thread Extracted from JIS B0206 (1973), JIS B0208 (1973)

■Unified coarse / fine thread standard chevron, official and standard dimensions



$H = \frac{25.4}{n}$　　$H = \frac{0.866025}{n} \times 25.4$　　$d = (d) \times 25.4$　　$D = d$

$H_1 = \frac{0.541266}{n} \times 25.4$　　$d_2 = \left(d - \frac{0.649519}{n} \right) \times 25.4$　　$D_2 = d_2$

$d_1 = \left(d - \frac{1.082532}{n} \right) \times 25.4$　　$D_1 = d_1$

n: 25.4mm of Thread height

Unified coarse thread

Unit: mm

Thread type*			Number of threads (Per 25.4 mm) n	Pitch P (reference)	Height of snag H1	Female thread		
						Diameter of valley D	Effective diameter D_2	Inner diameter D_1
1	2	(reference)				Male thread		
						Outer diameter d	Effective diameter d_2	Diameter of valley d_1
	No. 1-64 UNC	0.0730-64 UNC	64	0.3969	0.215	1.854	1.598	1.425
No. 2 - 56 UNC		0.0860-56 UNC	56	0.4536	0.246	2.184	1.890	1.694
	No. 3-48 UNC	0.0990-48 UNC	48	0.5292	0.286	2.515	2.172	1.941
No. 4 - 40 UNC		0.1120-40 UNC	40	0.6350	0.344	2.845	2.433	2.156
No. 5 - 40 UNC		0.1250-40 UNC	40	0.6350	0.344	3.175	2.764	2.487
No. 6 - 32 UNC		0.1380-32 UNC	32	0.7938	0.430	3.505	2.990	2.647
No. 8 - 32 UNC		0.1640-32 UNC	32	0.7938	0.430	4.166	3.650	3.307
No. 10 - 24 UNC		0.1900-24 UNC	24	1.0583	0.573	4.826	4.138	3.680
	No.12-24 UNC	0.2160-24 UNC	24	1.0583	0.573	5.486	4.798	4.341
1/4 - 20 UNC		0.2500-20 UNC	20	1.2700	0.687	6.350	5.524	4.976
5/16 - 18 UNC		0.3125-18 UNC	18	1.4111	0.764	7.938	7.021	6.411
3/8 - 16 UNC		0.3750-16 UNC	16	1.5875	0.859	9.525	8.494	7.805
7/16 - 14 UNC		0.4375-14 UNC	14	1.8143	0.982	11.112	9.934	9.149
1/2 - 13 UNC		0.5000-13 UNC	13	1.9538	1.058	12.700	11.430	10.584
9/16 - 12 UNC		0.5625-12 UNC	12	2.1167	1.146	14.288	12.913	11.996
5/8 - 11 UNC		0.6250-11 UNC	11	2.3091	1.250	15.875	14.376	13.376
3/4 - 10 UNC		0.7500-10 UNC	10	2.5400	1.375	19.050	17.399	16.299
7/8 - 9 UNC		0.8750- 9 UNC	9	2.8222	1.528	22.225	20.391	19.169
1 - 8 UNC		1.0000- 8 UNC	8	3.1750	1.719	25.400	23.338	21.963
1 1/8 - 7 UNC		1.1250- 7 UNC	7	3.6286	1.964	28.575	26.218	24.648
1 1/8 - 7 UNC		1.2500- 7 UNC	7	3.6286	1.964	31.750	29.393	27.823

* Select the 1 column preferentially, if necessary, in the 2nd.In the reference column, the designation of the screw is shown in decimal form.

Unified fine thread

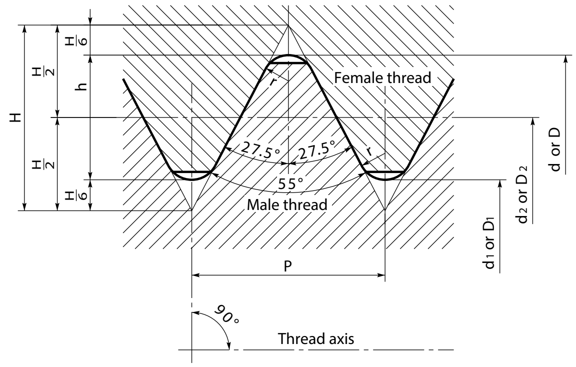
Unit: mm

No. 0 - 80 UNF		0.0600-80 UNF	80	0.3175	0.172	1.524	1.318	1.181
	No. 1-72 UNF	0.0730-72 UNF	72	0.3528	0.191	1.854	1.626	1.473
No. 2 - 64 UNF		0.0860-64 UNF	64	0.3969	0.215	2.184	1.928	1.755
	No. 3-56 UNF	0.0990-56 UNF	56	0.4536	0.246	2.515	2.220	2.024
No. 4 - 48 UNF		0.1120-48 UNF	48	0.5292	0.286	2.845	2.502	2.271
No. 5 - 44 UNF		0.1250-44 UNF	44	0.5773	0.312	3.175	2.799	2.550
No. 6 - 40 UNF		0.1380-40 UNF	40	0.6350	0.344	3.505	3.094	2.817
No. 8 - 36 UNF		0.1640-36 UNF	36	0.7056	0.382	4.166	3.708	3.401
No. 10 - 32 UNF		0.1900-32 UNF	32	0.7938	0.430	4.826	4.310	3.967
	No.12-28 UNF	0.2160-28 UNF	28	0.9071	0.491	5.486	4.897	4.503
1/4 - 28 UNF		0.2500-28 UNF	28	0.9071	0.491	6.350	5.761	5.367
5/16 - 24 UNF		0.3125-24 UNF	24	1.0583	0.573	7.938	7.249	6.792
3/8 - 24 UNF		0.3750-24 UNF	24	1.0583	0.573	9.525	8.837	8.379
7/16 - 20 UNF		0.4375-20 UNF	20	1.2700	0.687	11.112	10.287	9.738
1/2 - 20 UNF		0.5000-20 UNF	20	1.2700	0.687	12.700	11.874	11.326
9/16 - 18 UNF		0.5625-18 UNF	18	1.4111	0.764	14.288	13.371	12.761
5/8 - 18 UNF		0.6250-18 UNF	18	1.4111	0.764	15.875	14.958	14.348
3/4 - 16 UNF		0.7500-16 UNF	16	1.5875	0.859	19.050	18.019	17.330
7/8 - 14 UNF		0.8750-14 UNF	14	1.8143	0.982	22.225	21.046	20.262
1 - 12 UNF		1.0000-12 UNF	12	2.1167	1.146	25.400	24.026	23.109
1 1/8 - 12 UNF		1.1250-12 UNF	12	2.1167	1.146	28.575	27.201	26.284

* Select the 1 column preferentially, if necessary, in the 2nd.In the reference column, the designation of the screw is shown in decimal form.

Parallel Thread for Pipe Extracted from JIS B0202 (1999)

■Standard chevron shape of parallel threads for pipes, official and standard dimensions



$P = \frac{25.4}{n}$

$H = 0.960491\,P$

$h = 0.640327\,P$

$r = 0.137329\,P$

$d_2 = d - h$ $D_2 = d_2$

$d_1 = d - 2h$ $D_1 = d_1$

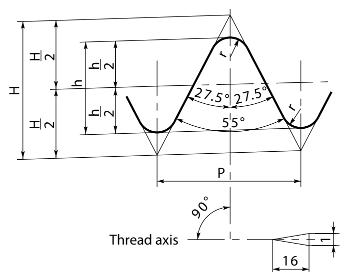
Unit: mm

Thread type	Number of threads (Per 25.4 mm) n	Pitch P (reference)	Thread height h	Round of peaks and valleys of mountains r	Male thread: Outer diameter d / Female thread: Diameter of valley D	Male thread: Effective diameter d_2 / Female thread: Effective diameter D_2	Male thread: Diameter of valley d_1 / Female thread: Inner diameter D_1
G1/16	28	0.9071	0.581	0.12	7.723	7.142	6.561
G1/8	28	0.9071	0.581	0.12	9.728	9.147	8.566
G1/4	19	1.3368	0.856	0.18	13.157	12.301	11.445
G3/8	19	1.3368	0.856	0.18	16.662	15.806	14.950
G1/2	14	1.8143	1.162	0.25	20.955	19.793	18.631
G5/8	14	1.8143	1.162	0.25	22.911	21.749	20.587
G3/4	14	1.8143	1.162	0.25	26.441	25.279	24.117
G7/8	14	1.8143	1.162	0.25	30.201	29.039	27.877
G1	11	2.3091	1.479	0.32	33.249	31.770	30.291
G1 1/8	11	2.3091	1.479	0.32	37.897	36.418	34.939
G1 1/4	11	2.3091	1.479	0.32	41.910	40.431	38.952
G1 1/2	11	2.3091	1.479	0.32	47.803	46.324	44.845
G1 3/4	11	2.3091	1.479	0.32	53.746	52.267	50.788
G2	11	2.3091	1.479	0.32	59.614	58.135	56.656
G2 1/4	11	2.3091	1.479	0.32	65.710	64.231	62.752
G2 1/2	11	2.3091	1.479	0.32	75.184	73.705	72.226
G2 3/4	11	2.3091	1.479	0.32	81.534	80.055	78.576
G3	11	2.3091	1.479	0.32	87.884	86.405	84.926
G3 1/2	11	2.3091	1.479	0.32	100.330	98.851	97.372
G4	11	2.3091	1.479	0.32	113.030	111.551	110.072
G4 1/2	11	2.3091	1.479	0.32	125.730	124.251	122.772
G5	11	2.3091	1.479	0.32	138.430	136.951	135.472
G5 1/2	11	2.3091	1.479	0.32	151.130	149.651	148.172
G6	11	2.3091	1.479	0.32	163.830	162.351	160.872

Taper Thread for Pipe Extracted from JIS B0203 (1999)

■Standard chevron shape of pipe taper thread, official and standard size

Standard chevron applicable to taper male thread and taper female thread



The thick solid line indicates the reference mountain shape.

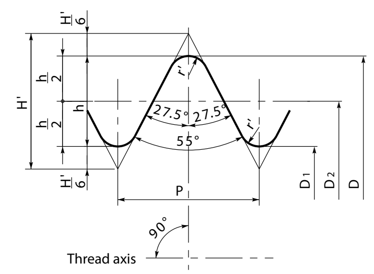
$P = \frac{25.4}{n}$

$H = 0.960\ 237\ P$

$h = 0.640\ 327\ P$

$r = 0.137\ 278\ P$

Standard chevrons to be applied to parallel internal threads



The thick solid line indicates the reference mountain shape.

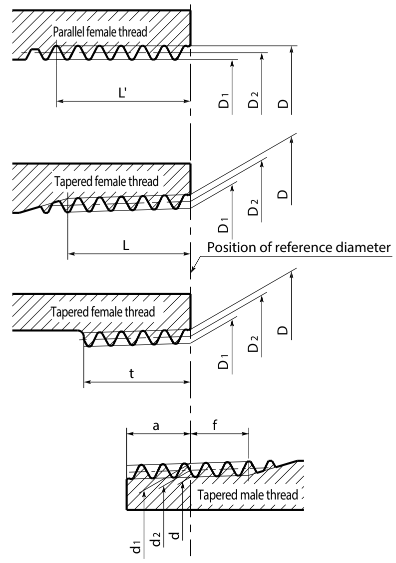
$P = \frac{25.4}{n}$

$H' = 0.960\ 491\ P$

$h = 0.640\ 327\ P$

$r' = 0.137\ 329\ P$

Fitting of taper thread with tapered female thread or parallel female thread



Unit: mm

*1 Thread type	ねじ山: Number of threads (Per 25.4 mm) n	ねじ山: Pitch P (reference)	ねじ山: Mountain Height h	ねじ山: Roundness r or r'	Reference diameter: Male thread Outer diameter d / Female thread Diameter of valley D	Reference diameter: Male thread Effective diameter d2 / Female thread Effective diameter D2	Reference diameter: Male thread Diameter of valley d1 / Female thread Inner diameter D1	Position of reference diameter: Male thread, From the pipe end: Length of reference a	Position of reference diameter: Male thread, From the pipe end: Axis direction Tolerance b	Position of reference diameter: Female thread, Pipe end: Axis direction Tolerance c	Tolerance of D, D2 and D1 of parallel internal thread	Effective thread length (minimum): Male thread, From the position of the reference diameter toward the larger diameter side, f	Female thread, When there is an incomplete thread portion: Taper female thread, From the position of the reference diameter toward the smaller diameter side, l	Female thread, When there is an incomplete thread portion: Parallel female thread, From the pipe or pipe joint end l'	Female thread, When there is no incomplete thread: Taper female thread, Parallel female thread *2 t	Dimensions of carbon steel pipe for piping (reference): Outline	Dimensions of carbon steel pipe for piping (reference): Thickness
R1/16	28	0.9071	0.581	0.12	7.723	7.142	6.561	3.97	±0.91	±1.13	±0.071	2.5	6.2	7.4	4.4	-	-
R1/8	28	0.9071	0.581	0.12	9.728	9.147	8.566	3.97	±0.91	±1.13	±0.071	2.5	6.2	7.4	4.4	10.5	2.0
R1/4	19	1.3368	0.856	0.18	13.157	12.301	11.445	6.01	±1.34	±1.67	±0.104	3.7	9.4	11.0	6.7	13.8	2.3
R3/8	19	1.3368	0.856	0.18	16.662	15.806	14.950	6.35	±1.34	±1.67	±0.104	3.7	9.7	11.4	7.0	17.3	2.3
R1/2	14	1.8143	1.162	0.25	20.955	19.793	18.631	8.16	±1.81	±2.27	±0.142	5.0	12.7	15.0	9.1	21.7	2.8
R3/4	14	1.8143	1.162	0.25	26.441	25.279	24.117	9.53	±1.81	±2.27	±0.142	5.0	14.1	16.3	10.2	27.2	2.8
R1	11	2.3091	1.479	0.32	33.249	31.770	30.291	10.39	±2.31	±2.89	±0.181	6.4	16.2	19.1	11.6	34	3.2
R1 1/4	11	2.3091	1.479	0.32	41.910	40.431	38.952	12.70	±2.31	±2.89	±0.181	6.4	18.5	21.4	13.4	42.7	3.5
R1 1/2	11	2.3091	1.479	0.32	47.803	46.324	44.845	12.70	±2.31	±2.89	±0.181	6.4	18.5	21.4	13.4	48.6	3.5
R2	11	2.3091	1.479	0.32	59.614	58.135	56.656	15.88	±2.31	±2.89	±0.181	7.5	22.8	25.7	16.9	60.5	3.8
R2 1/2	11	2.3091	1.479	0.32	75.184	73.705	72.226	17.46	±3.46	±3.46	±0.216	9.2	26.7	30.1	18.6	76.3	4.2
R3	11	2.3091	1.479	0.32	87.884	86.405	84.926	20.64	±3.46	±3.46	±0.216	9.2	29.8	33.3	21.1	89.1	4.2
R4	11	2.3091	1.479	0.32	113.030	111.551	110.072	25.40	±3.46	±3.46	±0.216	10.4	35.8	39.3	25.9	114.3	4.5
R5	11	2.3091	1.479	0.32	138.430	136.951	135.472	28.58	±3.46	±3.46	±0.216	11.5	40.1	43.5	29.3	139.8	4.5
R6	11	2.3091	1.479	0.32	163.830	162.351	160.872	28.58	±3.46	±3.46	±0.216	11.5	40.1	43.5	29.3	165.2	5.0

* 1 This is for taper threads. For tapered female threads and parallel female threads, let R be R or RP.
* 2 The length of the tapered screw from the position of the reference diameter toward the smaller diameter side, and the parallel female thread length from the end of the pipe or pipe joint.

Hardness Conversion Table SAE J417 * Revised in 1983

■Approximate conversion value for steel Rockwell C hardness (1)

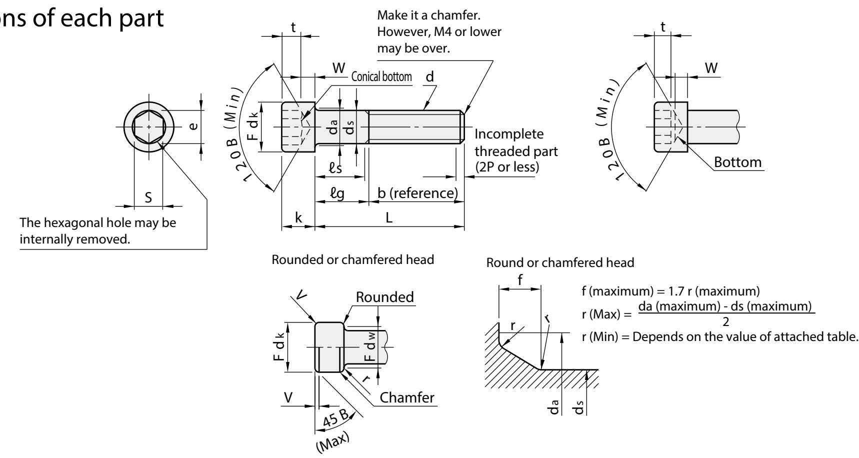
(HRC) Rockwell C scale hardness	(HV) Vickers hardness	Brinell hardness (HB) 10 mm ball Load 3000 kgf		Rockwell hardness (3)			Rockwell Super Superficial Hardness Diamond conical indenter			(Hs) Shore hardness	Tensile strength (approximate value) MPa (kgf/mm²) (2)	Rockwell C scale hardness (3)
		Standard ball	Tungsten Carbide ball	(HRA) A scale Load 60 kgf Diamond conical indenter	(HRB) B scale Load 100 kgf Diameter 1.6 mm (1/16 in) ball	(HRD) D scale Load 100 kgf Diamond conical indenter	15-N scale load 15 kgf	30-N scale load 30 kgf	45-N scale load 45 kgf			
68	940	-	-	85.6	-	76.9	93.2	84.4	75.4	97	-	68
67	900	-	-	85.0	-	76.1	92.9	83.6	74.2	95	-	67
66	865	-	-	84.5	-	75.4	92.5	82.8	73.3	92	-	66
65	832	-	(739)	83.9	-	74.5	92.2	81.9	72.0	91	-	65
64	800	-	(722)	83.4	-	73.8	91.8	81.1	71.0	88	-	64
63	772	-	(705)	82.8	-	73.0	91.4	80.1	69.9	87	-	63
62	746	-	(688)	82.3	-	72.2	91.1	79.3	68.8	85	-	62
61	720	-	(670)	81.8	-	71.5	90.7	78.4	67.7	83	-	61
60	697	-	(654)	81.2	-	70.7	90.2	77.5	66.6	81	-	60
59	674	-	(634)	80.7	-	69.9	89.8	76.6	65.5	80	-	59
58	653	-	615	80.1	-	69.2	89.3	75.7	64.3	78	-	58
57	633	-	595	79.6	-	68.5	88.9	74.8	63.2	76	-	57
56	613	-	577	79.0	-	67.7	88.3	73.9	62.0	75	-	56
55	595	-	560	78.5	-	66.9	87.9	73.0	60.9	74	2075(212)	55
54	577	-	543	78.0	-	66.1	87.4	72.0	59.8	72	2015(205)	54
53	560	-	525	77.4	-	65.4	86.9	71.2	58.5	71	1950(199)	53
52	544	(500)	512	76.8	-	64.6	86.4	70.2	57.4	69	1880(192)	52
51	528	(487)	496	76.3	-	63.8	85.9	69.4	56.1	68	1820(186)	51
50	513	(475)	481	75.9	-	63.1	85.5	68.5	55.0	67	1760(179)	50
49	498	(464)	469	75.2	-	62.1	85.0	67.6	53.8	66	1695(173)	49
48	484	451	455	74.7	-	61.4	84.5	66.7	52.5	64	1635(167)	48
47	471	442	443	74.1	-	60.8	83.9	65.8	51.4	63	1580(161)	47
46	458	432	432	73.6	-	60.0	83.5	64.8	50.3	62	1530(156)	46
45	446	421	421	73.1	-	59.2	83.0	64.0	49.0	60	1480(151)	45
44	434	409	409	72.5	-	58.5	82.5	63.1	47.8	58	1435(146)	44
43	423	400	400	72.0	-	57.7	82.0	62.2	46.7	57	1385(141)	43
42	412	390	390	71.5	-	56.9	81.5	61.3	45.5	56	1340(136)	42
41	402	381	381	70.9	-	56.2	80.9	60.4	44.3	55	1295(132)	41
40	392	371	371	70.4	-	55.4	80.4	59.5	43.1	54	1250(127)	40
39	382	362	362	69.9	-	54.6	79.9	58.6	41.9	52	1215(124)	39
38	372	353	353	69.4	-	53.8	79.4	57.7	40.8	51	1180(120)	38
37	363	344	344	68.9	-	53.1	78.8	56.8	39.6	50	1160(118)	37
36	354	336	336	68.4	(109.0)	52.3	78.3	55.9	38.4	49	1115(114)	36
35	345	327	327	67.9	(108.5)	51.5	77.7	55.0	37.2	48	1080(110)	35
34	336	319	319	67.4	(108.0)	50.8	77.2	54.2	36.1	47	1055(108)	34
33	327	311	311	66.8	(107.5)	50.0	76.6	53.3	34.9	46	1025(105)	33
32	318	301	301	66.3	(107.0)	49.2	76.1	52.1	33.7	44	1000(102)	32
31	310	294	294	65.8	(106.0)	48.4	75.6	51.3	32.7	43	980(100)	31
30	302	286	286	65.3	(105.5)	47.7	75.0	50.4	31.3	42	950(97)	30
29	294	279	279	64.7	(104.5)	47.0	74.5	49.5	30.1	41	930(95)	29
28	286	271	271	64.3	(104.0)	46.1	73.9	48.6	28.9	41	910(93)	28
27	279	264	264	63.8	(103.0)	45.2	73.3	47.7	27.8	40	880(90)	27
26	272	258	258	63.3	(102.5)	44.6	72.8	46.8	26.7	38	860(88)	26
25	266	253	253	62.8	(101.5)	43.8	72.2	45.9	25.5	38	840(86)	25
24	260	247	247	62.4	(101.0)	43.1	71.6	45.0	24.3	37	825(84)	24
23	254	243	243	62.0	100.0	42.1	71.0	44.0	23.1	36	805(82)	23
22	248	237	237	61.5	99.0	41.6	70.5	43.2	22.0	35	785(80)	22
21	243	231	231	61.0	98.5	40.9	69.9	42.3	20.7	35	770(79)	21
20	238	226	226	60.5	97.8	40.1	69.4	41.5	19.6	34	760(77)	20
(18)	230	219	219	-	96.7	-	-	-	-	33	730(75)	(18)
(16)	222	212	212	-	95.5	-	-	-	-	32	705(72)	(16)
(14)	213	203	203	-	93.9	-	-	-	-	31	675(69)	(14)
(12)	204	194	194	-	92.3	-	-	-	-	29	650(66)	(12)
(10)	196	187	187	-	90.7	-	-	-	-	28	620(63)	(10)
(8)	188	179	179	-	89.5	-	-	-	-	27	600(61)	(8)
(6)	180	171	171	-	87.1	-	-	-	-	26	580(59)	(6)
(4)	173	165	165	-	85.5	-	-	-	-	25	550(56)	(4)
(2)	166	158	158	-	83.5	-	-	-	-	24	530(54)	(2)
(0)	160	152	152	-	81.7	-	-	-	-	24	515(53)	(0)

Note (1) Blue numbers are based on ASTM E 140 Table 1 (SAE, ASM, ASTM jointly adjusted).
(2) Units and numerical values shown with parentheses () are converted from psi by JIS Z 8413 and Z 8438 conversion tables. Note that 1 MPa = 1 N / mm²
(3) Parentheses in the table Numbers in parentheses () are those which are not used much and are shown as reference.

Hexagon Socket Head Cap Screw Extracted from JIS B 1776 (2006)

■Correlation table of classification of reference dimension and tolerance range class of axis

1. Dimensions of each part



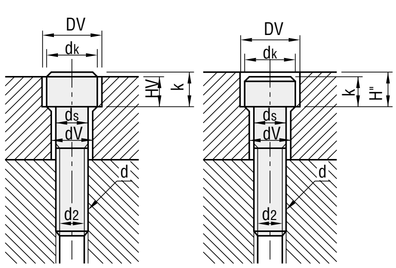
Unit: mm

Thread type(d)[15]			M3	M4	M5	M6	M8	M10	M12	(M14)	M16	(M18)	M20	(M22)	M24	(M27)	M30
Screw Pitch (P)[14]			0.5	0.7	0.8	1	1.25	1.5	1.75	2	2	2.5	2.5	2.5	3	3	3.5
b	Reference		18	20	22	24	28	32	36	40	44	48	52	56	60	66	72
dk	Maximum (reference dimension)*		5.5	7	8.5	10	13	16	18	21	24	27	30	33	36	40	45
	Maximum**		5.68	7.22	8.72	10.22	13.27	16.27	18.27	21.33	24.33	27.33	30.33	33.39	36.39	40.39	45.39
	Minimum		5.32	6.78	8.28	9.78	12.73	15.73	17.73	20.67	23.67	26.67	29.67	32.61	35.61	39.61	44.61
da	Maximum		3.6	4.7	5.7	6.8	9.2	11.2	13.7	15.7	17.7	20.2	22.4	24.4	26.4	30.4	33.4
ds	Maximum (reference dimension)		3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
	Minimum		2.86	3.82	4.82	5.82	7.78	9.78	11.73	13.73	15.73	17.73	19.67	21.67	23.67	26.67	29.67
e	Minimum		2.87	3.44	4.58	5.72	6.86	9.15	11.43	13.72	16.00	16.00	19.44	19.44	21.73	21.73	25.15
f	Maximum		0.51	0.60	0.60	0.68	1.02	1.02	1.45	1.45	1.45	1.87	2.04	2.04	2.04	2.89	2.89
k	Maximum (reference dimension)		3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
	Minimum		2.86	3.82	4.82	5.70	7.64	9.64	11.57	13.57	15.57	17.57	19.48	21.48	23.48	26.48	29.48
r	Minimum		0.1	0.2	0.2	0.25	0.4	0.4	0.6	0.6	0.6	0.6	0.8	0.8	0.8	1	1
s	Type (standard dimension)		2.5	3	4	5	6	8	10	12	14	14	17	17	19	19	22
	Minimum		2.52	3.02	4.02	5.02	6.02	8.025	10.025	12.032	14.032	14.032	17.050	17.050	19.065	19.065	22.065
	Maximum	1st column	2.580	3.080	4.095	5.140	6.140	8.175	10.175	12.212	14.212	14.212	17.230	17.230	19.275	19.275	22.275
		2nd column	2.560	3.080	4.095	5.095	6.095	8.115	10.115	12.142	14.142	14.142					
t	Minimum		1.3	2	2.5	3	4	5	6	7	8	9	10	11	12	13.5	15.5
v	Maximum		0.3	0.4	0.5	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.7	3
dw	Minimum		5.07	6.53	8.03	9.38	12.33	15.33	17.23	20.17	23.17	25.87	28.87	31.81	34.81	38.61	43.61
w	Minimum		1.15	1.4	1.9	2.3	3.3	4	4.8	5.8	6.8	7.7	8.6	9.5	10.4	12.1	13.1

Note(14) The first column of s (maximum) is applied to those of strength classes 8.8 and 10.9 and those of property class A2-50, A2-70, and the second column is applied to those of intensity class 12.9. However, according to the agreement between the delivering parties, one column can be applied to those with an intensity class of 12.9.
In addition, s (maximum) of screw nominal M 20 or more is applied to all strength classifications and property classifications.

Note(15) Do not use screw brackets with parentheses as much as possible.

Remarks
1. On the side of the head, attach a knurl or a knurled knurl [see JIS B 0951 (knurled eye)]. In this case, dK (maximum) shall be the value of the ** mark shown in this table. Also, if you need something without knurling, the ordering person specifies. However, its dK (maximum) shall be the value of * indicated in this table.
2. Recommended nominal length (ℓ) for screw calls shall be within the bold frame. If ℓ is shorter than the position indicated by the dotted line, all threads shall be used, and the incomplete thread length at the neck lower portion shall be about 3P.
3. ℓg (maximum) and ℓs (minimum) for those whose nominal length (ℓ) is longer than the position indicated by the dotted line are given by the following expressions.
   ℓ_g (max) = call length (ℓ) - b
   ℓ_s (minimum) = ℓ_g (maximum) - 5P



Reference: Dimensions of the hole and bolt holes for hexagon-slotted bolts

Unit: mm

Thread type(d)	M3	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30
ds	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
d'	3.4	4.5	5.5	6.6	9	11	14	16	18	20	22	24	26	30	33
dk	5.5	7	8.5	10	13	16	18	21	24	27	30	33	36	40	45
D'	6.5	8	9.5	11	14	17.5	20	23	26	29	32	35	39	43	48
K	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
H'	2.7	3.6	4.6	5.5	7.4	9.2	11	12.8	14.5	16.5	18.5	20.5	22.5	25	28
H"	3.3	4.4	5.4	6.5	8.6	10.8	13	15.2	17.5	19.5	21.5	23.5	25.5	29	32
d2	2.6	3.4	4.3	5.1	6.9	8.6	10.4	12.2	14.2	15.7	17.7	19.7	21.2	24.2	26.7

2. L and ℓs and ℓg of hexagon socket head bolts

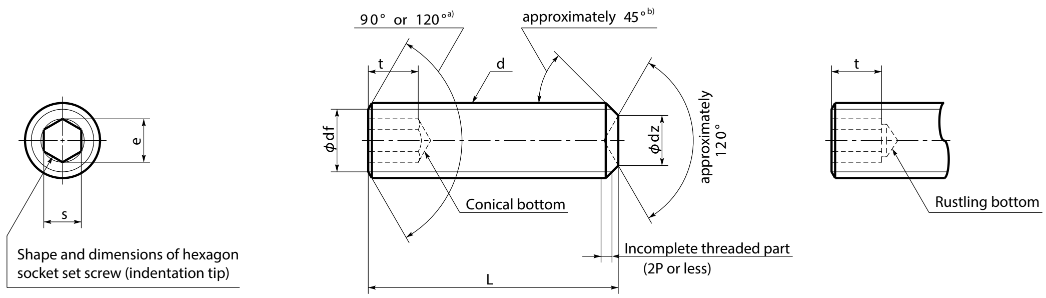
Unit: mm

Thread type (d)			M3		M4		M5		M6		M8		M10		M12		(M14)		M16		(M18)		M20		(M22)		M24		(M27)		M30	
L			ℓs min and ℓg max																													
Length	min	max	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min	ℓs min	ℓg min
5	4.76	5.24																														
6	5.76	6.24																														
8	7.71	8.29																														
10	9.71	10.29																														
12	11.65	12.35																														
16	15.65	16.35																														
20	19.58	20.42																														
25	24.58	25.42	4.5	7																												
30	29.58	30.42	9.5	12	6.5	10	4	8																								
35	34.5	35.5			11.5	15	9	13	6	11																						
40	39.5	40.5			16.5	20	14	18	11	16	5.75	12																				
45	44.5	45.5					19	23	16	21	10.75	17	5.5	13																		
50	49.5	50.5					24	28	21	26	15.75	22	10.5	18																		
55	54.4	55.6							26	31	20.75	27	15.5	23	10.25	19																
60	59.4	60.6							31	36	25.75	32	20.5	28	15.25	24	10	20														
65	64.4	65.6									30.75	37	25.5	33	20.25	29	15	25	11	21	4.5	17										
70	69.4	70.6									35.75	42	30.5	38	25.25	34	20	30	16	26	9.5	22										
80	79.4	80.6									45.75	52	40.5	48	35.25	44	30	40	26	36	19.5	32	15.5	28	11.5	24						
90	89.3	90.7											50.5	58	45.25	54	40	50	36	46	29.5	42	25.5	38	21.5	34	15	30	9	24		
100	99.3	100.7											60.5	68	55.25	64	50	60	46	56	39.5	52	35.5	48	31.5	44	25	40	19	34		
110	109.3	110.7													65.25	74	60	70	56	66	49.5	62	45.5	58	41.5	54	35	50	29	44	20.5	38
120	119.3	120.7													75.25	84	70	80	66	76	59.5	72	55.5	68	51.5	64	45	60	39	54	30.5	48
130	129.2	130.8															80	90	76	86	69.5	82	65.5	78	61.5	74	55	70	49	64	40.5	58
140	139.2	140.8															90	100	86	96	79.5	92	75.5	88	71.5	84	65	80	59	74	60.5	68
150	149.2	150.8																	96	106	89.5	102	85.5	98	81.5	94	75	90	69	84	60.5	78
160	159.2	160.8																	106	116	99.5	112	95.5	108	91.5	104	85	100	79	94	70.5	88
180	179.2	180.8																			119.5	132	115.5	128	111.5	124	105	120	99	114	90.5	108
200	199.05	200.95																					135.5	148	131.5	144	125	140	119	134	110.5	128
220	219.05	220.95																											139	154	130.5	148
240	239.05	240.95																											159	174	150.5	168
260	258.95	261.05																											179	194	170.5	188
280	278.95	281.05																											199	214	190.5	208
300	298.95	301.05																											219	234	210.5	228

Hexagon Socket Set Screw

Extracted from JIS B1177 (2007)

■Shape and dimensions of hexagon socket set screw (dent tip)



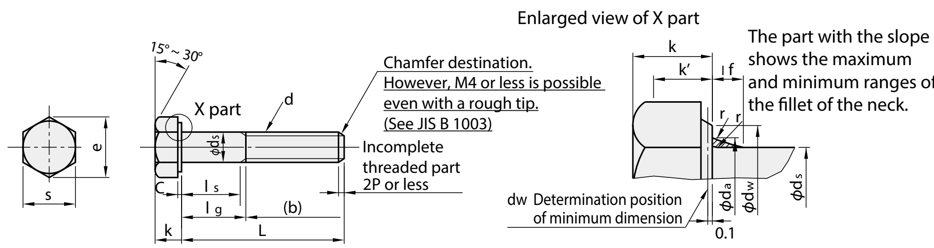
Unit: mm

Thread type (d)			M1.6	M2	M2.5	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
P c)			0.35	0.4	0.45	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2.5	3
dz	Maximum		0.8	1	1.2	1.4	2	2.5	3	5	6	8	10	14	16
	Minimum		0.55	0.75	0.95	1.15	1.75	2.25	2.75	4.7	5.7	7.64	9.64	13.57	15.57
df			Diameter of approximately the bottom of the screw												
e d),e)	Minimum		0.809	1.011	1.454	1.733	2.303	2.873	3.443	4.583	5.723	6.863	9.149	11.42	13.71
s	Type		0.7	0.9	1.3	1.5	2	2.5	3	4	5	6	8	10	12
	Maximum		0.724	0.913	1.300	1.58	2.08	2.58	3.08	4.095	5.14	6.14	8.175	10.17	12.21
	Minimum		0.71	0.887	1.275	1.52	2.02	2.52	3.02	4.02	5.02	6.02	8.025	10.02	12.03
t	Minimum	f)	0.7	0.8	1.2	1.2	1.5	2	2	3	4	4.8	6.4	8	10
		g)	1.5	1.7	2	2	2.5	3	3.5	5	6	8	10	12	15
L			(reference) Approximate mass per 100 pieces, unitkg (Density: 7.85kg/dm^3)												
Length	Minimum	Maximum													
2	1.8	2.2	0.019	0.029											
2.5	2.3	2.7	0.025	0.037	0.063										
3	2.8	3.2	0.029	0.044	0.075	0.1									
4	3.76	4.24	0.037	0.059	0.1	0.14	0.23								
5	4.76	5.24	0.046	0.074	0.125	0.18	0.305	0.42							
6	5.76	6.24	0.054	0.089	0.15	0.22	0.38	0.54	0.74						
8	7.71	8.29	0.07	0.119	0.199	0.3	0.53	0.78	1.09	1.88					
10	9.71	10.2		0.148	0.249	0.38	0.68	1.02	1.44	2.51	3.72				
12	11.6	12.3			0.299	0.46	0.83	1.26	1.79	3.14	4.73	6.7			
16	15.6	16.3				0.62	1.13	1.74	2.49	4.4	6.73	9.5	15.7		
20	19.5	20.4					1.4	2.22	3.19	5.66	8.72	12.3	20.9	31.1	
25	24.5	25.4						2.82	4.07	7.24	11.2	15.8	27.4	41.4	55.2
30	29.5	30.4							4.94	8.81	13.7	19.3	33.9	51.7	70.3
35	34.5	35.5								10.4	16.2	22.7	40.4	62	85.3
40	39.5	40.5								12	18.7	26.2	46.9	72.3	100
45	44.5	45.5									21.2	29.7	53.3	82.6	115
50	49.5	50.5									23.6	33.2	59.8	92.6	130
55	54.4	55.6										36.6	66.3	103	145
60	59.4	60.6										40.1	72.8	114	160

NOTE The recommended nominal length shall be within the thick line frame.
a) If the nominal length L is shown in the stepwise shading shown in the table above, bear the chamfer of 120 °.
b) An angle of about 45 ° applies to the slope below the diameter of the valley of the external thread.
c) P is the screw pitch.
d) emin = 1.14 s min
e) Gauge inspection of e and s is according to JIS B 1016.
f) Apply to shaded nominal threads.
g) Applicable to nominal length screws not shaded.

Hexagon Bolt Extracted from JIS B1180 (1999)

■ Shape and dimensions of hexagon bolt (part class A)



Unit: mm

Thread type (d)	Coarse thread I column	M2	M3	M4	M5	M6	M8	M10	M12	-	M16	M20	M24
	II column	-	-	-	-	-	-	-	-	M14	-	-	-
	Coarse pitch P	0.4	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2	2.5	3
	Fine thread I column	-	-	-	-	-	M8×1	M10×1	M12×1.5	-	M16×1.5	M20×1.5	M24×2
	II column	-	-	-	-	-	-	M10×1.25	M12×1.25	M14×1.5	-	M20×2	-
b (reference)	L≦125mm	10	12	14	16	18	22	26	30	34	38	46	54
	125<L≦150mm	-	-	-	-	-	-	-	-	40	44	52	60
c	Minimum	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.2	0.2	0.2
	Maximum	0.25	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.8	0.8	0.8
da	Maximum	2.6	3.6	4.7	5.7	6.8	9.2	11.2	13.7	15.7	17.7	22.4	26.4
ds	Reference dimension = maximum	2	3	4	5	6	8	10	12	14	16	20	24
	Minimum	1.86	2.86	3.82	4.82	5.82	7.78	9.78	11.73	13.73	15.73	19.67	23.67
dw	Minimum	3.07	4.57	5.88	6.88	8.88	11.63	14.63	16.63	*19.64	22.49	28.19	33.61
e	Minimum	4.32	6.01	7.66	8.79	11.05	14.38	17.77	20.03	23.36	26.75	33.53	39.98
lf	Maximum	0.8	1	1.2	1.2	1.4	2	2	3	3	3	4	4
k	Reference dimension = Type	1.4	2	2.8	3.5	4	5.3	6.4	7.5	8.8	10	12.5	15
	Minimum	1.275	1.875	2.675	3.35	3.85	5.15	6.22	7.32	8.62	9.82	12.285	14.785
	Maximum	1.525	2.125	2.925	3.65	4.15	5.45	6.58	7.68	8.98	10.18	12.715	15.215
k'	Minimum	0.89	1.31	1.87	2.35	2.7	3.61	4.35	5.12	6.03	6.87	8.6	10.35
r	Minimum	0.1	0.1	0.2	0.2	0.25	0.4	0.4	0.6	0.6	0.6	0.8	0.8
s	Reference dimension = maximum	4	5.5	7	8	10	13	16	18	21	24	30	36
	Minimum	3.82	5.32	6.78	7.78	9.78	12.73	15.73	17.73	20.67	23.67	29.67	35.38

Bolt length (L)			ℓs and ℓg																							
Nominal length (Reference dimension)	Minimum	Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum	ℓs Minimum	ℓg Maximum
16	15.65	16.35	4	6																						
20	19.58	20.42	8	10	5.5	8																				
25	24.58	25.42			10.5	13	7.5	11	5	9																
30	29.58	30.42			15.5	18	12.5	16	10	14	7	12														
35	34.5	35.5					17.5	21	15	19	12	17														
40	39.5	40.5					22.5	26	20	24	17	22	11.75	18												
45	44.5	45.5							25	29	22	27	16.75	23	11.5	19										
50	49.5	50.5							30	34	27	32	21.75	28	16.5	24	11.25	20								
55	54.4	55.6									32	37	26.75	33	21.5	29	16.25	25								
60	59.4	60.6									37	42	31.75	38	26.5	34	21.25	30	16	26						
65	64.4	65.6											36.75	43	31.5	39	26.25	35	21	31	17	27				
70	69.4	70.6											41.75	48	36.5	44	31.25	40	26	36	22	32				
80	79.4	80.6											51.75	58	46.5	54	41.25	50	36	46	32	42	21.5	34		
90	89.3	90.7													56.5	64	51.25	60	46	56	42	52	31.5	44	21	36
100	99.3	100.7													66.5	74	61.25	70	56	66	52	62	41.5	54	31	46
110	109.3	110.7															71.25	80	66	76	62	72	51.5	64	41	56
120	119.3	120.7															81.25	90	76	86	72	82	61.5	74	51	66
130	129.2	130.8																	80	90	76	86	65.5	78	55	70
140	139.2	140.8																	90	100	86	96	75.5	88	65	80
150	149.2	150.8																			96	106	85.5	98	75	90

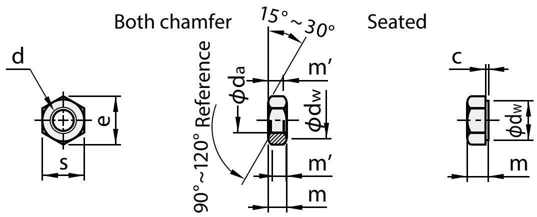
Remarks
1. The name of the thread shall be given priority in column 1. The way of expressing the call of the thread is according to JIS B 0123.
2. Recommended nominal length (L) for screw calls shall be within the bold frame.
3. The tolerance of the screw length (b) of the bolt which is longer than the maximum nominal length in the heavy line frame depends on the agreement between the delivering parties, but it is better in accordance with JIS B 1021.
4. lg maximum and ls minimum are as follows. lg maximum = nominal length (L) - b, ls minimum = lg maximum -5 P (P = coarse pitch)
5. The values of da and r specified in this table are in accordance with JIS B 1005.
6. The "chamfered destination" and "roughness" of the thread tip shape shall conform to JIS B 1003.
7. The numerical values marked with * in the table are the values obtained by correcting the errors of the corresponding international standards.

* Hexagon bolt, hexagonal nut M10 and M12 which are currently circulating are also equipped by Old JIS.

Hexagon Nut Extracted from JIS B1181 (1995)

■Hexagon nut

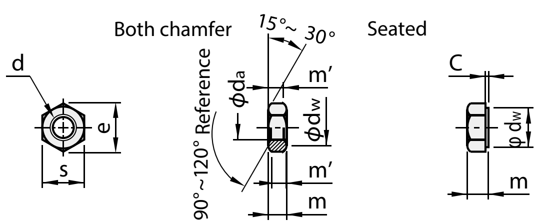
1. Shape and dimensions of hexagonal nut style Ⅰ (part grade A)



Unit: mm

Thread type (d)		M2	M3	M4	M5	M6	M8	M10	M12	(M14)	M16
Pitch Reference (P)		0.4	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2
c	Maximum	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.8
	Minimum	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.2
d_a	Minimum (reference dimension)	2	3	4	5	6	8	10	12	14	16
	Maximum	2.3	3.45	4.6	5.75	6.75	8.75	10.8	13	15.1	17.3
d_w	Minimum	3.07	4.6	5.9	6.9	8.9	11.6	14.6	16.6	19.6	22.5
e	Minimum	4.32	6.01	7.66	8.79	11.05	14.38	17.77	20.03	23.35	26.75
m	Maximum (reference dimension)	1.6	2.4	3.2	4.7	5.2	6.8	8.4	10.8	12.8	14.8
	Minimum	1.35	2.15	2.9	4.4	4.9	6.44	8.04	10.37	12.1	14.1
m*	Minimum	1.08	1.72	2.32	3.52	3.92	5.15	6.43	8.3	9.68	11.28
s	Maximum (reference dimension)	4	5.5	7	8	10	13	16	18	21	24
	Minimum	3.82	5.32	6.78	7.78	9.78	12.73	15.73	17.73	20.67	23.67

2. Shape and dimensions of hexagon nut style Ⅱ (part grade A)



Unit: mm

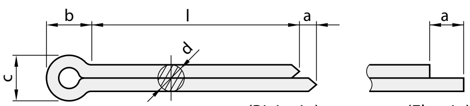
Thread type (d)		M5	M6	M8	M10	M12	(M14)	M16
Pitch Reference (P)		0.8	1	1.25	1.5	1.75	2	2
c	Maximum	0.5	0.5	0.6	0.6	0.6	0.6	0.8
	Minimum	0.15	0.15	0.15	0.15	0.15	0.15	0.2
d_a	Minimum (reference dimension)	5	6	8	10	12	14	16
	Maximum	5.75	6.75	8.75	10.8	13	15.1	17.3
d_w	Minimum	6.9	8.9	11.6	14.6	16.6	19.6	22.5
e	Minimum	8.79	11.05	14.38	17.77	20.03	23.35	26.75
m	Maximum (reference dimension)	5.1	5.7	7.5	9.3	12	14.1	16.4
	Minimum	4.8	5.4	7.14	8.94	11.57	13.4	15.7
m*	Minimum	3.84	4.32	5.71	7.15	9.26	10.7	12.6
s	Maximum (reference dimension)	8	10	13	16	18	21	24
	Minimum	7.78	9.78	12.73	15.73	17.73	20.67	23.67

Remarks 1. Do not use screw bracketed with parentheses.
2. The shape of the nut shall be double sided unless otherwise specified and the seating is as specified by the orderer.
Chamfering of the threaded portion of the seat is similar to "double side removal".

* Hexagon bolt, hexagonal nut M10 and M12 which are currently circulating are also equipped by Old JIS.

Split Pin Extracted from JIS B1351 (1987)

■ Shape and size of split pin



(Pixie tip) (Flat tip)

Unit: mm

<table>
<tr><th colspan="3">Diameter type</th><th>0.6</th><th>0.8</th><th>1</th><th>1.2</th><th>1.6</th><th>2</th><th>2.5</th><th>3.2</th><th>4</th><th>5</th><th>6.3</th><th>8</th><th>10</th><th>13</th><th>16</th><th>20</th></tr>
<tr><td colspan="2" rowspan="2">d</td><td>Base dimension</td><td>0.5</td><td>0.7</td><td>0.9</td><td>1</td><td>1.4</td><td>1.8</td><td>2.3</td><td>2.9</td><td>3.7</td><td>4.6</td><td>5.9</td><td>7.5</td><td>9.5</td><td>12.4</td><td>15.4</td><td>19.3</td></tr>
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-0.2</td><td colspan="3">0
-0.3</td></tr>
<tr><td colspan="2" rowspan="2">c</td><td>Base dimension</td><td>1</td><td>1.4</td><td>1.8</td><td>2</td><td>2.8</td><td>3.6</td><td>4.6</td><td>5.8</td><td>7.4</td><td>9.2</td><td>11.8</td><td>15</td><td>19</td><td>24.8</td><td>30.8</td><td>38.6</td></tr>
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-4.8</td></tr>
<tr><td colspan="2">b</td><td>approximately</td><td>2</td><td>2.4</td><td>3</td><td>3</td><td>3.2</td><td>4</td><td>5</td><td>6.4</td><td>8</td><td>10</td><td>12.6</td><td>16</td><td>20</td><td>26</td><td>32</td><td>40</td></tr>
<tr><td colspan="2">a</td><td>approximately</td><td>1.6</td><td>1.6</td><td>1.6</td><td>2.5</td><td>2.5</td><td>2.5</td><td>2.5</td><td>3.2</td><td>4</td><td>4</td><td>4</td><td>4</td><td>6.3</td><td>6.3</td><td>6.3</td><td>6.3</td></tr>
<tr><td rowspan="4">Applicable bolt and pin diameter</td><td rowspan="2">Bolt</td><td>Over</td><td>-</td><td>2.5</td><td>3.5</td><td>4.5</td><td>5.5</td><td>7</td><td>9</td><td>11</td><td>14</td><td>20</td><td>27</td><td>39</td><td>56</td><td>80</td><td>120</td><td>170</td></tr>
<tr><td>Below</td><td>2.5</td><td>3.5</td><td>4.5</td><td>5.5</td><td>7</td><td>9</td><td>11</td><td>14</td><td>20</td><td>27</td><td>39</td><td>56</td><td>80</td><td>120</td><td>170</td><td>-</td></tr>
<tr><td rowspan="2">Clevis pin</td><td>Over</td><td>-</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>8</td><td>9</td><td>12</td><td>17</td><td>23</td><td>29</td><td>44</td><td>69</td><td>110</td><td>160</td></tr>
<tr><td>Below</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>8</td><td>9</td><td>12</td><td>17</td><td>23</td><td>29</td><td>44</td><td>69</td><td>110</td><td>160</td><td>-</td></tr>
<tr><td colspan="2">Pin hole diameter</td><td>(Remarks)</td><td>0.6</td><td>0.8</td><td>1</td><td>1.2</td><td>1.6</td><td>2</td><td>2.5</td><td>3.2</td><td>4</td><td>5</td><td>6.3</td><td>8</td><td>10</td><td>13</td><td>16</td><td>20</td></tr>
<tr><td colspan="2" rowspan="33">ℓ</td><td>4</td><td rowspan="6">±0.5</td><td></td><td></td><td></td><td></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>5</td><td rowspan="7">±0.5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>16</td><td></td><td rowspan="13">±0.8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>18</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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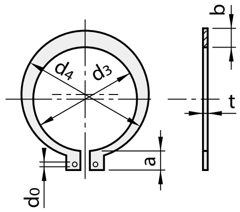
</table>

Remarks
1. Nominal diameter depends on pin hole diameter.
2. d is a value between the tip and L / 2.
3. The shape of the tip may be either a tip or a flat tip. Please specify if you need one of them.
4. The length (L) is within the frame of the bold line, and the numerical value within the frame indicates the tolerance. However, in the case where r other than this table is particularly required, r specify the type.
5. The head should not lean significantly from the axis.

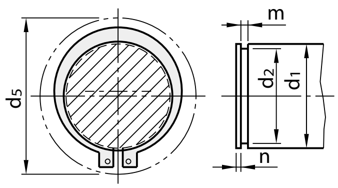
C Type Snap Ring Extracted from JIS B2804 (2001)

■C type snap ring

[For axis]



The position of the hole of the diameter d_0 should not be hidden in the groove when it is put in the shaft to which the snap ring is applied.



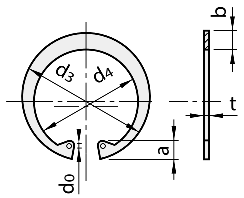
d_5 is the maximum diameter of the outer circumference when fitted to the shaft.

Unit: mm

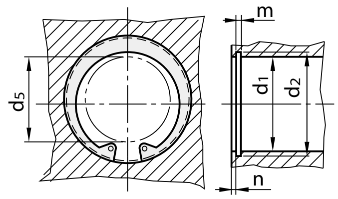
Type (1)	Retaining ring							Applicable wheel (reference)						
	d3		t		b	a	d0	d5	d1	d2		m		n
	Base dimension	Tolerance	Base dimension	Tolerance	(approximately)	(approximately)	(Minimum)			Base dimension	Tolerance	Base dimension	Tolerance	(Minimum)
10	9.3	±0.15	1	±0.05	1.6	3	1.5	17	10	9.6	0 / -0.09	1.15	+0.14 / 0	1.5
(11)	10.2				1.8	3.1		18	11	10.5	0 / -0.11			
12	11.1	±0.18			1.8	3.2	1.5	19	12	11.5				
(13)	12				1.8	3.3		20	13	12.4				
14	12.9				2	3.4	1.7	22	14	13.4				
15	13.8				2.1	3.5		23	15	14.3				
16	14.7				2.2	3.6		24	16	15.2				
17	15.7				2.2	3.7		25	17	16.2				
18	16.5		1.2	±0.06	2.6	3.8		26	18	17		1.35		
(19)	17.5				2.7	3.8	2	27	19	18				
20	18.5	±0.2			2.7	3.9		28	20	19	0 / -0.21			
(21)	19.5				2.7	4		30	21	20				
22	20.5				2.7	4.1		31	22	21				
(24)	22.2				3.1	4.2		33	24	22.9				
25	23.2				3.1	4.3		34	25	23.9				
(26)	24.2				3.1	4.4		35	26	24.9				
28	25.9		1.6 (2)		3.1	4.6		38	28	26.6		1.75		
(29)	26.9				3.5	4.7		39	29	27.6				
30	27.9				3.5	4.8		40	30	28.6				
32	29.6				3.5	5	2.5	43	32	30.3	0 / -0.25			
(34)	31.5	±0.25			4	5.3		45	34	32.3				
35	32.2				4	5.4		46	35	33				
(36)	33.2		1.8	±0.07	4	5.4		47	36	34		1.95		2
(38)	35.2				4.5	5.6		50	38	36				
40	37	±0.4			4.5	5.8		53	40	38				
(42)	38.5				4.5	6.2		55	42	39.5				
45	41.5				4.8	6.3		58	45	42.5				
(48)	44.5				4.8	6.5		62	48	45.5				
50	45.8		2		5	6.7		64	50	47		2.2		
(52)	47.8				5	6.8		66	52	49				
55	50.8	±0.45			5	7		70	55	52	0 / -0.3			
(56)	51.8				5	7		71	56	53				
(58)	53.8				5.5	7.1		73	58	55				
60	55.8				5.5	7.2		75	60	57				
(62)	57.8				5.5	7.2		77	62	59				
(63)	58.8				5.5	7.3		78	63	60				
65	60.8		2.5	±0.08	6.4	7.4		81	65	62		2.7		2.5
(68)	63.5				6.4	7.8		84	68	65				
70	65.5				6.4	7.8		86	70	67				
(72)	67.5				7	7.9		88	72	69				
75	70.5				7	7.9		92	75	72				
(78)	73.5				7.4	8.1		95	78	75				
80	74.5				7.4	8.2		97	80	76.5				

Note (1): Prioritize except ( ), use one of ( ) as necessary.
Note (2): Thickness (t) = 1.6 mm can be 1.5 mm for the time being. In this case, m is 1.65 mm.
Remarks 1. The minimum width of snap ring annulus shall not be smaller than plate thickness t.
2. The dimensions of the axis to be applied are indicated with reference to the recommended dimensions.
3. The d_4 dimension (mm) is preferably $d_4 = d_3 + (1.4 \text{ to } 1.5)$ b.
Reference The thickness t is based on Japan Spring Industry Association Standard JSMA No. 6-1976 (steel band for spring).

[For holes]



The position of the hole with the diameter d_0 should not get hidden in the groove when put in the hole to which the retaining ring is applied.



d_5 is the maximum diameter of the outer circumference when fitted to the shaft.

Unit: mm

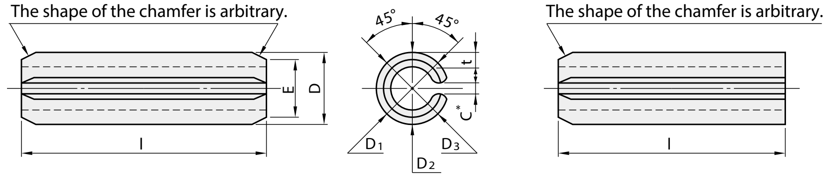
Type (1)	Retaining ring							Applicable wheel (reference)						
	d_3		t		b	a	d_0	d_5	d_1	d_2		m		n
	Base dimension	Tolerance	Base dimension	Tolerance	(approximately)	(approximately)	(Minimum)			Base dimension	Tolerance	Base dimension	Tolerance	(Minimum)
10	10.7				1.8	3.1	1.2	3	10	10.4				
11	11.8				1.8	3.2		4	11	11.4				
12	13				1.8	3.3	1.5	5	12	12.5				
(13)	14.1	±0.18			1.8	3.5		6	13	13.6	+0.11 / 0			
14	15.1				2	3.6		7	14	14.6				
15	16.2				2	3.6		8	15	15.7				
16	17.3		1	±0.05	2	3.7	1.7	8	16	16.8		1.15		
(17)	18.3				2	3.8		9	17	17.8				
18	19.5				2.5	4		10	18	19				
19	20.5				2.5	4		11	19	20				1.5
20	21.5				2.5	4		12	20	21				
(21)	22.5	±0.2			2.5	4.1		12	21	22				
22	23.5				2.5	4.1		13	22	23	+0.21 / 0			
(24)	25.9				2.5	4.3	2	15	24	25.2				
25	26.9				3	4.4		16	25	26.2				
(26)	27.9		1.2		3	4.6		16	26	27.2		1.35		
28	30.1				3	4.6		18	28	29.4				
30	32.1				3	4.7		20	30	31.4				
32	34.4			±0.06	3.5	5.2		21	32	33.7				
(34)	36.5	±0.25			3.5	5.2		23	34	35.7				
35	37.8				3.5	5.2		24	35	37				
(36)	38.8		1.6 (2)		3.5	5.2		25	36	38		1.75	+0.14 / 0	
37	39.8				3.5	5.2		26	37	39	+0.25 / 0			
(38)	40.8				4	5.3		27	38	40				
40	43.5				4	5.7		28	40	42.5				
42	45.5	±0.4			4	5.8		30	42	44.5				
45	48.5		1.8		4.5	5.9		33	45	47.5		1.95		
47	50.5				4.5	6.1		34	47	49.5				2
(48)	51.5				4.5	6.2		35	48	50.5				
50	54.2				4.5	6.5		37	50	53				
52	56.2			±0.07	5.1	6.5	2.5	39	52	55				
55	59.2				5.1	6.5		41	55	58				
(56)	60.2		2		5.1	6.6		42	56	59		2.2		
(58)	62.2				5.1	6.8		44	58	61				
60	64.2	±0.45			5.5	6.8		46	60	63	+0.3 / 0			
62	66.2				5.5	6.9		48	62	65				
(63)	67.2				5.5	6.9		49	63	66				
(65)	69.2				5.5	7		50	65	68				
68	72.5				6	7.4		53	68	71				
(70)	74.5				6	7.4		55	70	73				
72	76.5		2.5	±0.08	6.6	7.4		57	72	75		2.7		2.5
75	79.5				6.6	7.8		60	75	78				
(78)	82.5	±0.55			6.6	8		62	78	81	+0.35 / 0			
80	85.5				7	8		64	80	83.5				

Note (1): Prioritize except ( ), use one of ( ) as necessary.
Note (2): Thickness (t) = 1.6 mm can be 1.5 mm for the time being. In this case, m is 1.65 mm.
Remarks 1. The minimum width of snap ring annulus shall not be smaller than plate thickness t.
2. The dimensions of the axis to be applied are indicated with reference to the recommended dimensions.
3. The d4 dimension (mm) is preferably $d_4 = d_3 + (1.4 \text{ to } 1.5)\ b$.
Reference The thickness t is based on Japan Spring Industry Association Standard JSMA No. 6-1976 (steel band for spring).

Spring Pin Extracted from JIS B2808 (1995)/E Type Snap Ring Extracted from JIS B2805 (1978)

■Shape and dimension

Spring pin shape and size



* When clearance C is inserted into the hole to which the spring pin is applied, it must be dimensioned so that the side does not touch.

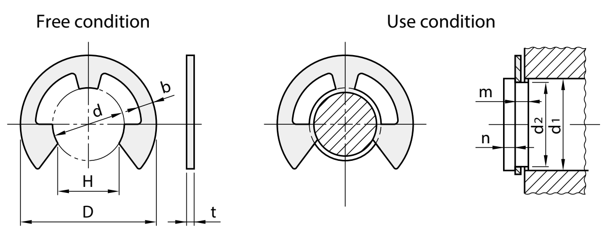
Unit: mm

Diameter type			1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
Spring pin	D (1)	Maximum	1.2	1.4	1.6	1.7	1.8	2.25	2.75	3.25	4.4	5.4	6.4	8.6	10.6	13.7
		Minimum	1.1	1.3	1.5	1.6	1.7	2.15	2.65	3.15	4.2	5.2	6.2	8.3	10.3	13.4
	t (Reference)	For general use	0.2	0.25	0.28	0.3	0.3	0.4	0.5	0.6	0.8	1	1.2	1.6	2	2.5
		For light load	0.1	0.12	0.15	0.15	0.15	0.2	0.25	0.3	0.4	0.5	0.6	-	-	-
	E	(maximum)	0.9	1.1	1.3	1.4	1.5	1.9	2.4	2.9	3.9	4.8	5.8	7.8	9.8	12.7
	Double shear Load kN {kgf} Minimum value	For general use	0.69 {70}	1.02 {104}	1.35 {138}	1.55 {158}	1.68 {171}	2.76 {281}	4.31 {440}	6.2 {633}	10.8 {1130}	17.25 {1760}	24.83 {2532}	44.13 {4500}	68.94 {7030}	112.78 {11500}
		For light load	0.38 {39}	0.56 {57}	0.8 {82}	0.87 {89}	0.93 {95}	1.55 {158}	2.42 {247}	3.49 {356}	6.21 {633}	9.7 {989}	13.96 {1424}	-	-	-
Applicable hole		Diameter	1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
		Dimensional tolerance	+0.08 0					+0.09 0			+0.12 0			+0.15 0		+0.2 0

ℓ	Dimensional tolerance	Diameter type 1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
4	+0.5 0	○	○	○	○	○									
5		○	○	○	○	○	○	○							
6		○	○	○	○	○	○	○	○						
8		○	○	○	○	○	○	○	○	○					
10		○	○	○	○	○	○	○	○	○	○				
12	+1.0 0		○	○	○	○	○	○	○	○	○	○			
14				○	○	○	○	○	○	○	○	○			
16						○	○	○	○	○	○	○	○		
18							○	○	○	○	○	○	○	○	
20							○	○	○	○	○	○	○	○	
22								○	○	○	○	○	○	○	○
25								○	○	○	○	○	○	○	○
28									○	○	○	○	○	○	○
32									○	○	○	○	○	○	○
36										○	○	○	○	○	○
40										○	○	○	○	○	○
45											○	○	○	○	○
50											○	○	○	○	○
56	+1.5 0											○	○	○	○
63												○	○	○	○
70													○	○	○
80													○	○	○
90														○	○
100														○	○
110															○
125															○
140															○

Note (1): D maximum is the maximum value on the circumference of the pin and D minimum is the average value of D 1, D 2, D 3. Reference value t is according to JSMA No. 6 (Japan Spring Industry Association standard).

Shapes and dimensions of E type retaining ring



Remarks Shape shows one example

Type	Retaining ring d (1) Reference dimension	d Tolerance	D Reference dimension	D Tolerance	H Reference dimension	H Tolerance	t Reference dimension	t Tolerance	b approximately	Applicable ring (reference) d1の区分 Over	d1の区分 Below	d2 Reference dimension	d2 Tolerance	m Reference dimension	m Tolerance	n Minimum
0.8	0.8	0 -0.08	2	±0.1	0.7	0 -0.25	0.2	±0.02	0.3	1	1.4	0.8	+0.05 0	0.3	+0.05 0	0.4
1.2	1.2	0 -0.09	3		1		0.3	±0.025	0.4	1.4	2	1.2	+0.06 0	0.4		0.6
1.5	1.5		4	±0.2	1.3		0.4	±0.03	0.6	2	2.5	1.5		0.5		0.8
2	2		5		1.7		0.4		0.7	2.5	3.2	2				1
2.5	2.5		6		2.1		0.4		0.8	3.2	4	2.5				
3	3		7		2.6		0.6	±0.04	0.9	4	5	3		0.7	+0.1 0	
4	4	0 -0.12	9		3.5	0 -0.3	0.6		1.1	5	7	4	+0.075 0			1.2
5	5		11		4.3		0.6		1.2	6	8	5				
6	6		12		5.2		0.8		1.4	7	9	6		0.9		
7	7	0 -0.15	14		6.1	0 -0.35	0.8		1.6	8	11	7	+0.09 0			1.5
8	8		16		6.9		0.8		1.8	9	12	8				1.8
9	9		18		7.8		0.8		2.0	10	14	9				2
10	10		20		8.7		1.0	±0.05	2.2	11	15	10		1.15	+0.14 0	
12	12	0 -0.18	23	±0.3	10.4		1.0		2.4	13	18	12	+0.11 0			2.5
15	15		29		13	0 -045	1.6 (2)	±0.06	2.8	16	24	15		1.75(2)		3
19	19	0 -0.21	37		16.5		1.6 (2)		4.0	20	31	19	+0.13 0			3.5
24	24		44		20.8	-8.5	2.0	±0.07	5.0	25	38	24		2.2		4

Note (1): Limit plug gauge is used for measuring d.
Note (2): Thickness (t) = 1.6 mm can be 1.5 mm for the time being. In this case, m is 1.65 mm.   Remarks The dimensions of the axis to be applied are indicated with reference to the recommended dimensions.

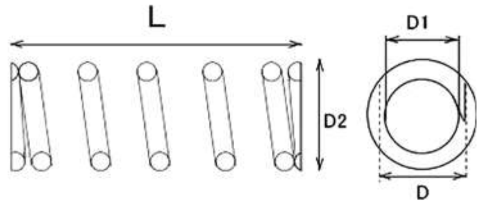
Spring Calculation

Extracted from JIS B2704 (2000)

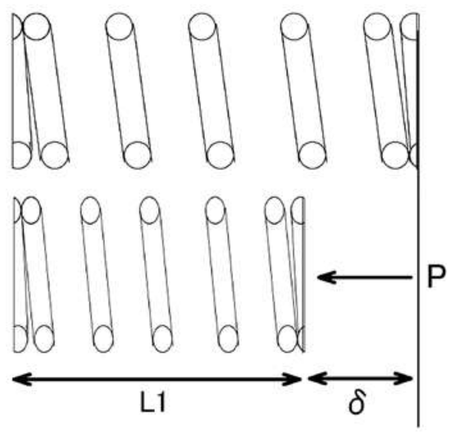
Symbol	Description
d	Wire diameter (φ)
D1	Coil inner diameter (mm)
D2	Coil outer diameter (mm)
D	Coil average diameter (D 1 + D 2) / 2
Na	Effective number of turns
Nt	Total turns
L	Free length (mm)
P	Load N (Kg)
δ	Deflection of spring
k	Spring constant N / mm (Kg / mm)
G	Transverse modulus of elasticity N / mm² (Kg / mm²)
c	Spring index (D / d)

Material	Transverse elastic modulus (N / mm))
Hard steel wire	78500
Piano wire	78500
Oil-tempered wire	78500
Stainless steel wire	68500

Material	Specific gravity (g/cm³)
Iron (Fe+0.06%C)	7.87
Steel (Fe+0.8%C)	7.84
SUS304 (18Cr-8C)	7.9



* D (Coil average diameter) · · · Dimensions between center and center of line



A. Calculate the weight of the spring

Example » Piano wire φ 2.0 Effective number of turns 5 (Total number of turns 7) Coil diameter φ 15.0

① Find the volume of the spring

Cross section of material × length of spring = volume of spring

Expression » (1.0 * 1.0 * 3.14) * (15.0 * 3.14 * 7) = 3.14 * 329.7 = 1035.258 mm³

② Find the weight of the spring

Weight × specific gravity = weight of spring

Expression » 1035.258 mm³ * 0.00784 g / mm³ = 8.116 g

B. Calculate the spring constant

$$k = \frac{Gd^4}{8NaD^3}$$

Example » Piano wire φ 2.0 Effective number of turns 5 Coil diameter φ 15.0

Expression » (78,500 * 2.0 ^ 4) / (8 * 5 * 15.0 ^ 3) = 1256000/135000 = 9.304 N / mm

C. Calculate load (compression spring)

$$P = \delta * k$$

Example » When the free length is 30 mm and the mounting length is 25 mm as the spring characteristic of the spring,

Expression » Calculate spring deflection δ = L - L 1 δ = 30 - 25 = 5

5 * 9.304 = 46.52 N

D. Calculate spring stress

$$\tau = \frac{8\kappa D}{\pi d^3} \quad P = \frac{\kappa d G}{\pi NaD^2}\,\delta$$

Example » In the case of the spring characteristics of the above spring,

Expression » Calculate the correction factor c = 7.5

κ = ({4 * 7.5 - 1) (/ 4 * 7.5 - 4)} + (0.615 / 7.5) = 1.1974

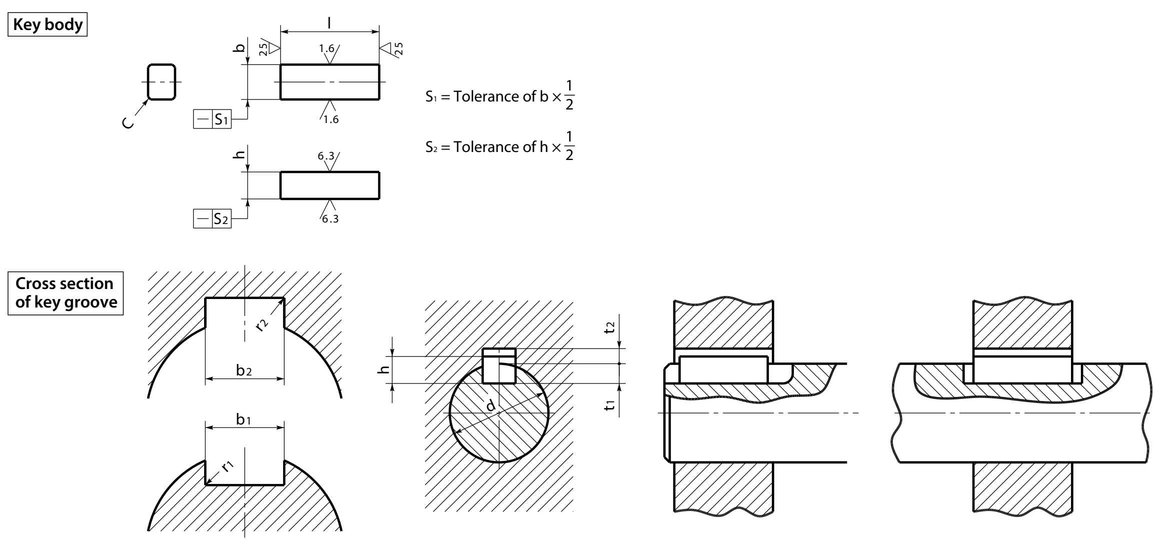
κ (Whar correction coefficient) = {(4 c - 1) / 4 c - 4} + 0.615 / c) {(8 * 1.1974 * 15.0) / (3.14 * 2.0 ^ 3)} * 46.52 = (143.688 / 25.12) / * 46.52

= 266.097 N / mm²

Key and Key Groove Extracted from JIS B1301 (1996)

■Key and key groove

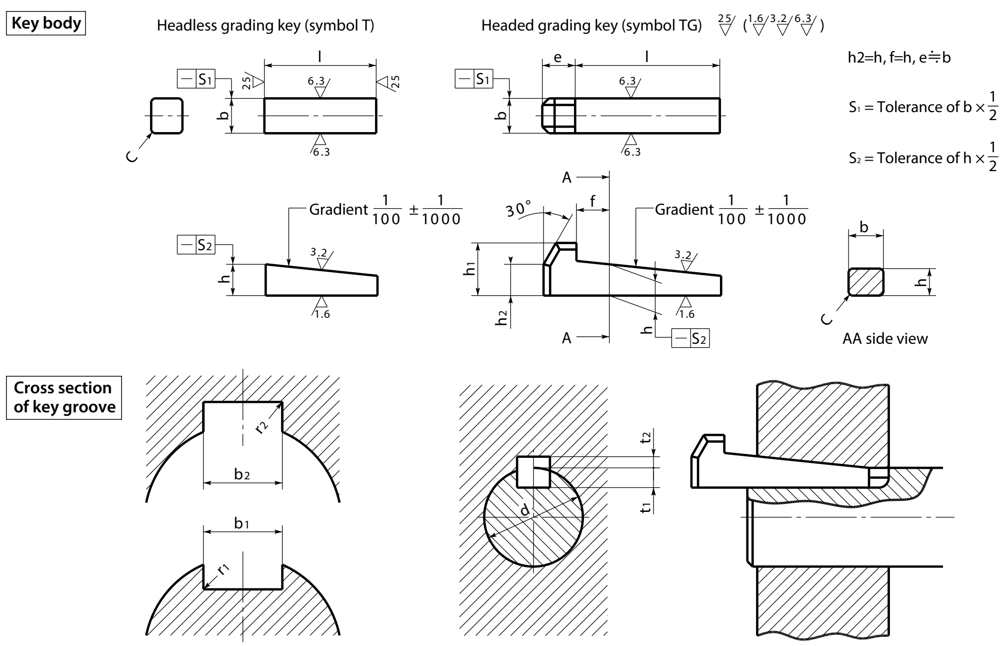
1. Shape and dimensions of parallel key and key groove



Unit: mm

Key Nominal dimensions b×h	Key dimensions: b Base dimension	b Tolerance (h9)	h Base dimension	h Tolerance		C	l	Size of key groove: Base dimensions b1 and b2	Sliding shape b1 Tolerance (H9)	Sliding shape b2 Tolerance (D10)	Normal form b1 Tolerance (N9)	Normal form b2 Tolerance (Js9)	Tightening type b1 and b2 Tolerance (P9)	r1 and r2	Base dimensions t1	Base dimensions t2	Tolerance t1 and t2	Reference: Applicable shaft diameter d
2×2	2	0 −0.025	2	0 −0.025	h9	0.16 - 0.25	6 - 20	2	+0.025 0	+0.060 +0.020	−0.004 −0.029	±0.0125	−0.006 −0.031	0.08 - 0.16	1.2	1.0	+0.1 0	6 - 8
3×3	3		3				6 - 36	3							1.8	1.4		8 - 10
4×4	4	0 −0.030	4	0 −0.030		0.25 - 0.40	8 - 45	4	+0.030 0	+0.078 +0.030	0 −0.030	±0.0150	−0.012 −0.042		2.5	1.8		10 - 12
5×5	5		5				10-56	5						0.16 - 0.25	3.0	2.3		12 - 17
6×6	6		6				14 - 70	6							3.5	2.8		17 - 22
(7×7)	7	0 −0.036	7	0 −0.036			16 - 80	7	+0.036 0	+0.098 +0.040	0 −0.036	±0.0180	−0.015 −0.051		4.0	3.3	+0.2 0	20 - 25
8×7	8		7	0 −0.090	h11		18 - 90	8							4.0	3.3		22 - 30
10×8	10		8			0.40 - 0.60	22 - 110	10						0.25 - 0.40	5.0	3.3		30 - 38
12×8	12	0 −0.043	8				28 - 140	12	+0.043 0	+0.120 +0.050	0 −0.043	±0.0215	−0.018 −0.061		5.0	3.3		38 - 44
14×9	14		9				36 - 160	14							5.5	3.8		44 - 50
(15×10)	15		10				40 - 180	15							5.0	5.3		50 - 55
16×10	16		10				45 - 180	16							6.0	4.3		50 - 58
18×11	18		11	0 −0.110			50 - 200	18							7.0	4.4		58 - 65
20×12	20	0 −0.052	12			0.60 - 0.80	56 - 220	20	+0.052 0	+0.149 +0.065	0 −0.052	±0.0260	−0.022 −0.074	0.40 - 0.60	7.5	4.9		65 - 75
22×14	22		14				63 - 250	22							9.0	5.4		75 - 85
(24×16)	24		16				70 - 280	24							8.0	8.4		80 - 90
25×14	25		14				70 - 280	25							9.0	5.4		85 - 95
28×16	28		16				80 - 320	28							10.0	6.4		95 - 110
32×18	32	0 −0.062	18				90 - 360	32	+0.062 0	+0.180 +0.080	0 −0.062	±0.0310	−0.026 −0.088		11.0	7.4		110 - 130

2. Shape and dimension of gradient key · headed gradient key and key groove



Unit: mm

Key Nominal dimensions bxh	Key dimensions: b Base dimension	b Tolerance (h9)	h Base dimension	h Tolerance		h1	C	l	Size of key groove: b1 and b2 Base dimension	b1 and b2 Tolerance (D10)	r1 and r2	Base dimensions t1	Base dimensions t2	Tolerance t1 and t2	Reference: Applicable shaft diameter d
2×2	2	0 −0.025	2	0 −0.025	h9	-	0.16 - 0.25	6 - 30	2	+0.060 +0.020	0.08 - 0.16	1.2	0.5	+0.05 0	6 - 8
3×3	3		3			-		6 - 36	3			1.8	0.9		8 - 10
4×4	4	0 −0.030	4	0 −0.030		7		8 - 45	4	+0.078 +0.030		2.5	1.2	+0.1 0	10 - 12
5×5	5		5			8	0.25 - 0.40	10 - 56	5		0.16 - 0.25	3.0	1.7		12 - 17
6×6	6		6			10		14 - 70	6			3.5	2.2		17 - 22
(7×7)	7	0 −0.036	7.2	0 −0.036		10		16 - 80	7	+0.098 +0.040		4.0	3.0		20 - 25
8×7	8		7	0 −0.090	h11	11		18 - 90	8			4.0	2.4	+0.2 0	22 - 30
10×8	10		8			12	0.40 - 0.60	22 - 110	10		0.25 - 0.40	5.0	2.4		30 - 38
12×8	12	0 −0.043	8			12		28 - 140	12	+0.120 +0.050		5.0	2.4		38 - 44
14×9	14		9			14		36 - 160	14			5.5	2.9		44 - 50
(15×10)	15		10.2	0 −0.070	h10	15		40 - 180	15			5.0	5.0	+0.1 0	50 - 55
16×10	16		10	0 −0.090	h11	16		45 - 180	16			6.0	3.4	+0.2 0	50 - 58
18×11	18		11	0 −0.110		18		50 - 200	18			7.0	3.4		58 - 65
20×12	20	0 −0.052	12			20	0.60 - 0.80	56 - 220	20	+0.149 +0.065	0.40 - 0.60	7.5	3.9		65 - 75
22×14	22		14			22		63 - 250	22			9.0	4.4		75 - 85
(24×16)	24		16.2	0 −0.070	h10	24		70 - 280	24			8.0	8.0	+0.1 0	80 - 90
25×14	25		14	0 −0.070	h11	22		70 - 280	25			9.0	4.4	+0.2 0	85 - 95
28×16	28		16			25		80 - 320	28			10.0	5.4		95 - 110
32×18	32	0 −0.062	18			28		90 - 360	32	+0.180 +0.080		11.0	6.4		110 - 130

Surface Treatment Excerpted from Mechanical Engineering Handbook of the Japan Society of Mechanical Engineers

■Method and type of surface treatment

1. Method of surface treatment

Method	Principle and features	Material	Property
Electroplating	The material is immersed in a plating bath as a cathode, and a metal film is electrodeposited on the surface of the material by direct current.	Materials are metal, plastic (electroplating the surface with electroless plating and electroplating).	For ornamental use 1 µm or less, for corrosion prevention, for industrial use 1 - several tens of µm or more, in many cases pinholes are left.
Hot Dip Plating	The material is pulled after dipping into molten metal, solidification and coating the dissolved metal.	Materials are mainly steel materials, Al, Zn, Sn, Pb etc. as coating metal.	A thick coating is possible. Adherence and deformability depend on the properties of the alloy layer formed between the coating layer and the material.
Diffusion plating	Diffuse and infiltrate the metal element into the material surface layer. Since the processing temperature (around 1000 °C.) is high, post-heat treatment is required.	Materials are mainly steel materials, Fe group, Ni-based heat resistant alloy and so on.	Coating metals are Al, Cr, Si, etc. The alloy layer thickness is several tens - several hundred µm.
Vapor Deposition Plating	Physical vapor deposition method: Coating by vacuum evaporation, sputtering, ion plating or the like. Chemical vapor deposition method: Coating by decomposition of gas compounds.	Materials are metal, ceramic, plastic, coating material is metal, ceramic.	Physical vapor deposition methods generally have low deposition rates. The chemical vapor deposition method can not pursue high temperature treatment.
Spraying	Powder or particles of a spraying material heated to a molten state are sprayed on the surface of the material to form a film. The material temperature during thermal spraying is about 200 °C or lower.	Materials are metals, ceramics, plastics and others, spraying materials are metals, ceramics, plastics or mixtures thereof.	The adhesion strength is relatively low. The film has pores. Practical coating thickness is about 0.6 mm or less.
Laminating plate	Rolling pressure welding method, explosion welding method, etc. Processing targets are simple shapes such as board surface and cylinder inner surface.	The material is metal, mostly steel materials. The laminated plate material is metal, alloy.	In explosive welding, the thickness of the laminated plate is about 3 mm or less.
Anodization	In an electrolytic solution such as anodic oxidation sulfuric acid or oxalic acid, electrolysis is performed using the material as an anode, and an oxide film is formed on the surface of the material.	The main material is Al and its alloy. Others such as Mg.	The oxide film consists of a dense layer and a porous layer. Usually, a sealing treatment is performed. Good adhesion. Colorable.
Chemical conversion treatment	A phosphoric acid salt or chromate film is formed on the surface of the material by a dipping method or a spraying method.	Materials are steel materials, Al, Zn, etc.	Primarily, a phosphate type coating film is applied to the steel material, and a chromate film is applied to Al.
Carburizing	Diffuse and permeate carbon into the material surface layer. Processing temperature is 850 - 950 °C. Perform quenching after treatment.	The material is steel with a C content of 0.2% or less (hardened steel)	The carburized depth is 0.5 - 5 mm, the hardness is 700 - 850 HV. Beware of material deformation due to quenching after treatment.
Nitriding	Diffusion penetration of nitrogen into the material surface layer. Processing temperature is 475 - 580 °C. Heat treatment and machining can be done before processing.	Materials are nitrided steel (containing Cr, Mo, Al, etc.) in gas nitriding. Most of the steel types in ion nitriding.	Nitriding depth is 0.9 mm or less. Hardness is 600 - 1150 HV. The deformation of the material is small.
Carbonitriding	Simultaneously with carburizing, nitriding is performed. The treatment temperature is 700 - 900 °C. Perform quenching after treatment.	The material is the same as for carburizing. It can also be applied to carbon steel.	Carbonitriding depth is 1 mm or less. The hardness is about 800HV.
Infiltration	Diffuse and penetrate sulfur into the material surface layer. The treatment temperature is 400 - 600 °C.	Materials are steel and steel types.	The friction coefficient decreases from the thickness of the iron sulfide film of 0.2 µm.
Sulfonitridation	Simultaneously with the sulfurization, nitriding is performed. The treatment temperature is 560 - 570 °C.	The material is the same as nitriding.	The nitrosyl nitrification depth is 0.1 - 0.5 mm.
Induction quenching	The induction hardened material surface is rapidly heated by high-frequency induction current - quenched and quenched.	The material is steel materials. Especially medium carbon steel, alloy steel, cast and forged products.	The thickness of the hardened layer is 0.4 - 5 mm. Working time is short. The deformation of the material is small.
Flame quenching	Quickly heat the material surface with oxygen-fuel flame - quench and quench.	Same as above	The thickness of the hardened layer is 1 - several mm.
Other surface quenching	Rapid heat-quenching of the material surface with laser beam and electron beam.	There is no particular limitation on the material as long as it has hardenability.	long as it has hardenability. The hardened layer is extremely thin. Local curing is possible.
Plastic lining	Cover material surface by sheet lining method, thermal spraying method, and coating method etc.	Coating materials are polyethylene, vinyl chloride, fluorine resin, rubber and so on.	A thick coating is possible. It may be 1 mm or more.
Ceramic coating	Cover material surface by evaporation method, spraying method, baking method and so on.	Glassy ceramic (enamel) as a covering material. Various ceramics.	Adhesion is not very good. Repeated heating and cooling may cause cracks in the film.

2. Types of Surface Treatment, Usage Examples, Features

Name	Layer thickness (μm)	Materials that can be processed	Example of use	Purpose / feature	Remarks
Zinc plated	3~20	Steel	Thin Wire	· Anti-rust, low price · No good appearance	-
Chromate plating	1~2	Steel	Sheet metal part bolt and nut	· Anti-rust, low price · Suitable for mass production products · The appearance of nickel-plated fall Alternative	-
Unichrome plating	1~2	Steel	-		
Trivalent Chromate	1~2	Steel	bolt and nut	· Anti-rust, low price · It does not contain hexavalent chromium	-
Nickel plating	-	Steel Copper Brass	-	· Corrosion resistance improvement, decoration · Chrome plating is more corrosion-resistant in the atmosphere	· Coat copper base plating as necessary · Deep dent is impossible
Electroless Nickel plating	Addressable	Steel Stainless Copper Aluminum alloy Glass Plastic	Parts that can not be plated with nickel	· 10 times more price than nickel plating · Easy film thickness control · Corrosion resistance and abrasion resistance large · Conductivity of nonmetals possible	-
Kanigen plating			Parts to be subjected to hardening treatment after plating	· Same as the feature of electroless nickel plating · It can be hardened by heat treatment after plating	
Chrome-plated	-	Steel Copper Brass	-	· Shiny appearance · Corrosion resistance good · Sliding of chrome plating is easily seizure	· If necessary, base plating of nickel · Deep dent is impossible
Tetraferric oxide film (dye to black)	-	Steel	bolt nut Measuring instrument	· Painting base · Appearance (glossy) · Easy to rust than Taft ride	· To produce a tetraferric oxide (black)
Low Temperature Black Chrome-plated	1~2	Steel Copper Stainless	Accuracy required Corrosion resistance is desired more than black dye	· Long-term rust prevention ability · Excellent corrosion resistance · Ultra thin film	· Because of low temperature treatment, there is no influence of heat on the material, and the bonded parts with plastic rubber etc. can be processed as it is.
Alumite White	3~5	Aluminum alloy	-	· Corrosion resistance, abrasion resistance · No electrical conductivity · Heat-resistant	· There are colored alumite which forms a tough oxide film on the surface and colors by utilizing the pores of the oxide film.
Black	5~10				

Mechanical Materials

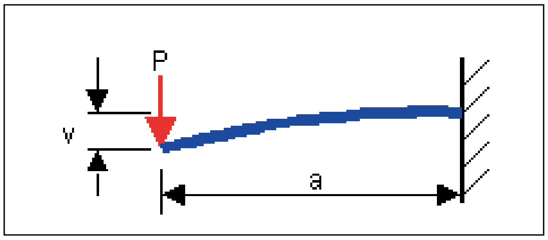
■Mechanical materials

	Material	Classification	Elastic coefficient	Poisson's ratio	Shear modulus of elasticity	Density	Tensile strength	Coefficient of thermal expansion	Thermal conductivity	Specific heat
			N/m^2		N/m^2	kg/m^3	N/m^2	/K	W(m･K)	J/(kg･K)
1	A1050-0	Aluminum	69x10^9	0.3	25x10^9	2705	75x10^6	2.4x10^-5	231	900
2	A1100-0		69x10^9	0.3	26x10^9	2710	90x10^6	2.36x10^-5	222	904
3	A2011-T3		70x10^9	0.3	26x10^9	2820	380x10^6	2.31x10^-5	152	864
4	A2017-T4		71.6x10^9	0.3	27.2x10^9	2790	425x10^6	2.36x10^-5	134	864
5	A5052-H34		69.3x10^9	0.3	25.9x10^9	2680	260x10^6	2.38x10^-5	137	900
6	A5056-H38		71.7x10^9	0.3	25.9x10^9	2640	415x10^6	2.41x10^-5	112	904
7	A6061-T6		68.3x10^9	0.3	26x10^9	2700	310x10^6	2.36x10^-5	167	896
8	A6063SS-T5		68.3x10^9	0.3	25.8x10^9	2690	185x10^6	2.34x10^-5	209	900
9	A6063SS-T6		68.3x10^9	0.3	25.8x10^9	2690	240x10^6	2.34x10^-5	201	900
10	A6N01SS-T5		68.9x10^9	0.3	25.8x10^9	2700	270x10^6	2.35x10^-5	188	900
11	AC4C-T6		73.5x10^9	0.3	24x10^9	2680	230x10^6	2.15x10^-5	159	963
12	ADC12-F		70x10^9	0.3	26.5x10^9	2680	295x10^6	2.1x10^-5	92	963
13	ADC14-F		81x10^9	0.3	26x10^9	2730	320x10^6	1.8x10^-5	134	963
14	FCD450	Steel material	161x10^9	0.27	63.4x10^9	7100	450x10^6	1.2x10^-5	33.5	544
15	S45C		210x10^9	0.3	80.8x10^9	7800	690x10^6	1.12x10^-5	45	490
16	SCM415		206x10^9	0.3	79.2x10^9	7840	830x10^6	1.23x10^-5	42.7	490
17	SK3		208x10^9	0.3	80x10^9	7840	850x10^6	1.06x10^-5	45	490
19	SS400		210x10^9	0.3	80.8x10^9	7900	400x10^6	1.17x10^-5	51.6	473
22	SUJ2		204x10^9	0.29	79.1x10^9	7810	1570x10^6	1.16x10^-5	46	480
24	SECC-ZC	Steel plate	205x10^9	0.3	78.8x10^9	7860	270x10^6	1.18x10^-5	50	480
26	GIN6	Stainless	204x10^9	0.3	78.5x10^9	7780	735x10^6	1.03x10^-5	25	461
27	QD51		204x10^9	0.3	78.5x10^9	7750	540x10^6	1.02x10^-5	24.3	460
29	SUS13		197x10^9	0.3	75.8x10^9	8030	481x10^6	1.59x10^-5	16.3	499
30	SUS303		197x10^9	0.3	75.8x10^9	7930	520x10^6	1.72x10^-5	16	500
31	SUS304		197x10^9	0.3	75.8x10^9	7930	520x10^6	1.73x10^-5	16.3	500
32	SUS430		204x10^9	0.3	78.5x10^9	7700	450x10^6	1.04x10^-5	25.6	460
33	SUS440		204x10^9	0.3	78.5x10^9	7750	540x10^6	1.02x10^-5	24.3	460
35	C3604BD	Brass	96x10^9	0.32	36.4x10^9	8430	335x10^6	2.05x10^-5	117	377

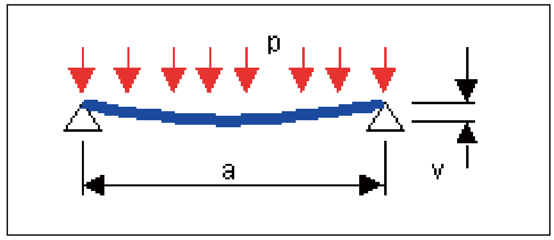
Deflection Calculation Formula

■ Deflection / Cross section second moment calculation formula

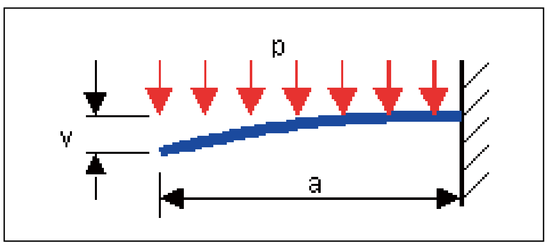
The deflection of a typical beam [V] is recorded. I is the second moment of the cross section *, E is the Young's modulus of each material.
The capital letter P indicates the concentrated load (force), and the lower case p indicates the distributed load (pressure).



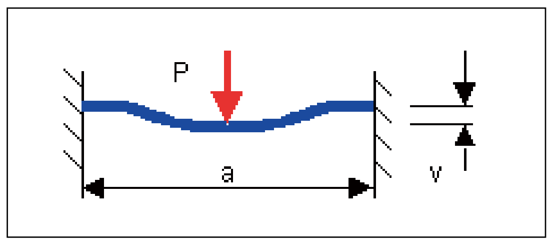
$$v=\frac{Pa^3}{3EI}$$



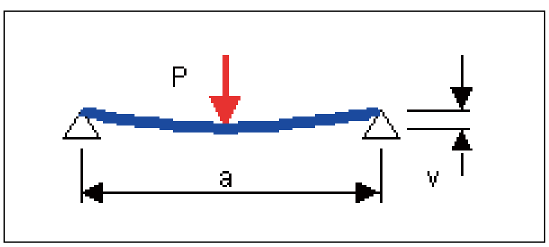
$$v=\frac{5Pa^3}{384EI}\quad (P=pa)$$



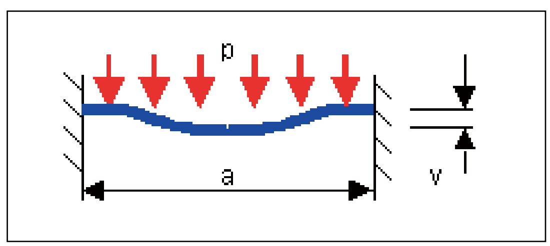
$$v=\frac{Pa^3}{8EI}\quad (P=pa)$$



$$v=\frac{Pa^3}{192EI}$$

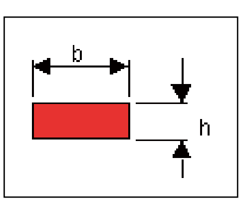


$$v=\frac{Pa^3}{48EI}$$

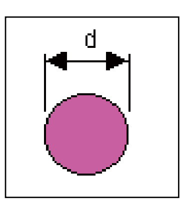


$$v=\frac{Pa^3}{384EI}\quad (P=pa)$$

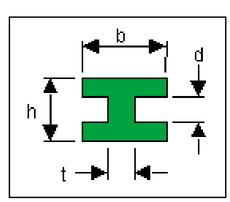
* Second moment of cross section
The second-order moment [I] of a typical cross section is recorded.



$$I=\frac{bh^3}{12}$$



$$I=\frac{\pi d^4}{64}$$



$$I=\frac{bh^3-(b-t)d^3}{12}$$

Classification and Features of Plastics

■Plastic classification and feature list

Classification			Symbol	Japanese name	Common name
Thermoplastic resin	General purpose plastic		PE	Polyethylene	-
			PVC	PVC	PVC resin, PVC
			PP	Polypropylene	-
			PS	Polystyrene	Styrene resin
			ABS	Acrylonitrile · butadiene · styrene resin	ABS resin
			AS	Acrylonitrile · styrene resin	-
			PMMA	Polymethylmethacrylate	Methacrylic resin, acrylic
			PVA	Polyvinyl alcohol	Poval resin
			PVDC	Polyvinylidene chloride	-
			PBD	Polybutadiene	Butadiene resin
			PET	Polyethylene terephthalate	-
	Engineering plastics	General purpose engineering plastics	PA	Polyamide	Nylon
			POM	Polyacetal	Acetal resin
			PC	Polycarbonate	-
			PPE	Modified polyphenylene ether	Polyphenylene oxide
			PBT	Polybutylene terephthalate	-
			GF-PET	Reinforced polyethylene terephthalate	-
			UHPE	Ultra high molecular weight polyethylene	-
		Super engineering plastic	PSU	Polysulfone	-
			PES	Polyethersulfone	-
			PPS	Polyphenylene sulfide	-
			PAR	Polyarylate	-
			PAI	Polyamide imide	-
			PEI	Polyetherimide	-
			PEEK	Polyether ether ketone	-
			PI	Polyimide	-
			LCP	Liquid crystal polymer	-
			FR	Fluororesin	-
Thermosetting resin			PF	Phenol	-
			UF	Urea	Urea resin
			MF	Melamine	-
			PAK	Polyester alkyd	Alkyd resin
			UP	Unsaturated polyester	-
			EP	Epoxy	-
			DAP	Diallyl phthalate	-
			PUR	Polyurethane	Urethane resin
			SI	Silicone	Silicon resin

Reference

Thermoplastic resin: It softens when heated and becomes processable, and solidifies on cooling. It softens when heated and can be used repeatedly.

Thermosetting resin: It softens when heated and solidifies by chemical reaction. Those once solidified by heating are not dissolved even if they are heated again.

General purpose plastic: The resin price is relatively low, and it is easy to process thermoplastic resin. Heat distortion temperature less than 100 °C, tensile strength less than 500 kgf / cm², impact resistance less than 5 kgf · cm / cm. Among them, PE, PP, PVC, and PS are called four general purpose resins.

General purpose engineering plastics: A thermoplastic resin with a thermal deformation temperature of 100 °C or higher, a tensile strength of 500 kgf / cm² or higher, and an impact resistance of 5 kgf · cm / cm or higher.

Super engineering plastic: A thermoplastic resin that can be used for a long time even at a heat distortion temperature of 150 °C. or higher even higher than general purpose engineering plastics.

Major applications	Major features
Packaging film · laminate · toy · daily necessities etc.	It is inexpensive, resistant to low temperature, no water absorption and excellent chemical resistance.
Agricultural film · pipe · hose · wire breakage	Although it is inexpensive and excellent in weather resistance, injection molding is difficult.
Household kitchenware, film, container	It is inexpensive, has good surface gloss, is strong in thin film state but is weak in low temperature.
Transparent daily necessities · containers · stationery · high firing products	It is inexpensive, has good moldability and is excellent in electrical insulation, but is weak to heat and brittle.
Injection molded products such as automobiles, domestic electric appliances, daily necessities	The molding shrinkage ratio is small and well-balanced. It also has good plating properties.
Automotive parts / electric parts / fan blades / lighter containers	It is strong against mineral oil such as gasoline, and it is not easily scratched.
Optical fiber · lens · optical disc · tail light	It is perfectly colorless and transparent, the transmittance of light rays is close to 100%, and it does not discolor even when it hits sunlight.
Films, cosmetic raw materials and pharmaceutical additives, paper processing agents (clear coat)	Easy to handle. Low acetic acid odor and thermal discoloration.
Household wrapping, food packaging film, food preservation packaging material	It has barrier property (property of blocking gas permeation) against both oxygen and water vapor (moisture).
Household wrap, laminate film, tube, hose	Excellent flexibility, transparent and light.
PET Bottle, Recording Tape, Home Appliances Parts	It is tough and has excellent heat resistance, it is non-toxic and has less water absorption, but it is vulnerable to hot water and alkali.
Gear, pulley, shaft, bobbin with electric parts / machine parts / automobile parts etc.	It is excellent in oil resistance and heat resistance, has a small friction coefficient and is resistant to abrasion, but has water absorption.
Gears · cam · motor parts · fasteners · valves	Excellent in chemical resistance, good friction and wear characteristics, good rebound resilience.
Protective wall · Lighting equipment · Signal machine lens · Bin	It is transparent, heat resistant and very strong against impact, but it is inferior in chemical resistance.
OA equipment, auto parts	It is excellent in mechanical properties, heat resistance and electrical properties, but it has very high heat resistance and difficulty in formability.
Coil bobbin · connector · carburetor · gas cap	It is tough and has high heat resistance and good formability but it is vulnerable to hot water and alkaline.
Coil bobbin · electrical components, exterior parts, switches	Excellent in electrical properties, flame retardancy, appearance and light discoloration resistance.
Lining, battery separator, fiber (fishing line, elastic sheet)	Excellent in impact resistance, abrasion resistance, self lubricity and non water absorption.
Electronic parts, camera parts, medical equipment	It is excellent in coloring, plating, heat resistance, toughness, dimensional stability, chemical resistance.
Motor case, battery case, sterilizer · tray	Excellent in high-temperature creep characteristics, dimensional stability, steam resistance.
Chemical plant · carburetor · piston ring	Excellent heat resistance, abrasion resistance, chemical resistance and high rigidity.
Switches, floppy disk hub and drive unit	Excellent toughness at high temperature and low temperature, excellent in spring recoverability, heat resistance, dimensional stability, abrasion resistance, chemical resistance.
Bearing · Gear · Valve	Excellent heat resistance, low wear and good impact resistance.
Connector · Bobbin · Interior decoration material for aircraft · Medical equipment	It is excellent in heat resistance, chemical resistance, moldability, and is refractory.
Chemical plant · Copy parts · Hot water resistant products	Excellent in fatigue resistance and abrasion resistance, and withstands steam at 300 °C in a short time.
Coil bobbin · IC socket · piston ring · bush	Excellent impact resistance and heat resistance, little change in characteristics from low temperature to high temperature.
Connector, Resistor, DVD / CD Chassis, Micro Motor, Optical Fiber	It is excellent in low water absorption, heat resistance and dimensional stability.
Wafer carrier, wire coating, gasket, packing	Excellent in heat resistance, chemical resistance, non-sticking and self lubricating properties.
Electronic component base · socket · handle of the kettle	It has good electrical properties and withstands high temperatures.
Adhesive · tableware	It is colorless transparent and has good coloring but poor impact resistance. 80% or more for adhesive applications
Adhesive · paint · tableware · decorative board	It is colorless, corrosion-resistant, durable and beautiful.
Primers for automobile parts, industrial machinery etc.	It is excellent in corrosion resistance and solvent solubility.
Fishing boat, boat, yacht, bath tub, tank	Suitable for making large products, FRP mainstream with glass fiber.
Adhesive · paint · fishing rod · connector cover	It has a small molding shrinkage rate, is excellent in mechanical properties and can be solidified at room temperature.
Switch, connector, coil bobbin	Excellent tracking resistance, dimensional stability and water absorption.
Paints, adhesives, shoe products, auto parts	Excellent in elasticity, abrasion resistance, solvent resistance, chemical resistance, and electrical properties.
Rubber roll · pot parts · sealing materials · condensers	It has excellent heat resistance, oil resistance, water resistance and weather resistance are good.

Material - Steel

■Steel

1. Carbon bar steel / wire rod / wire of JIS standard

Bar steel · wire rod			
Standard number	Standard name	Symbol	Symbol Main application
G 3101	Rolled steel for general structure	SS	Bolt, nut, pin
G 4051	Carbon steel steel for machine structural use	S-C	Nut, bolt, shaft, auto parts
G 3108	General steel for polishing steel bar	SGD	Nut, shaft, auto parts
G 4804	Sulfur and sulfur composite free-cutting steel materials	SUM	Precision mechanical parts such as watches and cameras, auto parts
G 4401	Carbon tool steel steel material	SK	Cutting tool, pair file, trowel, stamp
G 3112	Steel bar for reinforced concrete	SR, SD	Reinforcing bar for concrete
G 3123	Polished steel bar	SGD-D	Nut, shaft, auto parts
G 3104	Round steel for rivet	SV	Rivet
G 3105	Round steel for chain	SBC	Chain
G 3109	Steel bar	SBPR	For prestressed concrete

Wire		
Standard number	Standard name	Symbol
G 3505	Soft steel wire rod	SWRM
G 3506	Hard steel wire rod	SWRH
G 3502	Piano Wire	SWRS
G 3507	Carbon steel wire for cold forging	SWRCH
G 3503	Coated arc Wire for welding rod core wire	SWRY

Wire			
Standard number	Standard name	Symbol	Application example
G 3532	Iron wire { Ordinary iron wire Cast iron wire Nail wire for nails	SWM-B SWM-A SWM-N	For general use, wire mesh For general use, wire mesh For nails
G 3544	Molten aluminum plated iron wire and steel wire	SWMA	Various wire mesh
G 3521	Hard steel wire	SW	Various wire springs, wire rope, steel cord, Bead wire, spoke wire
G 3538	PC hard steel wire	SWCR SWCD	Prestressed concrete tank · pipe
G 3525	Wire rope		Wire rope
G 3560	Spring oil Tempered wire	SWO-A, B	Various wire spring
G 3537	Galvanized steel wire		Overground ground wire, buried ground wire, butterfly wire
G 3544	Molten aluminum plated iron wire and steel wire	SWHA	Overhead ground wire, butterfly wire, ACSR core wire
G 3522	Piano wire	SWP	Valve spring, music wire, high grade rope, Steel cord
G 3536	PC steel wire and PC steel wire	SWPR SWPD	Prestressed concrete
G 3561	Valve spring oil tempered wire	SWO-V	Valve spring
G 3544	Molten aluminum plated iron wire and steel wire	SWHA	Overhead ground wire, butterfly wire, ACSR core wire
G 3539	Carbon steel wire for cold forging	SWCH	Bolt, nut, small screw, rivet
G 3523	Covered arc welding rod core wire	SWY	Core wire of welding rod

2. Main types and mechanical properties of steel materials

Material name	Symbol	Symbol tensile strength (N/mm^2)	Yield point (N/mm^2)	Hardness	Elongation (%)
Rolled steel for general structure	SS330	330 - 430	195 or more	-	26 or more
	SS400	400 - 510	235 or more	-	21 or more
	SS490	490 - 610	275 or more	-	19 or more
Hot-rolled mild steel plate and steel strip	SPHC	270 or more	-	-	27 - 31 or more
	SPHD	270 or more	-	-	30 - 39 or more
	SPHE	270 or more	-	-	31 - 41 or more
Cold rolled steel sheet and steel strip	SPCC	(270 or more)	-	1/8Hard: 50 - 71HRB, 95 - 130HV 1/4Hard: 65 - 80HRB, 115 - 150HV 1/2Hard: 74 - 89HRB, 135 - 185HV Hard: 85 HRB or more, 170 HV or more	(32 - 39 or more)
	SPCD	270 or more	-		34 - 41 or more
	SPCE	270 or more	-		36 - 43 or more
Carbon steel steel for machine structural use	S25C-N	440 or more	265 or more	123 - 183HB	27 or more
	S35C-N	305 or more	305 or more	149 - 207HB	23 or more
	S35C-H	390 or more	390 or more	167 - 235HB	22 or more
	S45C-N	570 or more	345 or more	167 - 229HB	20 or more
	S45C-H	690 or more	490 or more	201 - 269HB	17 or more
Chrome steel product	SCr430	780 or more	635 or more	229 - 293HB	18 or more
	SCr435	880 or more	735 or more	255 - 321HB	15 or more
	SCr440	930 or more	785 or more	269 - 331HB	13 or more
Chrome molybdenum steel steel material	SCM430	830 or more	685 or more	241 - 302HB	18 or more
	SCM435	930 or more	785 or more	269 - 331HB	15 or more
	SCM440	980 or more	835 or more	285 - 352HB	12 or more
Carbon tool steel steel material	SK3	-	-	Annealing 212 HB or more Quenching and tempering 63 HRC or more	-
High carbon chrome bearing steel steel material	SUJ2	-	-	Spheroidizing annealed less than 201 HB Spheroidizing annealed 94 HRB or less	-
	SUJ3	-	-	Spheroidizing annealed less than 207 HB Spheroidizing annealed 95 HRB or less	-
Carbon steel forged steel goods	SF340A	340 - 440	175 or more	90HB or more	27 or more
	SF440A	440 - 540	225 or more	121HB or more	24 or more
	SF540A	540 - 640	275 or more	152HB or more	20 or more
Carbon steel cast steel products	SC360	360 or more	175 or more	-	23 or more
	SC410	410 or more	205 or more	-	21 or more
	SC450	450 or more	225 or more	-	19 or more
	SC480	480 or more	245 or more	-	17 or more
Mouse cast iron item	FC150	150 or more	-	212 HB or less (casting diameter of test material and diameter 30 mm)	-
	FC200	200 or more	-	223 HB or less (casting diameter of test material and diameter 30 mm)	-
	FC250	250 or more	-	241 HB or less (casting diameter of test material and diameter 30 mm)	-
	FC300	300 or more	-	262 HB or less (casting diameter of test material and diameter 30 mm)	-
Spherical graphite cast iron product	FCD400	400 or more	250 or more	201HB or less	15 or more
	FCD450	450 or more	280 or more	143 - 217HB	10 or more
	FCD500	500 or more	320 or more	170 - 241HB	7 or more
	FCD600	600 or more	370 or more	192 - 269HB	3 or more
Stainless steel bar	SUS303	520 or more	-	187HB or less	40 or more
	SUS304	520 or more	-	187HB or less	40 or more
	SUS410	540 or more	-	159HB or more	25 or more
	SUS416	540 or more	-	159HB or more	25 or more
	SUS440C	780 or more	-	56HRC or more	15 or less

● The values in the table above are representative values and will vary depending on the thickness of the steel material and heat treatment.

Material - Stainless Steel

■Stainless steel

1. Stainless steel

Stainless steel refers to alloy steels containing chromium (Cr) · nickel (Ni) in 6 large elements of iron and having a Cr content of about 11% or more. Stainless steel is based on an Fe - Cr alloy containing about 11% or more of Cr, and Ni, Mo, Cu, Al, Si, etc. are added to improve corrosion resistance, mechanical properties, processability and other properties.

From the aspect of Cr and Ni, the main raw material is roughly divided into Cr type and Cr - Ni type, and it is divided into metallic structure, martensite type, ferrite type and austenite type. In addition, there are austenitic ferritic stainless steel and precipitation hardened stainless steel.

●Classification of stainless steel

Classification	Cr series		Cr-Ni series
Metal structure	Martensitic system	Ferrite type	Austenite type
Curability	Quench hardenability	Non hardening curability	Work hardening property

●Effect of each element on performance

Elements		Improved performance
C	Low carbon	Corrosion resistance (intergranular corrosion resistance)
	High carbon	Strength · Hardness
Mo		Corrosion resistance (pitting corrosion resistance)
Cu		Acid resistance
Ti • Nb		Corrosion resistance (intergranular corrosion resistance)
Si • Al		Oxidation resistance
S • Se		Machinability

2. Types and characteristics of stainless steel

Types of symbols	Characteristic
SUS302	Standard type of 18Cr-8Ni steel. Both SUS303 and SUS304 are SUS302 with improvements added. Good corrosion resistance and mechanical properties by Ni addition.
SUS303	S / P added to SUS 302 to improve machinability. However, corrosion resistance is somewhat inferior. Mo is added to improve corrosion resistance.
SUS304 SUS304L	It is an improved type of SUS 302, which has low carbon content and is excellent in corrosion resistance and weldability. The most standard of austenitic stainless steel. SUS304L has a carbon content lower than that of SUS 304 to improve intergranular corrosion resistance and weldability.
SUS310S	By addition of Ni · Cr, corrosion resistance and oxidation resistance are good, as well as high temperature characteristics, it is used as heat resisting steel. The work hardening property by cold working is suppressed and at the same time the magnetism is weakened, and it is also used as a low work hardening steel / non-magnetic steel.
SUS316 SUS316L	By addition of Mo, corrosion resistance (pitting corrosion) · acid resistance is good, high temperature strength is high, and it is used as heat resistant steel. SUS 316 L has a lower carbon content than SUS 316 to improve intergranular corrosion resistance and weldability.
SUSXM7	The work hardening property by cold working is suppressed by adding Cu to SUS 304.
SUS430	Good for cold workability and corrosion resistance with standard type of 18Cr steel. Because it is inexpensive, it is used in many applications.
SUS434	Those which improved Mo corrosion resistance by adding Mo to SUS 430.
SUS410	Representative martensitic stainless steel. It has excellent mechanical properties and corrosion resistance after heat treatment.
SUS403	It has improved the corrosion resistance and the toughness after heat treatment by reducing the component range of Si · Cr. Valves, pump shafts, blades, bolts, nuts, steam turbine blades, jet engine parts, etc. are used.
SUS416	Improved machinability of 13Cr steel by adding S · P. Corrosion resistance is slightly inferior to the standard type.
SUS431	Improved toughness by adding Ni, improved corrosion resistance by adding Cr, corrosion resistance is the best in heat-treatable martensitic systems. It is used for papermaking machines, shafts for ships and aircraft parts.
SUS440C	It has the highest hardness among stainless steels, has excellent wear resistance, and is used for dice and ball bearings and the like.
SUS631J1	It is a precipitation hardening type stainless steel, which is the most heat resistant among JIS steel types, and is used in thin plates and wire springs.

3. Chemical composition and mechanical properties of various stainless steel materials

●Austenite type

Types of symbols	Chemical composition (%)									Mechanical properties		
	C	Si	Mn	P	S	Ni	Cr	Mo	Other	Tensile strength (N/mm^2)	Elongation (%)	Brinel Hardness (HB)
SUS302	0.15 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	8.00 - 10.00	17.00 - 19.00	-	-	520 or more	40 or more	187 or less
SUS303	0.15 or less	1.00 or less	2.00 or less	0.20 or less	0.15 or more	8.00 - 10.00	17.00 - 19.00	0.60 or less	-	520 or more	40 or more	187 or less
SUS304	0.08 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	8.00 - 10.50	18.00 - 20.00	-	-	520 or more	40 or more	187 or less
SUS304L	0.03 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	9.00 - 13.00	18.00 - 20.00	-	-	480 or more	40 or more	187 or less
SUS310S	0.08 or less	1.50 or less	2.00 or less	0.045 or less	0.03 or less	19.00 - 22.00	24.00 - 26.00	-	-	520 or more	40 or more	187 or less
SUS316	0.08 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	10.00 - 14.00	16.00 - 18.00	2.00 - 3.00	-	520 or more	40 or more	187 or less
SUS316L	0.03 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	12.00 - 15.00	16.00 - 18.00	2.00 - 3.00	-	480 or more	40 or more	187 or less
SUSXM7	0.08 or less	1.00 or less	2.00 or less	0.045 or less	0.03 or less	8.50 - 10.50	17.00 - 19.00	-	Cu: 3.00 - 4.00	480 or more	40 or more	187 or less

●Ferrite type

Types of symbols	Chemical composition (%)									Mechanical properties		
	C	Si	Mn	P	S	Ni	Cr	Mo	Other	Tensile strength (N/mm^2)	Elongation (%)	Brinel Hardness (HB)
SUS430	0.12 or less	0.75 or less	1.00 or less	0.04 or less	0.03 or less	0.60 or less	16.00 - 18.00	-	-	450 or more	22 or more	183 or less
SUS434	0.12 or less	1.00 or less	1.00 or less	0.04 or less	0.03 or less	0.60 or less	16.00 - 18.00	0.75 - 1.25	-	450 or more	22 or more	183 or less

●Martensitic system

Types of symbols	Chemical composition (%)									Mechanical properties		
	C	Si	Mn	P	S	Ni	Cr	Mo	Other	Tensile strength (N/mm^2)	Elongation (%)	Brinel Hardness (HB)
SUS410	0.15 or less	1.00 or less	1.00 or less	0.04 or less	0.03 or less	0.60 or less	11.50 - 13.50	-	-	540 or more	25 or more	159 or more
SUS410	0.15 or less	1.00 or less	1.25 or less	0.06 or less	0.15 or more	0.60 or less	12.00 - 14.00	0.60 or less	-	540 or more	17 or more	159 or more
SUS440C	0.95 - 1.20	1.00 or less	1.00 or less	0.04 or less	0.03 or less	0.60 or less	16.00 - 18.00	0.75 or less	-	780 or more	15 or less	56HRC or more

●The numbers in the table are reference values, not guaranteed values.

Material - Aluminum Alloy

■Aluminum alloy

1. Types and Overview of Aluminum Alloys

Alloy system	Types of symbols	Overview
Al-Cu type	A2011 A2014 A2017 A2024	2017 · 2024 which is known by the name of duralumin or super duralumin is representative and has strength comparable to steel material. The machinability is good, especially 2011 in which Pb and Bi are added, are often used as mechanical parts as free cutting alloys. In addition, 2014 has wide application as a high strength forged material. Since it contains a relatively large amount of copper, it is inferior in corrosion resistance, and when it is exposed to a corrosive environment, sufficient corrosion protection treatment is required.
Al-Mn type	A3003 A3004	3003 is a representative alloy, the addition of Mn slightly increases the strength without decreasing the workability and corrosion resistance of pure aluminum. It has wide application in containers, building materials, containers, etc.3004 added with about 1% Mg to the alloy corresponding to 3003 is further high in strength, and is often used as a material for aluminum cans, roof boards and door panel materials.
Al-Si type	A4032	4032 is a product obtained by adding about 1% of each of Cu, Ni and Mn to each of which the coefficient of thermal expansion is suppressed and the abrasion resistance is improved by the addition of Si, and the heat resistance is improved. It has good heat resistance and low thermal expansion, so it is suitable for forged piston material.
Al-Mg type	A5005 A5052 A5083	As an alloy with a small addition amount of Mg, 5005 is representative, and it is used for interior ceiling boards for vehicles, building materials, container materials. For medium containing Mg, 5052 is representative and is the most common material with moderate strength. 5083 with a high Mg content is a specific heat treatment alloy and has the best strength as a non-heat treated alloy and has good weldability. Therefore, it is used as a welded structural material for ships, vehicles, chemical plants.
Al-Mg-Si type	A6061 A6063	Alloys of this system are also good in strength and corrosion resistance, and are used as structural materials. 6061 is a material with increased strength by adding a small amount of Cu. Although corrosion resistance decreases a little, it is excellent in forgeability and it is used for rivet materials and small parts of automobiles. With a yield strength of 254 N / mm 2 or more, there is an advantage that an allowable stress equivalent to that of SS 400 steel can be obtained. (When design deflection does not become a problem) 6063 is used as a structural material which is low in strength but excellent in extrudability and does not require strength as much as 6061.
Al-Zn type	A7075 A7N01	Among aluminum alloys, it can be classified into Al - Zn - Mg - Cu alloy having the highest strength and Al - Zn - Mg alloy for welding structure not containing Cu. Since the Al - Zn - Mg alloy has a relatively high strength, the heat affected zone after welding also recovers to a strength close to the base metal due to natural aging, so excellent joint efficiency can be obtained. 7N01 is a representative alloy and used as a material for welding construction in railway vehicles.

2. Chemical composition of aluminum alloy

Types of symbols	Chemical composition (%)									
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Other
A2011	0.4 or less	0.7 or less	5.0 - 6.0	-	-	-	0.30 or less	-	The rest	Pb: 0.20 - 0.6
A2014	0.50 - 1.2	0.7 or less	3.9 - 5.0	0.40 - 1.2	0.20 - 0.8	0.10 or less	0.25 or less	-	The rest	Zr+Ti: 0.20 or less
A2017	0.20 - 0.8	0.7 or less	3.5 - 4.5	0.40 - 1.0	0.40 - 0.8	0.10 or less	0.25 or less	-	The rest	Zr+Ti: 0.20 or less
A2024	0.5 or less	0.5 or less	3.8 - 4.9	0.30 - 0.9	1.2 - 1.8	0.10 or less	0.25 or less	-	The rest	Zr+Ti: 0.20 or less
A3003	0.6 or less	0.7 or less	0.05 - 0.20	1.0 - 1.5	-	-	0.10 or less	-	The rest	-
A3004	0.3 or less	0.7 or less	0.25 or less	1.0 - 1.5	0.8 - 1.3	-	0.25 or less	-	The rest	-
A4032	11.0 - 13.5	1.0 or less	0.50 - 1.3	-	0.8 - 1.3	0.10 or less	0.25 or less	-	The rest	Ni: 0.50 - 1.3
A5005	0.3 or less	0.7 or less	0.20 or less	0.20 or less	0.50 - 1.1	0.10 or less	0.25 or less	-	The rest	-
A5052	0.25 or less	0.4 or less	0.10 or less	0.10 or less	2.2 - 2.8	0.15 - 0.35	0.10 or less	-	The rest	-
A5083	0.4 or less	0.4 or less	0.10 or less	0.40 - 1.0	4.0 - 4.9	0.05 - 0.25	0.25 or less	0.15 or less	The rest	-
A6061	0.40 - 0.8	0.7 or less	0.15 - 0.40	0.15 or less	0.8 - 1.2	0.04 - 0.35	0.25 or less	0.15 or less	The rest	-
A6063	0.20 - 0.6	0.35 or less	0.10 or less	0.10 or less	0.45 - 0.9	0.10 or less	0.10 or less	0.10 or less	The rest	-
A7075	0.4 or less	0.5 or less	1.2 - 2.0	0.30 or less	2.1 - 2.9	0.18 - 0.28	5.1 - 6.1	0.20 or less	The rest	Zr+Ti: 0.25

2. Aluminum alloy quality indicator Excerpt from JIS H 0001-1998

Symbol	Definition	Meaning
F	Production as it is	obtained from a manufacturing process that does not make special adjustment for work hardening or heat treatment.
O	For annealed products	for an expanded material, annealed to obtain the softest condition. For castings, they are annealed for increased elongation or dimensional stability.
H	Work hardened	Strength increased by work hardening with or without additional heat treatment to moderate softness.
T	Heat treated by stable quality other than F · O · H	In order to make it stable by quality, heat treated regardless of additional work hardening.

Subdivision mark	Meaning
H1	Work hardening only: work hardened only without additional heat treatment to obtain predetermined mechanical properties.
H2	Those subjected to moderate softening heat treatment after work hardening: those which have been work hardened to a predetermined value or more and then reduced to a predetermined strength by appropriate heat treatment. For alloys that soften at room temperature, this quality has almost the same strength as H3 quality. For other alloys, this quality has almost the same strength as H1 quality but elongation shows somewhat higher values.
H3	Stabilized after work hardening: A work hardened product stabilized by low temperature heating. As a result, the strength decreases and the elongation increases. This stabilization treatment is applied only to alloys containing magnesium which gradually undergoes age softening at room temperature.
T1	Natural aging after cooling from high-temperature machining: those that have been naturally aged to a sufficiently stable state without actively cold working after cooling from the high-temperature manufacturing process as extruded materials. Therefore, the effect of the cold working is small even if corrected.
T2	After cooling cooling from high-temperature processing, and further natural aging: it performs cold working to increase the cooling strength from the high-temperature manufacturing process as an extrusion material, and further to a sufficiently stable state it is a natural prescription.
T3	The cold working after the solution treatment, and further natural aging: it performs cold working to increase the strength after solution treatment, which was naturally aging to a more stable state.
T4	The natural aging after solution treatment: without cold working after solution treatment, it is a natural prescription to a sufficiently stable state. Therefore, the effect of the cold working is small even if corrected.
T5	After cooling from high-temperature processing, the artificial aging hardening treatment: the one that the artificial aging hardening was treated without actively cold processing after cooling from the manufacturing process of the high temperature like the casting or the extrusion material. Therefore, the effect of the cold working is small even if corrected.
T6	After solution treatment, the artificial aging hardening treatment: without actively cold working after the solution treatment, it is an artificial aging curing treatment. Therefore, the effect of the cold working is small even if corrected.
T7	Stabilization treatment after solution treatment: A solution subjected to excessive aging treatment exceeding artificial age hardening treatment conditions to obtain maximum strength in order to adjust to special properties after solution treatment.
T8	Cold worked after solution treatment and further subjected to artificial age hardening: cold worked to increase the strength after solution treatment, and further subjected to artificial age hardening treatment.
T9	After solution heat treatment, artificial age hardening treatment was carried out and further cold worked: strongly artificial age hardening treatment was carried out after solution treatment and further cold worked to increase the strength.

3. Mechanical Properties of Aluminum Alloys

Type (JIS name)	By quality	Tensile strength (N/mm^2)	Strength (N/mm^2)	Elongation (%)	Brinell hardness (HBS 10/500)	Fatigue Strength * (N/mm^2)
A2014	T6	485	415	13	135	125
A2017	O	180	70	22	45	90
A2024	T4	470	325	20	120	140
A3003	O	110	40	30	28	50
A4032	T6	380	315	9	120	110
A5052	H38	290	255	7	77	140
A5083	H116	315	230	16	-	160
A6061	T6	310	275	12	95	95
A6063	T6	240	215	12	73	70
A7075	T6	570	505	11	150	160
A7N01	T5	345	295	15	100	125

* Represents 50 x 107 fatigue strengths due to rotational bending.
● The values in the above table are reference values, not guaranteed values.

Material - Resin/Rubber

■Resin/Rubber

Characteristic item	Thermoplastic resin						
	FRP	Polyacetal	Polypropylene	Nylon6	Nylon66	Polycarbonate	ABS
Specific gravity	1.5 - 2.1	1.42	0.9 - 1.04	1.12 - 1.14	1.13 - 1.15	1.20	1.04 - 1.07
Hardness (Rockwell)	M70 - 120	M94	R80 - 110	R119	R100 - 118	M78	R90 - 115
Tensile strength (N/mm^2)	98 - 200	69	29 - 38	69 - 81	75 - 82	64 - 79	35 - 59
Compressive strength (N/mm^2)	98 - 200	130	38 - 55	89	110	76	18 - 56
Izod impact value (kJ/m^2)	11 - 100	11	2.7 - 10.9	8	10	90	15 - 50
Flexural strength (N/mm^2)	69 - 270	98	41 - 55	120	120	94	49 - 88
Heat resistant temperature (°C)	150 - 180	90 - 100	120 - 130	80 - 120	80 - 150	120	60 - 95
Flame resistance	Burning	Fire retardant	Slow burning	Extremely slow burning	Extremely slow burning	Self-extinguishing	Slow burning
Weather resistance	Slight discoloration	Slight discoloration	To give rise to cracks	Slight discoloration	Slight discoloration	Be excellent	Discoloring
Weak acid resistance	Good	Endure roughly	Resistance is large	Withstand	Withstand	Good	Good
Strong acid resistance	Endure roughly	Be subjected	Withstand other than oxidizing acids	Be subjected	Be subjected	Endure roughly	Endure roughly
Weak alkaline resistance	Slight change	Endure roughly	Extremely resistant	Constant	Constant	Withstand	Constant
Strong alkaline resistance	Resistance to organic solvent	Endure roughly	Extremely resistant	Constant	Constant	Be subjected	Constant
Organic solvent resistance	Slight change	Having resistance	Under 80 °C endure	Having resistance	Having resistance	Be subjected	Be subjected

Characteristic item	Thermosetting resin		
	Phenol resin	Urea resin	Melamine resin
Specific gravity	1.36 - 1.42	1.5	1.47 - 1.52
Hardness (Rockwell)	M110 - 116	M110 - 120	M110 - M125
Tensile strength (N/mm^2)	41 - 52	38 - 69	49 - 90
Compressive strength (N/mm^2)	180 - 210	180 - 260	170 - 294
Izod impact value (kJ/m^2)	1.5 - 5	1.5 - 3.3	1.5 - 3.3
Flexural strength (N/mm^2)	62 - 75	55 - 110	69 - 110
Heat resistant temperature (°C)	150 - 180	77	100
Flame resistance	Extremely slow burning	Extremely slow burning	Self-extinguishing
Weather resistance	Gradual discoloration	Discoloration to gray	Discoloration to gray
Weak acid resistance	Good	Slight change	Constant
Strong acid resistance	Other than being affected by oxidizing acid is good.	The surface is eroded.	Be subjected
Weak alkaline resistance	Good	Slight change	Constant
Strong alkaline resistance	It is affected by thermal strong alkaline.	To decompose.	Be subjected.
Organic solvent resistance	Having resistance	Slight change	Having resistance

Characteristic item	Rubber					
	Natural rubber (NR)	Synthetic natural rubber (IR)	Styrene rubber (SBR)	Butadiene rubber (BR)	Chloroprene rubber (CR)	Butyl rubber (IIR)
Specific gravity	0.92	0.92 - 0.93	0.93 - 0.94	0.91 - 0.94	1.15 - 1.25	0.91 - 0.93
Tensile strength (N/mm²)	3 - 30	5 - 20	5 - 20	2 - 20	5 - 25	5 - 15
Elongation (%)	100 - 1000	100 - 1000	100 - 800	100 - 800	100 - 1000	100 - 800
Elasticity elasticity	Excellent	Excellent	Excellent	Excellent	Excellent	Possible
Tear	Excellent	Good	Possible	Good	Good	Good
Abrasion resistance	Excellent	Excellent	Excellent	Excellent	Good	Good
Flexural crack resistance	Excellent	Excellent	Good	Possible	Good	Excellent
Usable temperature (°C)	−70 - 120	−70 - 120	−60 - 120	−73 - 120	−55 - 120	−55 - 120
Aging resistance	Good	Good	Good	Good	Excellent	Excellent
Light fastness	Good	Good	Good	Good	Good	Excellent
Electrical insulating property (Ω・cm)	10^{10} - 10^{15}	10^{10} - 10^{15}	10^{10} - 10^{15}	10^{14} - 10^{15}	10^{10} - 10^{12}	10^{16} - 10^{18}
Gasoline · light oil	Not available	Not available	Not available	Not available	Good	Not available
Benzene · toluene	Not available	Not available	Not available	Not available	Not available	Possible
Alcohol	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Ether	Not available	Not available	Not available	Not available	Not available	Possible
Ethyl acetate	Not available	Not available	Not available	Not available	Not available	Excellent
Water	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Organic acids	Not available	Not available	Not available	Not available	Not available	Possible
High temperature inorganic acid	Not available	Not available	Not available	Not available	Good	Excellent
Low temperature inorganic acid	Good	Good	Good	Good	Excellent	Excellent
Weak alkaline resistance	Good	Good	Good	Good	Excellent	Excellent
Strong alkaline resistance	Good	Good	Good	Good	Excellent	Excellent

Characteristic item	Rubber				
	Nitrile rubber (NBR)	Propylene rubber (EPDM)	Urethane rubber (U)	Silicone rubber (Si)	Fluororubber (FPM)
Specific gravity	1.00 - 1.20	0.86 - 0.87	1.00 - 1.30	0.95 - 0.98	1.80 - 1.82
Tensile strength (N/mm²)	5 - 25	5 - 20	20 - 45	4 - 10	7 - 20
Elongation (%)	100 - 800	100 - 800	300 - 800	50 - 590	100 - 500
Elasticity elasticity	Good	Good	Excellent	Excellent	Possible
Tear	Good	Possible	Excellent	Not available	Good
Abrasion resistance	Excellent	Good	Excellent	Not available	Excellent
Flexural crack resistance	Good	Good	Excellent	Not available	Good
Usable temperature (°C)	−20 - 110	−50 - 150	−40 - 80	−70 - 200	−30 - 230
Aging resistance	Excellent	Excellent	Good	Excellent	Excellent
Light fastness	Good	Excellent	Excellent	Excellent	Excellent
Electrical insulating property (Ω・cm)	10^{8} - 10^{10}	10^{12} - 10^{15}	10^{9} - 10^{12}	10^{11} - 10^{15}	10^{15} - 10^{18}
Gasoline · light oil	Excellent	Not available	Excellent	Not available	Excellent
Benzene · toluene	Not available	Possible	Not available	Not available・Possible	Excellent
Alcohol	Excellent	Excellent	Possible	Excellent	Excellent
Ether	Not available	Good	Not available	Not available	Not available
Ethyl acetate	Not available	Excellent	Possible	Good	Not available
Water	Excellent	Excellent	Possible	Good	Excellent
Organic acids	Not available	Not available	Not available	Not available	Not available
High temperature inorganic acid	Possible	Good	Not available	Possible	Excellent
Low temperature inorganic acid	Good	Excellent	Possible	Good	Excellent
Weak alkaline resistance	Good	Excellent	Not available	Excellent	Possible
Strong alkaline resistance	Good	Excellent	Not available	Excellent	Not available

(Note) This characteristic list is a reference value as a guide only, so it is not a guarantee. Please be sure to check the actual test with a test specimen.

Electric Wire

■Permissible Current Formula

The permissible current of the wire is the maximum current value that can be flown at all times without impairing its characteristics.
Calculate the permissible current I of an insulated wire by the following formula.

$$I=Ko\sqrt{\frac{T_1-T_2}{\gamma\,Rth}}$$

I: allowable electricity (A), Ko: allowable current reduction ratio in the case of multi-staged laying, γ: conductor effective resistance (Ω / cm) at T_1 °C., Rth: total thermal resistance of the wire (°C / W / cm), T_1: maximum allowable temperature of the wire (°C), T_2: ambient (base) temperature (°C)
γ_C: Direct current maximum conductor resistance (Ω / km) at 20 °C.
a: Conductor resistance temperature coefficient (0.00393 in copper at 20 °C, aluminum 0.0040)

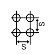
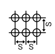
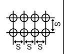
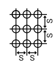
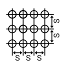
The total thermal resistance Rth of the electric wire is calculated as follows.

$$Rth=R_1+R_2$$
$$R_1=\frac{P_1}{2\pi}\log_e\frac{d_2}{d_1}$$
$$R_2=\frac{10P_2}{\pi d_2}$$

R_1: thermal resistance of insulator and coating (°C / W / cm)
R_2: Thermal resistance of the wire surface (°C / W / cm)
d_1: Outside conductor (mm)
d_2 Outer diameter of wire (mm)

P_1: Insulator specific heat resistance (°C / W / cm)
P_2: Surface dissipation thermal resistance (°C / W / cm^2)

Table 1. Maximum Allowable Current Reduction Ratio for Multi-story Cable Installation

Conditions	1	2	3	6	4	6	8	9	12
Array Center Interval									
s=d	-	0.85	0.80	0.70	0.70	0.60	-	-	-
s=2d	1.00	0.95	0.95	0.90	0.90	0.90	0.85	0.80	0.85
s=3d	-	1.00	1.00	0.95	0.95	0.95	0.90	0.85	0.85

d = wire outer diameter s = wire center distance

Table 2. Maximum allowable temperature T_1

Material	Maximum allowable temperature (°C)
General vinyl	60
Heat resistant vinyl	80, 105
Crosslinked vinyl	105
Polyethylene	75
Crosslinked polyethylene	90, 105
TFE	250
FEP	200
Nylon	90
Silicon rubber	180

Conductor effective resistance γ (Ω/cm)
$\gamma=\gamma_0\{1+a(T1-20)\}\times10^{-5}$

Current reduction coefficient when ambient temperature is different from 30 °C

Rated temperature (°C) \ Ambient temperature (°C)	30	40	50	60
60	1.00	0.82	0.57	-
80	1.00	0.90	0.77	0.63
90	1.00	0.92	0.82	0.71
105	1.00	0.93	0.85	0.78
125	1.00	0.95	0.89	0.83
150	1.00	0.96	0.91	0.95
200	1.00	0.97	0.93	0.90

Table 3. Specific Thermal Resistance of Insulator

Material	Intrinsic thermal resistance P_1(°C/W/cm)
Vinyl	600
Crosslinked vinyl	600
Polyethylene	450
Crosslinked polyethylene	450
TFE	450
FEP	400
Nylon	450
Silicon rubber	500

Table 4. Surface dissipation thermal resistance P_2

Material	Surface dissipation thermal resistance P_2(°C/W/cm)
Materials shown in Table 3	$500+10\cdot d_2(d_2\leqq 40)$
Impregnated braid	$400+20\cdot d_2(d_2\leqq 20)$

Allowable current reduction coefficient when wires are bundled

Number of wires	Coefficient	Number of wires	Coefficient
1	1.00	11	0.43
2	0.85	12	0.42
3	0.75	13	0.41
4	0.68	14	0.40
5	0.62	15	0.39
6	0.56	16	0.38
7	0.52	17	0.37
8	0.49	18	0.37
9	0.46	19	0.36
10	0.44	20	0.35

■Voltage drop

Voltage drop is the voltage drop in the equipment due to the resistance of the wire itself when wiring the equipment with electric wires, causing a voltage drop in the wire.
Voltage drop depends on load power, power factor, AC resistance and inductance of the line.
Supposing that the receiving end voltage is Er, the current is I, the power factor angle of the current is Θ, the resistance of the line is R, the reactance of the line is X, and the length of the line is ℓ, the transmitting end voltage Es

$$Es=\sqrt{(Er\cos\Theta+RI\,\ell)^2+(Er\sin\Theta+XI\,\ell)^2}.$$

Since the above equation can be expressed simply as

$$Es=Er+I\,(R\cos\theta+X\sin\theta)\,\ell,$$

the voltage drop of the line is

$$Es-Er=I\,(R\cos\theta+X\sin\theta)\,\ell.$$

In the above equation, ignoring the reactance of the circuit and assuming that the power factor can be regarded as 1, the following simplified expression is often used to obtain an approximate value.
In the case of a single-phase two-wire system (Figure B)

$$e=Es-Er=R\cdot I\cdot\ell\times2$$

In the case of three-phase three-wire system (Figure C)

$$e=Es-Er=R\cdot I\cdot\ell\times\sqrt{3}$$

In the case of a single-phase 3-wire system, calculate it as if the load is balanced and the current can not flow to the neutral wire (Figure D)

$$e'=Es-Er=R\cdot I\cdot\ell$$

Where e' is the voltage drop between the neutral line and the outer line or one phase of each phase.

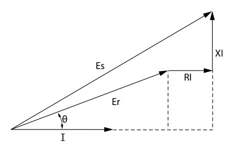


Figure A Vector diagram of voltage drop

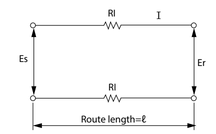


Figure B Single phase 2 wire type

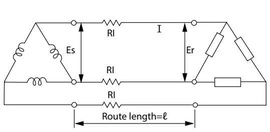


Figure C Three-phase 3 wire type

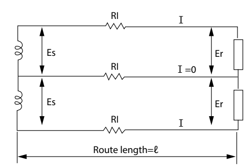


Figure D Three-phase 4 wire type and single-phase 3 wire type

Gauge			Diameter		Cross Area			Weight kg/km	
mmG	AWG	SWG	mm	mil	mm²	in²	CM	Steel	Aluminum
-	6/0	-	14.73	580.1	170.5	0.2643	336.500	1.516	460.4
-	5/0	-	13.12	500.0	135.2	0.2096	266.900	1.202	365.0
-	-	7/0	12.70	516.6	126.7	0.1964	250.000	1.126	342.1
12	-	-	12.00	472.4	113.1	0.1753	223.200	1.005	305.4
-	-	6/0	11.79	464.0	109.1	0.1691	215.300	969.9	294.6
-	4/0	-	11.68	460.0	107.2	0.1662	211.600	953.0	289.4
-	-	5/0	10.97	432.0	94.59	0.1466	186.600	840.9	255.4
-	3/0	-	10.40	409.6	85.04	0.1318	167.800	756.0	229.6
-	-	4/0	10.16	400.0	81.10	0.1257	160.000	721.0	219.0
10	-	-	10.00	393.7	78.54	0.1217	155.000	698.2	212.1
-	-	3/0	9.449	372.0	70.13	0.1087	138.400	623.5	189.4
-	2/0	-	9.266	364.8	67.43	0.1045	133.100	599.5	182.1
9	-	-	9.000	354.3	63.62	0.09961	125.600	565.6	171.8
-	-	2/0	8.839	348.0	61.37	0.09512	121.100	545.6	165.7
-	0	-	8.252	324.9	53.49	0.08291	105.600	475.5	144.4
-	-	0	8.230	324.0	53.20	0.08245	105.000	472.9	143.6
8	-	-	8.000	315.0	50.27	0.07791	99.210	446.9	135.7
-	-	1	7.620	300.0	45.61	0.07069	90.000	405.5	123.1
-	1	-	7.348	289.3	42.41	0.06573	83.690	377.0	114.5
-	-	2	7.010	276.0	38.60	0.05983	76.180	343.2	104.2
7	-	-	7.000	275.6	38.48	0.05964	75.940	342.1	103.9
-	2	-	6.543	257.6	33.63	0.05212	66.380	299.0	90.80
6.5	-	-	6.500	255.9	33.18	0.05143	65.480	295.0	89.59
-	-	3	6.401	252.0	32.18	0.04999	63.500	286.1	86.89
6	-	-	6.000	236.2	28.27	0.04382	55.790	251.3	76.33
-	-	4	5.893	232.0	27.27	0.04227	53.820	242.4	73.63
-	3	-	5.827	229.4	26.67	0.04133	52.820	237.1	72.01
5.5	-	-	5.500	216.5	23.76	0.03693	46.890	211.2	64.15
-	-	5	5.385	212.0	22.78	0.03530	44.940	202.5	61.51
-	4	-	5.189	204.3	21.15	0.03278	41.740	188.0	57.11
5	-	-	5.000	196.9	19.64	0.03041	38.760	174.6	53.03
-	-	6	4.877	192.0	18.68	0.02895	36.880	166.1	50.44
-	5	-	4.620	181.9	16.77	0.02599	33.090	149.0	45.25
4.5	-	-	4.500	177.2	15.90	0.02464	31.380	141.4	42.93
-	-	7	4.470	176.0	15.70	0.02433	30.980	139.6	42.39
-	6	-	4.115	162.0	13.30	0.02061	26.240	118.2	35.91
-	-	8	4.064	160.0	12.97	0.02011	25.600	115.3	35.02
4	-	-	4.000	157.5	12.57	0.01949	24.810	111.7	33.94
-	7	-	3.685	144.3	10.55	0.01635	20.820	93.79	28.49
-	-	9	3.658	144.0	10.51	0.01629	20.740	93.43	28.38
3.5	-	-	3.500	137.8	9.621	0.01491	18.900	85.53	25.98
-	8	-	3.264	128.5	8.368	0.01297	16.510	74.39	22.59
-	-	10	3.251	128.0	8.304	0.01287	16.380	73.82	22.42
3.2	-	-	3.200	126.0	8.042	0.01246	15.870	71.49	21.71
-	-	11	2.946	116.0	6.820	0.01057	13.460	60.63	18.41
-	9	-	2.906	114.4	6.633	0.01029	13.090	58.97	17.91
2.9	-	-	2.900	114.2	6.605	0.01024	13.040	58.72	17.83
-	-	12	2.642	104.0	5.481	0.008495	10.820	48.73	14.80
2.6	-	-	2.600	102.4	5.309	0.008228	10.480	47.20	14.33
-	10	-	2.588	101.9	5.262	0.008155	10.380	46.78	14.21
-	-	13	2.337	92.0	4.289	0.006649	8.464	38.13	11.58
-	11	-	2.304	90.7	4.169	0.006461	8.226	37.06	11.26
2.3	-	-	2.300	90.6	4.155	0.006440	8.200	36.94	11.22
-	12	-	2.052	80.8	3.309	0.005128	6.529	29.42	8.934
-	-	14	2.032	80.0	3.243	0.005027	6.400	28.83	8.756
2.0	-	-	2.000	78.7	3.142	0.004870	6.201	27.93	8.483
-	13	15	1.829	72.0	2.627	0.004072	5.184	23.35	7.093
1.8	-	-	1.800	70.9	2.545	0.003945	5.023	22.63	6.872
-	14	-	1.628	64.1	2.082	0.003227	4.109	18.51	5.621
-	-	16	1.626	64.0	2.076	0.003217	4.096	18.46	5.605
1.6	-	-	1.600	63.0	2.011	0.003117	3.969	17.99	5.430
-	15	-	1.450	57.1	1.652	0.002561	3.260	14.69	4.460
-	-	17	1.422	56.0	1.589	0.002463	3.136	14.13	4.290
1.4	-	-	1.400	55.1	1.539	0.002385	3.037	13.69	4.155
-	16	-	1.290	50.8	1.308	0.002027	2.581	11.63	3.532

Gauge			Diameter		Cross Area			Weight kg/km	
mmG	AWG	SWG	mm	mil	mm²	in²	CM	Steel	Aluminum
-	-	18	1.129	48.0	1.168	0.001910	2.304	10.38	3.154
1.2	-	-	1.200	47.2	1.131	0.001753	2.232	10.05	3.054
-	17	-	1.151	45.3	1.040	0.001612	2.052	9.246	2.809
-	18	-	1.024	40.3	0.8233	0.001276	1.624	7.319	2.223
-	-	19	1.016	40.0	0.8110	0.001257	1.600	7.210	2.190
1.0	-	-	1.000	39.4	0.7854	0.001217	1.550	6.982	2.121
-	-	20	0.9144	36.0	0.6568	0.001018	1.296	5.839	1.773
-	19	-	0.9119	35.9	0.6529	0.001012	1.289	5.804	1.763
0.9	-	-	0.8000	35.4	0.6362	0.0009961	1.256	5.656	1.718
-	20	21	0.8128	32.0	0.5189	0.0009042	1.024	4.613	1.401
0.8	-	-	0.8000	34.5	0.5027	0.0007791	992.1	4.469	1.357
-	21	-	0.7239	28.5	0.4116	0.0006379	812.3	3.659	1.111
-	-	22	0.7112	28.0	0.3973	0.0006159	784.0	3.532	1.073
0.7	-	-	0.7000	27.6	0.3848	0.0005964	759.4	3.421	1.039
0.65	-	-	0.6500	25.6	0.3318	0.0005143	854.8	2.950	0.8959
-	22	-	0.6426	25.3	0.3243	0.0005027	640.1	2.883	0.8756
-	-	23	0.6096	24.0	0.2919	0.0004524	576.0	2.595	0.7881
0.60	-		0.6000	23.6	0.2827	0.0004282	557.9	2.513	0.7633
-	23	-	0.5740	22.6	0.2589	0.0004012	510.8	2.302	0.6990
-	-	24	0.5588	22.0	0.2452	0.0003801	484.0	2.180	0.6620
0.55	-	-	0.5500	21.7	0.2376	0.0003683	468.9	2.112	0.6416
-	24	-	0.5105	20.1	0.2047	0.0003173	404.0	1.820	0.5527
-	-	25	0.5090	20.0	0.2027	0.0003142	400.0	1.802	0.5473
0.50	-	-	0.5000	19.7	0.1964	0.0003044	387.6	1.746	0.5393
-	-	26	0.4572	18.0	0.1642	0.0002545	324.0	1.460	0.4483
-	25	-	0.4547	17.9	0.1624	0.0002517	320.4	1.444	0.4385
0.45	-	-	0.4500	17.7	0.1590	0.0002464	313.8	1.414	0.4233
-	-	27	0.4166	16.4	0.1363	0.0002112	269.0	1.212	0.3690
-	26	-	0.4039	15.9	0.1281	0.0001996	252.8	1.139	0.3459
0.40	-	-	0.4000	15.7	0.1257	0.0001948	248.1	1.117	0.3384
-	-	28	0.3759	14.8	0.1110	0.0001720	219.0	0.9868	0.2987
-	27	-	0.3607	14.2	0.1022	0.0001584	201.6	0.9086	0.2769
0.35	-	-	0.3500	13.8	0.09621	0.0001491	189.9	0.8553	0.2598
-	-	29	0.3454	13.6	0.09375	0.0001453	185.0	0.8334	0.2581
-	28	-	0.3200	12.6	0.08046	0.0001247	158.8	0.7153	0.2172
0.32	-	-	0.3200	12.6	0.08042	0.0001246	58.7	0.7149	0.2171
-	-	30	0.3150	12.4	0.07794	0.0001208	153.8	0.6929	0.2104
-	-	31	0.2946	11.6	0.08620	0.0001057	134.6	0.6063	0.1841
0.29	-	-	0.2900	11.4	0.06605	0.0001024	130.4	0.5872	0.1783
-	29	-	0.2870	11.3	0.06471	0.0001003	127.7	0.5753	0.1747
-	-	32	0.2743	10.8	0.05911	0.00009161	116.6	0.5255	0.1596
0.26	-	-	0.2600	10.2	0.05309	0.00008228	104.8	0.4720	0.1433
-	30	33	0.2540	10.0	0.05067	0.00007854	100.0	0.4505	0.1368
-	-	34	0.2337	9.2	0.04289	0.00006648	84.64	0.3813	0.1159
0.23	-	-	0.2300	9.1	0.04155	0.00006440	82.00	0.3694	0.1122
-	31	-	0.2261	8.9	0.04014	0.00006221	79.21	0.3568	0.1084
-	-	35	0.2134	8.4	0.03576	0.00005542	70.56	0.3179	0.09655
-	32	-	0.2032	8.0	0.03243	0.00005027	64.00	0.2883	0.08756
0.20	-	-	0.2000	7.9	0.03142	0.00004870	62.01	0.2793	0.08483
-	-	36	0.1930	7.6	0.02927	0.00004536	57.76	0.2602	0.07933
-	33	-	0.1803	7.1	0.02554	0.00003959	50.41	0.2271	0.06696
0.18	-	-	0.1800	7.1	0.02545	0.00003915	50.23	0.2263	0.06972
-	-	37	0.1727	6.8	0.02343	0.00003632	46.24	0.2083	0.06326
0.16	34	-	0.1600	6.3	0.02011	0.00003117	39.69	0.1788	0.05430
-	-	38	0.1524	6.0	0.01824	0.00002827	36.00	0.1622	0.04925
-	35	-	0.1422	5.6	0.01589	0.00002463	31.36	0.1413	0.04290
0.14	-	-	0.1400	5.5	0.01539	0.00002385	30.37	0.1368	0.04155
-	-	39	0.1321	5.2	0.01370	0.00002124	27.04	0.1218	0.03688
-	36	-	0.1270	5.0	0.01267	0.00001964	25.00	0.1126	0.03421
-	-	40	0.1219	4.8	0.01168	0.00001810	23.04	0.1038	0.03154
0.12	-	-	0.1200	4.7	0.01131	0.00001753	22.32	0.1005	0.03054
-	37	-	0.1143	4.5	0.01026	0.00001590	20.25	0.09121	0.02770
-	-	41	0.1118	4.4	0.009813	0.00001521	19.36	0.08724	0.02650
-	38	42	0.1016	4.0	0.008110	0.00001257	16.0	0.07210	0.02190
0.10	-	-	0.1000	3.9	0.007854	0.00001217	15.50	0.06982	0.02121

Discontinued and Replacement Models

Classification	Series			Discontinued time	Successor models (REPLACEMENTS) *
Actuator	Single axis robot	DS	SA4 SA5 SA6 A4R A5R A6R	October 2008 (Power supply voltage DC24V specification) February 2021 (Power supply voltage AC100/200V specification)	RCA (Power supply voltage DC24V specification) RCS2 (Power supply voltage AC100/200V specification)
		DSCR	SA5 SA6	February 2021	RCACR (Power supply voltage DC24V specification) RCS2CR (Power supply voltage AC100/200V specification)
		SS	S M	February 2021	RCS2, RCS3
		SSCR	S M	February 2021	RCS2CR, RCS3CR
		EX	12EX	August 2007	RCP5-BA
		AS	All models	October 2003	ISB
		E/F	12E 12ED 12F 12FD	October 2003	ISB, RCA
		IS	T-X-S S-X-M S-Y-M S-Z-M M-X-S M-X-M M-X-MX M-Y-S M-Y-M M-Z-S M-Z-M L-X-S L-X-M L-X-MX L-X-UWX L-Y-S L-Y-M L-Z-S L-Z-M	August 2014	ISB
		ISP	S-X-M S-Y-M S-Z-M M-X-S M-X-M M-X-MX M-Y-S M-Y-M M-Z-S M-Z-M L-X-S L-X-M L-X-MX L-X-MX L-X-UWX L-X-UWX L-Y-S L-Y-M L-Z-S L-Z-M W-X-M W-X-MX	September 2015	ISPB

* Refer to IAI website for the compatibility with the successor models, or contact our representative.

Notice on discontinued models

http://www.iai-robot.co.jp/product/discontinued/index.html

Classification	Series			Discontinued time	Successor models (REPLACEMENTS) *
Actuator	Single axis robot	ISD	S M MX L LX	September 2015	ISDB ISPDB ISDBCR ISPDBCR
		ISPD	S M MX L LX		
		ISDCR	S M MX L LX		
		ISPDCR	S M MX L LX W WX		
		FS	N□ W□ L□ HM	Scheduled on August 2021	IF
	Orthogonal robot	ICSP2		September 2015	ICSB2
		ICSP3			ICSB3
		ICS2		August 2014	ICSB2
		ICS3			ICSB3
	Tabletop type robot	TT-300		August 2007	TTA
	ROBO Cylinder	ERC	All models	Scheduled on August 2021	ERS2
		RC	–	October 2004	RCP6
		RC-S	–		
		RCS	SA4 SA5 SA6 S4 S5 S6 SS SM SSR SMR RA35-GN RA35-GS RA35-GD RA45-GN RA45-GS RA45-GD RA55-GN RA55-GS RA55-GD RA35R RA45R RA55R RB7525_GN RB7525_GS RB7525_GD RB7530_GN RB7530_GS RB7530_GD RB7535_GN RB7535_GS RB7535_GD F45 F55 G20 R10, R20, R30	September 2019	RCS2/RCA

* Refer to IAI website for the compatibility with the successor models, or contact our representative.

Discontinued and Replacement Models

Classification	Series			Discontinued time	Successor models (REPLACEMENTS) *
Actuator	ROBO Cylinder	RCP	SA5 SA6 SS SM SSR SMR RSA RMA RSW RMW RSI RMI RSIW RMIW RSGS RMGS RSGD RMGD RSGB RMGB G10	October 2004	RCP6
Actuator	ROBO Cylinder	RCP2W	SA16C	November 2020	RCP4W (Note 1)
Actuator	TA	TA	28 35	December 2003	RCP3, RCP6
Actuator	TX	TX	20 28 35	February 2016	RCP3, RCP6
Actuator	DD	DD DDCR	T18S T18P H18S H18P T18CS T18CP H18CS H18CP	December 2019	DDA
Controller	DS controller	DS-S-C1		October 2008	ASEL
Controller	DS controller	SA-C1, C2, C3, C4		December 2001	ASEL
Controller	DS controller	DS-C1, C2, C3, C4		December 2001	ASEL
Controller	Super SEL Controller	S-SEL-F		August 2007	SSEL
Controller	Super SEL Controller	S-SEL-ES-1		April 2005	SSEL
Controller	Super SEL Controller	M-SEL-GS-2~4		April 2005	SSEL XSEL-P/RA
Controller	Super SEL Controller	S-SEL-E-1-□ S-SEL-EDS-1-□		April 2005	SSEL
Controller	Super SEL Controller	M-SEL-G-2~8 M-SEL-GDS-2~8 M-SEL-GID-2~8 M-SEL-GX-2~9		April 2005	SSEL XSEL-P/RA
Controller	Super SEL Controller	SEL-A-1 A-3 A-2 A-4		October 2003	SSEL XSEL-P/RA
Controller	Super SEL Controller	SEL-B-2 B-7 B-3 B-8 B-4		October 2003	XSEL-P/RA
Controller	Super SEL Controller	SEL-H-2, 4 SEL-HAB-2, 4		October 2003	XSEL-P/RA
Controller	Super SEL Controller	SEL-D-2		December 2001	SSEL
Controller	Multi-controller	SEL-2~4		December 2001	SSEL XSEL-P/RA
Controller	Single controller	S-SEL-35/60/100/200		October 2003	SSEL
Controller	Single controller	S C-S		December 2001	SCON-CB

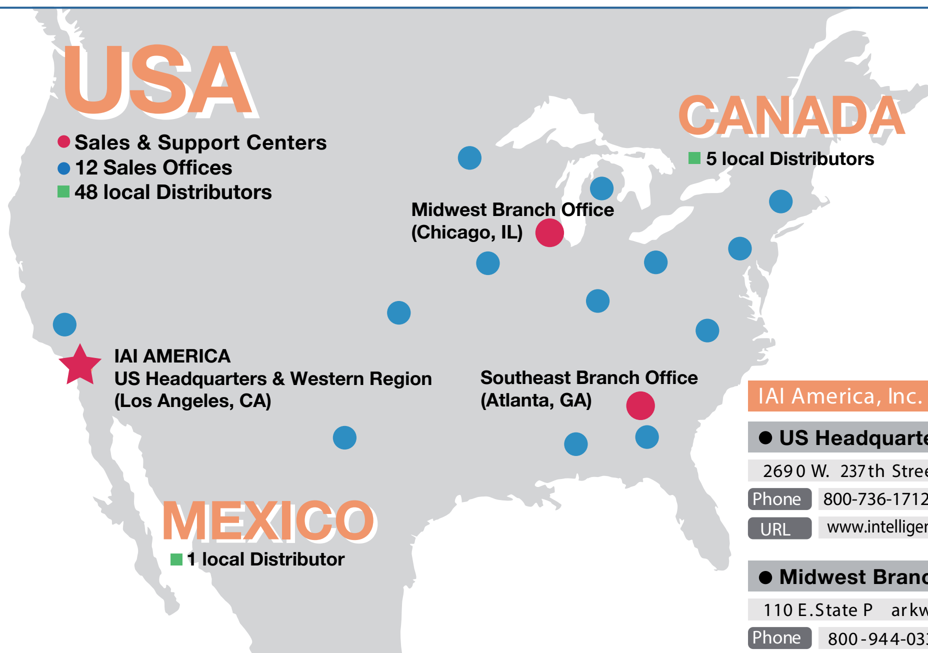
* Refer to IAI website for the compatibility with the successor models, or contact our representatives.
(Note 1) The degree of protection for RCP2W-SA16C is IP67, while that for PCP4W-SA□C is IP65.

Classification	Series		Discontinued time	Successor models (REPLACEMENTS) *
Controller	Position controller	RCP2-C/CF	May 2014	PCON-CB/CFB
		RCS-C		SCON-CB(100V,200V) ACON-CB(24V)
		RCS-E	June 2014	ACON-CB
		ECON	May 2014	SCON-CB
		PDR		SCON-CB
		RCP-C-□	October 2004	PCON-CB
		AMEC/PMEC	Scheduled on September 2021	ACON-CYB DCON-CYB PCON-CYB
		ASEP/DSEP/PSEP		
	Controller for TA	TA-C1	December 2003	PCON-CB
	Controller for TX	TX-C1	February 2016	PCON-CB
	Program controller	XSEL-J, JX	December 2017 (Plan)	XSEL-P, PX XSEL-Q, QX XSEL-RA, RAX, RAXD8 XSEL-SA, SAX, SAXD8
		XSEL-K, KE, KET, KETX KEX, KT, KX	December 2016	XSEL-P, PX XSEL-Q, QX XSEL-RA, RAX, RAXD8 XSEL-SA, SAX, SAXD8
Table top type	TT-300		August 2007	TTA
Display	Touch panel display	RCM-PM-01	December 2013	–
Teaching box	Simple teaching for RC	RCM-E	March 2014	TB-02
	Data setting device for RC	RCM-P		–
	Standard teaching for RC	RCM-T	August 2008	TB-02
	Teaching for XSEL	IA-T-X IA-T-X-J IA-T-X-JS IA-T-XD IA-T-XD-J IA-T-XD-JS	October 2015	TB-02
	Teaching for position controller	CONT-T/TG/TGS	Scheduled on June 2021	TB-02
	Teaching for program controller	SEL-T/TD/TG	Scheduled on June 2021	TB-02

* Refer to IAI website for the compatibility with the successor models, or contact our representative.

SUPPORT A network of authorized representatives in the US to serve you.

Support for phase of planning, product selection, quotation, problem solving, maintenance, training, etc.



www.intelligentactuator.com/inquiry/

IAI America, Inc.

● US Headquarters & Western Region (Los Angeles, CA)

2690 W. 237th Street, Torrance, CA 90505

Phone 800-736-1712 FAX 310-891-0815

URL www.intelligentactuator.com

● Midwest Branch Office (Chicago, IL)

110 E.State Parkway, Schaumburg, IL 60173

Phone 800-944-0333 FAX 847-908-1399

● Southeast Branch Office (Atlanta, GA)

1220 Kennestone Circle, Suite 108, Marietta, GA 30066

Phone 888-354-9470 FAX 678-354-9471

The information contained in this booklet may change without prior notice due to product improvement.

Contact us for your local distributor information.

IAI America, Inc.

US HeadquarterS & Western Region (Los Angeles): 2690 W. 237th Street, Torrance, CA 90505 (800) 736-1712
Midwest Branch Office (Chicago) : 110 E. State Pkwy, Schaumburg, IL 60173 (800) 944-0333
Southeast Branch Office (Atlanta): 1220 Kennestone Circle, Suite 108, Marietta, GA 30066 (888) 354-9470

www.intelligentactuator.com

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IAI Industrieroboter GmbH
Ober der Röth 4, D-65824 Schwalbach am Taunus, Germany

IAI (Shanghai) Co., Ltd.
Shanghai Jiahua Business Center A8-303, 808, Hongqiao Rd., Shanghai 200030, China

IAI Robot (Thailand) Co., Ltd.
825 Phairojkijja Tower 7th Floor, Debaratana Rd., Bangna Nuea, Bangna, Bangkok 10260, Thailand