



**ROBO Cylinder  
Rod Type  
RCS2 Actuator**

[Ultra High-Thrust Type: RA13R]

**Operating Manual**

===== First Edition =====



***IAI America, Inc.***

### Transporting the Unpacked Actuator

The table below lists the weights of this actuator.

Stroke	Weight
50 mm	33 kg
100 mm	34 kg
150 mm	35 kg
200 mm	36 kg

When transporting or installing the actuator, always work in a group of two or more to securely support the actuator body, and exercise due caution to prevent injury.

- Prohibited handling practices



Do not hold the rod when transporting the actuator.









Do not hold the motor cover when transporting the actuator.

## Safety Precautions (Please Read Before Use)

Before installing, operating, maintaining or inspecting this product, peruse this operating manual as well as operating manuals and related documentations for all equipment and peripherals connected to this product to ensure the correct use of the product. Also keep in mind that these tasks must be performed by individuals who possess sufficient knowledge of the applicable equipment and safe operation thereof. The precautions provided below are intended to prevent bodily injury and/or property damage by making sure the product is used correctly and safely.

In this operating manual, safety precautions are classified as “danger,” “warning,” “caution” and “note.”

 <b>Danger</b>	Failure to observe the instruction will result in an imminent danger leading to death or serious injury.
 <b>Warning</b>	Failure to observe the instruction may result in death or serious injury.
 <b>Caution</b>	Failure to observe the instruction may result in injury or property damage.
 <b>Note</b>	The user should take heed of this information to ensure the proper use of the product, although failure to do so will not result in injury.

Take note that, depending on the situation, a failure to heed the directions accompanied by  **Caution** or  **Note** may still result in serious consequences.

All instructions provide important information. Read them carefully and handle the product with due care.

Keep this operating manual in a convenient place so that it can be readily referenced whenever necessary, and also make sure the manual gets to the hands of the end-users.



### [General]

- Do not use this product for the following applications:
  1. Medical equipment used to maintain, control or otherwise affect human life or physical health
  2. Mechanisms and machinery designed for the purpose of moving or transporting people
  3. Important safety parts of machinery

This product has not been planned or designed for applications requiring high levels of safety. Use of this product in such applications may jeopardize the safety of human life. The warranty covers only the product as it is delivered.

### [Installation]

- Do not use this product in a place exposed to ignitable, inflammable or explosive substances. The product may ignite, burn or explode.
- When installing the product, be sure to securely support and affix it (including the work). Failure to do so may cause the product to tip over, drop or malfunction, resulting in injury.

- Avoid using the product in a place where the main unit or controller may come in contact with water or oil droplets.
- Never cut and/or reconnect the cables supplied with the product for the purpose of extending or shortening the cable length. Doing so may result in fire.

#### [Operation]

- Do not enter the machine's range of operation while the product is operating or standing by. The actuator may move suddenly, causing injury.
- Do not pour water onto the product. Spraying water over the product, washing it with water or using it in water may cause the product to malfunction, resulting in injury, electric shock, fire, etc.

#### [Maintenance, Inspection, Repair]

- Never modify the product. Unauthorized modification may cause the product to malfunction, resulting in injury, electric shock, fire, etc.
- Do not disassemble and reassemble the components relating to the basic structure of the product or its performance and function. Doing so may result in injury, electric shock, fire, etc.



### **Warning**

#### [General]

- Do not use the product outside the specifications. Using the product outside the specifications may cause it to fail, stop functioning or sustain damage. It may also significantly reduce the service life of the product. In particular, observe the maximum loading capacity and speed.

#### [Installation]

- If the machine will stop in the case of system problem such as emergency stop or power failure, design a safety circuit or other device that will prevent equipment damage or injury.
- Before supplying power to and operating the product, always check the operation area of the equipment to ensure safety. Supplying power to the product carelessly may cause electric shock or injury due to contact with the moving parts.
- Wire the product correctly by referring to the operation manual. Securely connect the cables and connectors so that they will not be disconnected or come loose. Failure to do so may cause the product to malfunction or cause fire.

#### [Operation]

- Before operating the moving parts of the product by hand (for the purpose of manual positioning, etc.), confirm that the servo is turned off (using the teaching pendant). Failure to observe this instruction may result in injury.
- Do not scratch the cables. Scratching, forcibly bending, pulling, winding, crushing with heavy object or pinching a cable may cause it to leak current or lose continuity, resulting in fire, electric shock, malfunction, etc.
- Turn off the power to the product in the event of power failure. Failure to do so may cause the product to suddenly start moving when the power is restored, thus resulting in injury or product damage.
- If the product is generating heat, smoke or a strange smell, turn off the power immediately. Continuing to use the product may result in product damage or fire.
- If noise or abnormally high vibration is detected, stop the operation immediately. Continuing to use the product may result in product damage, malfunction due to damage, runaway machine, etc.
- If any of the internal protective devices (alarms) of the product has actuated, turn off the power immediately. Continuing to use the product may result in product damage or injury due to malfunction. Once the power supply is cut off, investigate and remove the cause and then turn on the power again.
- Do not step on the product, use it as a footstool or place any object on it. You may lose your footing or the product may tip over, resulting in a fall and consequent injury, product damage, malfunction due to damage, runaway machine, etc.

## [Maintenance, Inspection, Repair]

- Before conducting maintenance/inspection, parts replacement or other operations on the product, completely shut down the power supply. At this time, take the following measures:
  1. Display a sign that reads, "WORK IN PROGRESS. DO NOT TURN ON POWER" at a conspicuous place, in order to prevent a person other than the operator from accidentally turning on the power while the operation is working.
  2. When two or more operators are to perform maintenance/inspection together, always call out every time the power is turned on/off or an axis is moved in order to ensure safety.

## [Disposal]

- Do not throw the product into fire. The product may burst or generate toxic gases.



## [Installation]


- Do not use the product under direct sunlight (ultraviolet ray), in a place exposed to dust, salt or iron powder, in a humid place, or in an atmosphere of organic solvent, phosphate-ester machine oil, etc. The product may lose its function over a short period of time, or exhibit a sudden drop in performance or its service life may be significantly reduced.
- Do not use the product in an atmosphere of corrosive gases (sulfuric acid or hydrochloric acid). Rust may form and reduce the structural strength of the product.
- When using the product in any of the places specified below, provide a sufficient shield. Failure to do so may result in malfunction:
  1. Place where large current or high magnetic field is present
  2. Place where welding or other operations are performed that cause arc discharge
  3. Place subject to electrostatic noise
  4. Place with potential exposure to radiation
- Do not install this product in places where the product may receive vibration or shock.
- Provide an emergency-stop device in a readily accessible position so the device can be actuated immediately upon occurrence of a dangerous situation during operation. Lack of such device in an appropriate position may result in injury.
- Provide sufficient maintenance space when installing the product. Routine inspection and maintenance cannot be performed without sufficient space, which will eventually cause the equipment to stop or the product to sustain damage.
- When transporting or installing the product, exercise due caution to prevent injury. For example, securely hold the product using a lift or support or engage multiple operators to carry the product.
- Do not hold the moving parts of the product or its cables during installation. It may result in injury.
- Always use IAI's genuine cables for connection between the controller and the actuator. Also use IAI's genuine products for the key component units such as the actuator, controller and teaching pendant.
- The brake mechanism is designed to prevent the slider from dropping when the power to the vertical axis is turned off. Do not use it as a safety brake, etc.
- Before installing or adjusting the product or performing other operations on the product, display a sign that reads, "WORK IN PROGRESS. DO NOT TURN ON POWER." If the power is turned on inadvertently, injury may result due to electric shock or sudden activation of an actuator.

## [Operation]

- Turn on the power to individual equipment one by one, starting from the equipment at the highest level in the system hierarchy. Failure to do so may cause the product to start suddenly, resulting in injury or product damage.
- Do not insert a finger or object in the openings in the product. It may cause fire, electric shock or injury.
- Do not step on the product, use it as a footstool or place any object on it. It may cause scoring, dents or deformation of the driving part, resulting in product damage, unintended stopping due to damage, or performance drop.

## [Maintenance, Inspection, Repair]

- Wear protective goggles when applying grease to the actuator. Failure to do so may result in eye inflammation due to spattered grease.

 **Note**

## [Installation]

- If the product is used in a vertical setup, be sure to use the vertical specification (with brake).
- Protection covers or other guards must be provided for the moving parts of the equipment to avoid direct contact with the operators.
- Do not configure a control circuit that will cause the work to drop in case of power failure. Configure a control circuit that will prevent the table or work from dropping when the power to the machine is cut off or an emergency stop is actuated.
- Take the following precautions to increase the linear traveling accuracy of the rod and ensure smooth movement of the ball screw:
  1. Flatness of the mounting surface must be within 0.05 mm.
  2. The mounting surface area must be large enough to ensure the rigidity of the actuator.

## [Installation, Operation, Maintenance]

- When handling the product, wear protective gloves, protective goggles, safety shoes or other necessary gear to ensure safety.

## [Maintenance, Inspection, Repair]

- To grease the rod during maintenance, use the specified grease. In particular, do not mix fluorine grease and lithium grease, as it may cause insufficient lubrication, higher resistance or other unwanted outcomes and ultimately damage the machine.

## [Disposal]

- When the product becomes no longer usable or necessary, dispose of it properly as an industrial waste.

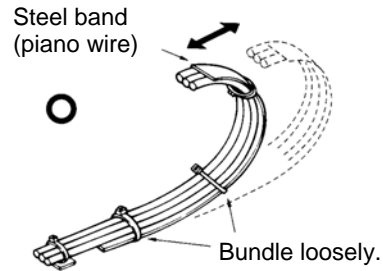
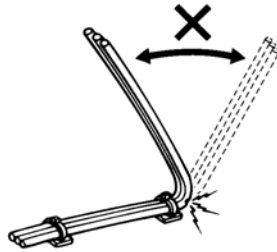
**Others**

- v IAI shall not be liable whatsoever for any loss or damage arising from a failure to observe the items specified in "Safety Precautions."

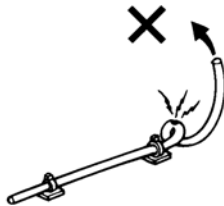
## Prohibited Handling of Cables

When designing an application system using IAI actuators and controllers, incorrect wiring or connection of each cable may cause unexpected problems such as a disconnected cable or poor contact, or even a runaway system. This section explains prohibited handling of cables. Read the information carefully to connect the cables properly.

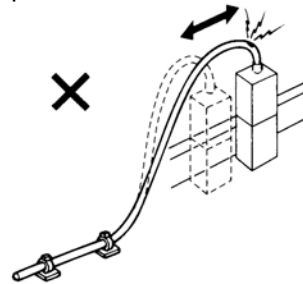
1. Do not let the cable flex at a single point.



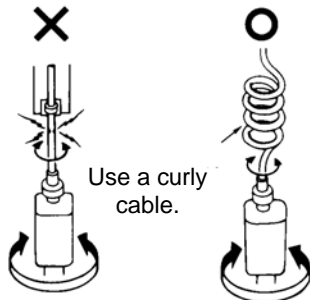
2. Do not let the cable bend, kink or twist.



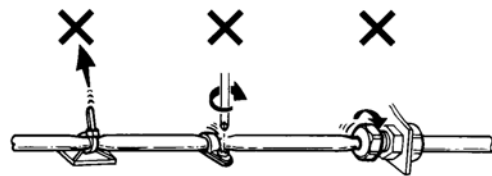
3. Do not pull the cable with a strong force.



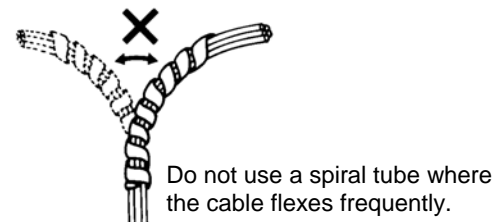
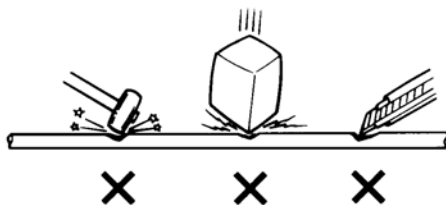
4. Do not let the cable receive a turning force at a single point.



5. When fixing the cable, provide a moderate slack and do not tension it too tight.

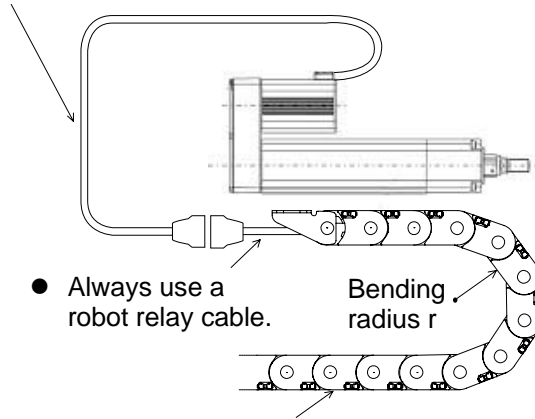


6. Do not pinch, drop a heavy object onto or cut the cable.



## 7. Cautions for use of a cable bearer

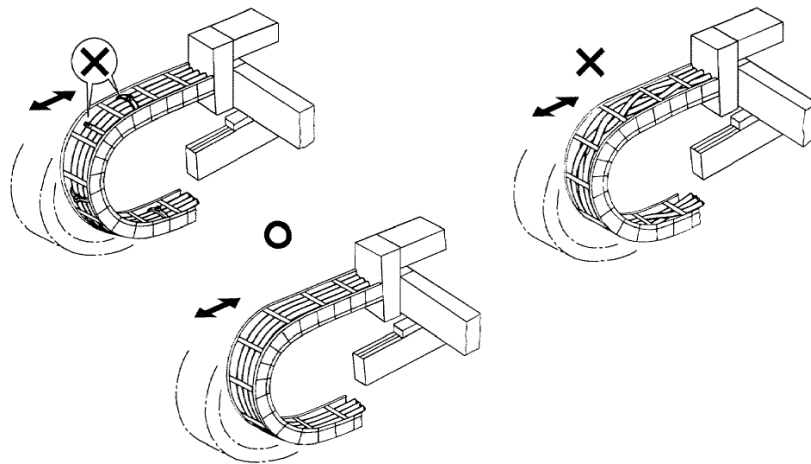
- The supplied cable is not a robot cable, so never store it in a cable bearer.



- Always use a robot relay cable.

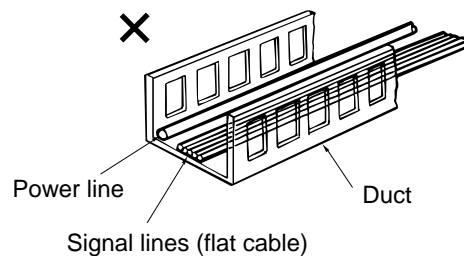
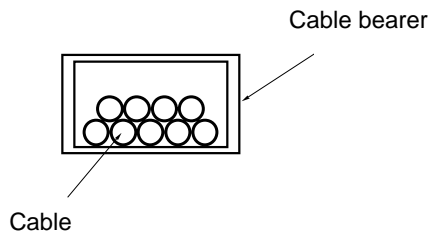
- If a cable bearer is used, select one with a bending radius  $r$  of at least 50 mm.

- Do not let the cable get tangled or kinked in a cable bearer or flexible tube. When bundling the cable, keep a certain degree of flexibility (so that the cable will not become too taut when bent).



- Do not cause the cables to occupy more than 60% of the space in the cable bearer.

- Do not lay signal lines together with circuit lines that create a strong electric field.





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## **1. Foreword**

Thank you for purchasing the Robo Cylinder Actuator. This manual explains the structure, correct operation and maintenance of the Robo Cylinder Actuator. Please read this manual carefully before using the actuator. For more complete information on operating the actuator, please refer to the controller operating manual.

## **2. Safety Precautions**

### **2.1 Basic Operating Instructions**

- Please do not attempt to use or operate the actuator in any manner not indicated in this manual or the controller manual.
- Please be sure to use only the cable provided by IAI to connect the actuator and controller.
- Please do not allow people within the moving range of the unit when it is in operation or when the power is ON since this is dangerous.

### **2.2 Maintenance and Inspection**

- When doing maintenance and inspection work, always shut down the controller power first.
- When doing inspection, make sure that no one can inadvertently turn the power ON.
- Make sure that a sign indicating work in progress is clearly visible.
- If several persons are working, be sure to watch out for each other's safety. In particular, check before turning power ON or OFF and let others know if you are doing work involving axis movement.

#### **(Notes)**

- The contents of this manual are subject to change without notice for the purposes of improvement.
- This manual has been written with the utmost attention to accuracy. However, it is possible that the manual may still contain technical inaccuracies or typographical or other errors. Should you come across any inaccuracy or if you have any feedback regarding this manual, please contact IAI.

### **3. Warranty**

#### **3.1 Warranty Period**

The warranty period corresponds to one of the following periods, whichever elapses first:

- 18 months after the shipment from IAI
- 12 months after the delivery to the specified location
- 2,500 hours of operation

#### **3.2 Scope of Warranty**

All defects in materials or craftsmanship found during the warranty period specified above will be repaired free of charge. Note, however, that the following items are excluded from the scope of this warranty:

- Natural fading of exterior paint and other changes due to aging
- Wear of consumable parts from use
- Noises and other subjective conditions that do not affect function
- Inappropriate handling by the user or failure to conduct maintenance/inspection
- Modification not performed by IAI or its authorized dealer
- Breakdown resulting from using a controller not manufactured by IAI
- Anything caused by an act of God, accident, fire, etc.

This warranty covers only the product delivered. IAI shall not be liable for any secondary loss or damage arising from a defect in the product. To enjoy free warranty repairs, the customer must bring the defective product to IAI's factory.

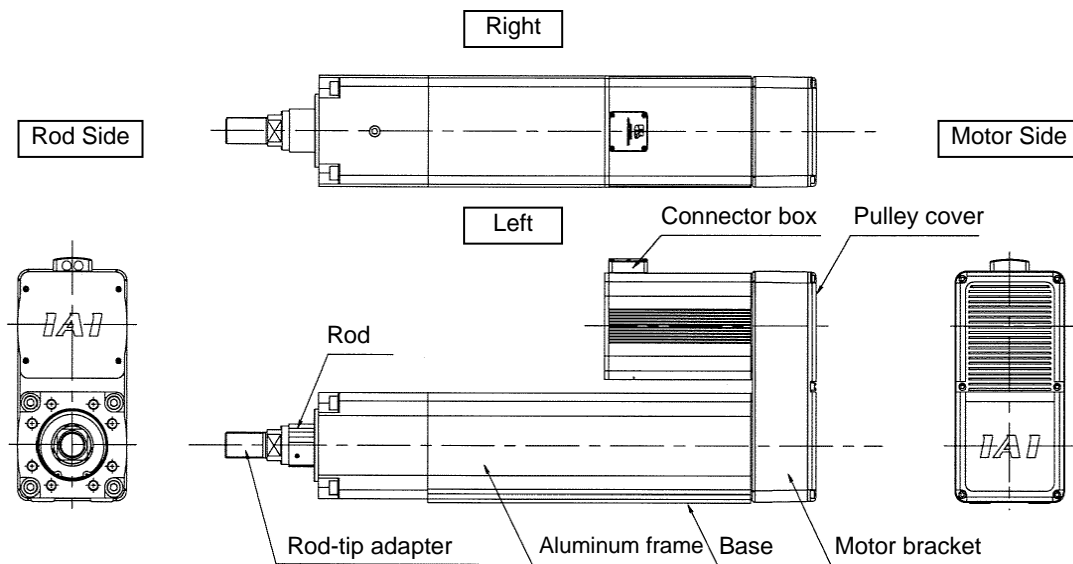
Should you require an onsite repair by our engineer, separate fees will be chargeable even during the warranty period.

## 4. Names of the Parts

The name of the actuator parts are indicated below.

In this manual, the left and right sides are indicated by looking at the actuator from the motor side in top view.

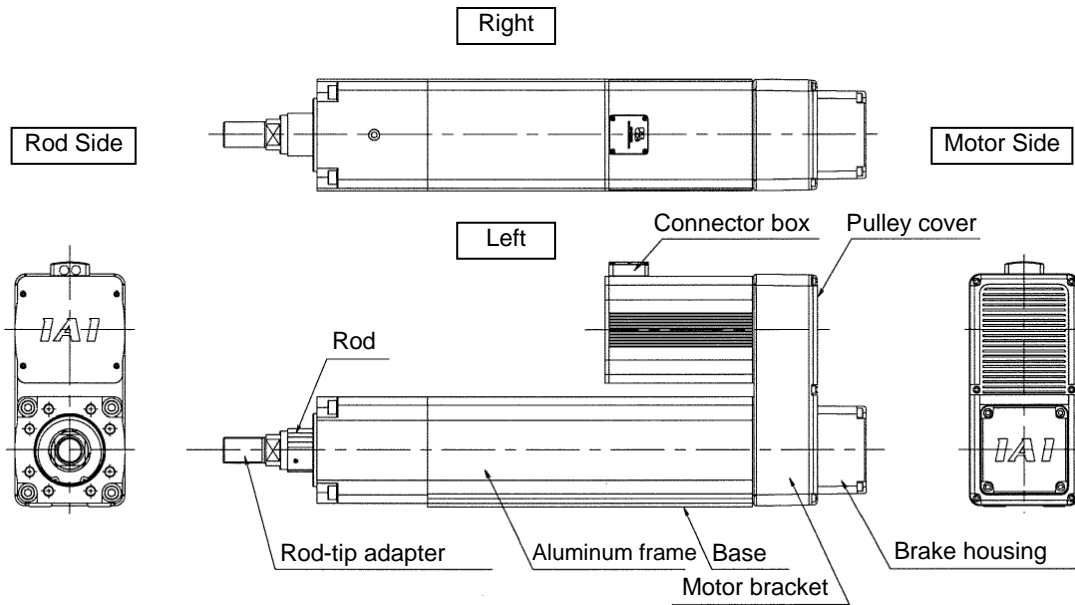
### 4.1 Standard Specification



\* The motor-reversing direction varies depending on the specification of the delivered product.

**Caution:** Even if you specified a robot cable, the cable extending from the actuator is not a robot cable. Design an appropriate wiring layout so that this cable will not receive a flexing force. The robot cable specification applies to the relay cable.

## 4.2 Brake Specification



\* The motor-reversing direction varies depending on the specification of the delivered product.

Caution: Even if you specified a robot cable, the cable extending from the actuator is not a robot cable. Design an appropriate wiring layout so that this cable will not receive a flexing force. The robot cable specification applies to the relay cable.

## 5. Transporting and Handling

### 5.1 Handling the Unassembled Actuator

#### 5.1.1 Handling the Packed Unit

Unless otherwise specified, each single-axis actuator is packed and shipped individually. When transporting the packed actuator, exercise due caution to avoid dropping the box or hitting it against an object, structure, etc.

- Heavy shipping boxes should be carried by two or more persons.
- If the shipping box is left standing, it should be in a horizontal position.
- Do not climb on top of the shipping box.
- Do not place heavy objects on top of the shipping box.

#### 5.1.2 Handling the Actuator After It is Unpacked

The table below lists the weights of this actuator.

Stroke	Weight
50 mm	33 kg
100 mm	34 kg
150 mm	35 kg
200 mm	36 kg

When transporting or installing the actuator, always work in a group of two or more to securely support the actuator body, and exercise due caution to prevent injury.

- When carrying the actuator, exercise care not to hit it against an object, structure, etc. Pay particular attention to the motor unit and pulley case.
- Do not exert an excessive force on any part of the actuator.
- Do not pull any of the cables.

Supplement) Refer to 4, "Names of the Parts" for the name of each actuator part.

#### ● Prohibited handling practices



Do not hold the rod when transporting the actuator.



Do not hold the motor cover when transporting the actuator.

## 5.2 Handling the Assembled Actuator

Take heed of the following precautions when transporting the actuator after each axis has been assembled.

### 5.2.1 Preassembled Actuator

If specified, IAI assembles the mechanical components at our factory, conducts a shipping inspection on the assembly, and ships the assembled actuator by packing it with skid plates bolted to the exterior frame. The rod is secured to prevent sudden movement during transport. If the actuator is of combination type, the extremities are also secured to prevent excessive swinging caused by external vibration.

- The above packing specification does not reflect special considerations for protection against impact resulting from dropping or bumping the box. Handle the box carefully. The outer frame is not designed to withstand loads from the above, so do not place heavy objects on the frame.
- If the box is suspended using ropes, etc., pass the ropes around the reinforcement frame at the bottom face of skid plates. Similarly when lifting the actuator with a forklift, place the forks below the skid plates.
- Set down the box carefully to prevent application of impact or bouncing of the box upon landing.

Once the actuator is unpacked, handle the actuator by observing the instructions below.

### 5.2.2 Handling the Actuator Assembled with Peripherals

When transporting the unpacked machine preassembled at IAI or customer-assembled machine, take heed of the following handling precautions:

- Secure the rod to prevent sudden movement during transport.
- If the actuator has any overhung extremity, properly secure the extremity to prevent excessive swinging caused by external force.
- If the actuator must be transported with its extremities not secured, make sure the actuator does not receive impact loads greater than 0.3 G.
- When suspending the actuator/peripherals using ropes, etc., do not allow the ropes to contact the actuator directly.
- When passing ropes, guide them around the base by inserting an appropriate buffer material between the rope and base.
- Exercise caution not to apply loads on the brackets, covers and connector box. Also protect the cables against pinching or excessive deformation.



## 6. Operating and Storage Environment

### 6.1 Operating Environment

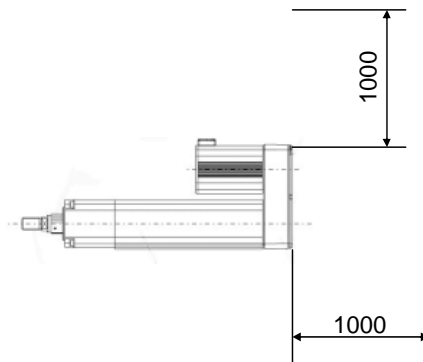
The actuator should be set up in an environment which meets the following criteria:

- Avoid direct sunlight.
- Avoid radiant heat from strong heat sources such as a furnace.
- Ambient temperature should be 0 ~ 40°C.
- The humidity should be less than 85% and there should be no condensation.
- Avoid exposure to corrosive or combustible gases.
- The area should have very little dust and be suitable for normal assembly operations.
- Avoid exposure to oil mist or fluids using in cutting.
- The actuator should not be subject to vibration or shock.
- The actuator should not be subject to significant levels of electromagnetic waves, ultraviolet rays or radiation.
- This product is not designed for use in a chemical environment.

In general, the environment should be one in which an operator can work without protective gear.

Work space required for maintenance/inspection

Provide the work space specified below if you want to replace the motor, belt, etc., without removing the actuator.



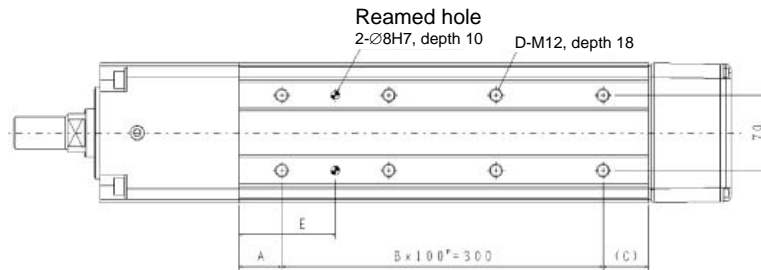
### 6.2 Storage Environment

The storage environment should be similar to the operating environment. In addition, you must take precautions against condensation if the unit is to be stored for a long period of time. Unless there are special instructions, we do not include moisture absorption agents when shipping the unit. If you are storing the unit where condensation might occur, then you must treat the entire package or treat the unit itself after it is unpacked to prevent condensation. The unit can withstand up to 60°C during a short storage interval but only up to 50°C if the storage period is longer than one month.

## 7. Installation

### 7.1 Installing the Main Body

(1) Using the tapped holes in the back of the base



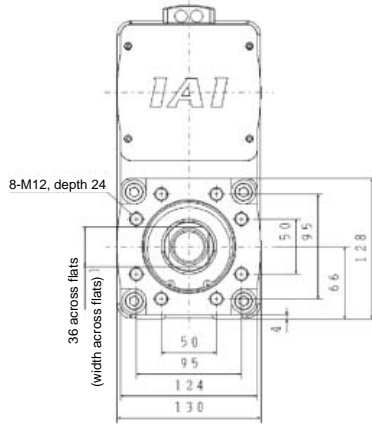
Tap size	Maximum thread length
M12	18 mm

Stroke	A	B	C	D	E
50	90	40	2	42.5	6
100	115	65	2	67.5	6
150	90	40	3	42.5	8
200	115	65	3	67.5	8

Tapped holes are provided in the back of the base for mounting. You can use these tapped holes to install the actuator. The maximum thread length of base mounting screws is specified above. Make sure the bolt ends do not project through the holes.

There are also reamed positioning holes, which can be used if necessary.

(2) Using the tapped holes on the rod side

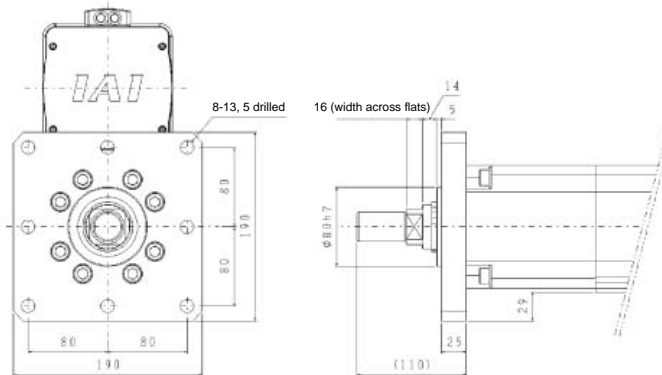


Tap size	Maximum thread length
M12	24 mm

Tapped holes are provided on the rod side for mounting. You can use these tapped holes to install the actuator. The maximum thread length of rod mounting screws is specified above. Make sure the bolt ends do not project through the holes.

(3) Using a flange (optional) with screws

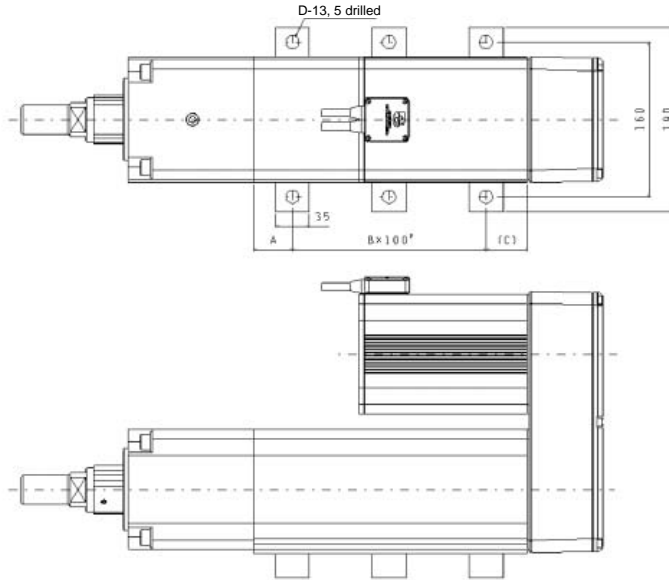
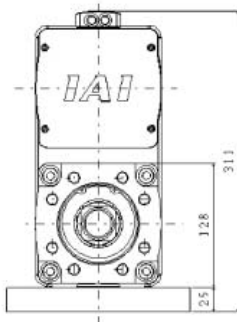
An optional flange is available. You can use this flange to install the actuator.



(4) Using foot brackets (optional)

Optional foot brackets are available. You can use these brackets to install the actuator.

st	A	B	C	D
50	40	2	42.5	6
100	65	2	67.5	6
150	40	3	42.5	8
200	65	3	67.5	8



## 8. Wiring Cable

- In an application where the cable cannot be anchored, try to place the cable so that it sags only under its own weight or use self-standing type cable as large radial wire duct to limit the load on the cable.
- Never cut and/or reconnect the cables supplied with the product for the purpose of extending or shortening the cable length.
- The standard cable provides excellent flexibility, but it is not a robot cable. Use a robot cable if the cable is to be stored in a moving cable duct (cable bearer, etc.).

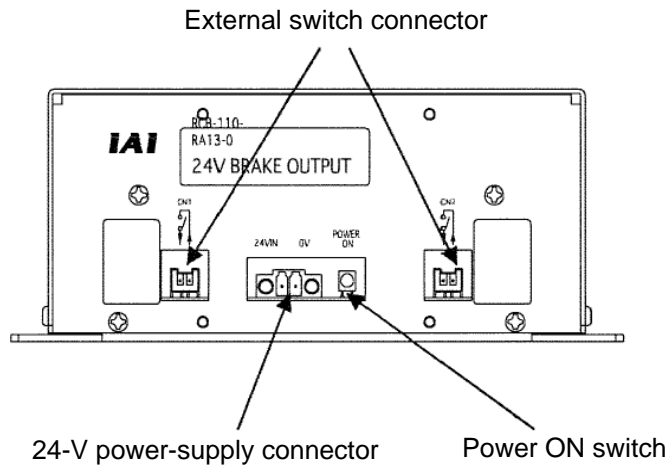
For cable modification, please contact IAI.

## 9. Installing the External Brake Connection Box for the Brake Specification

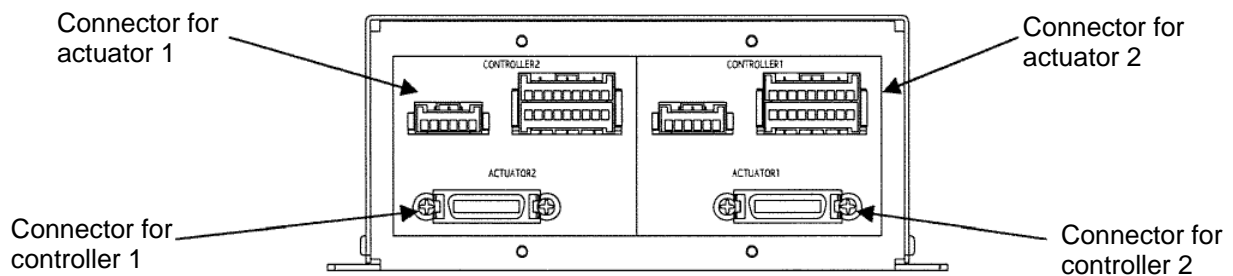
If the actuator is equipped with a brake, an external brake connection box must be installed.

- External brake connection box Model: RCB-110-RA13-0

[Front view]



[Rear view]



(1) Wiring and starting the external brake connection box

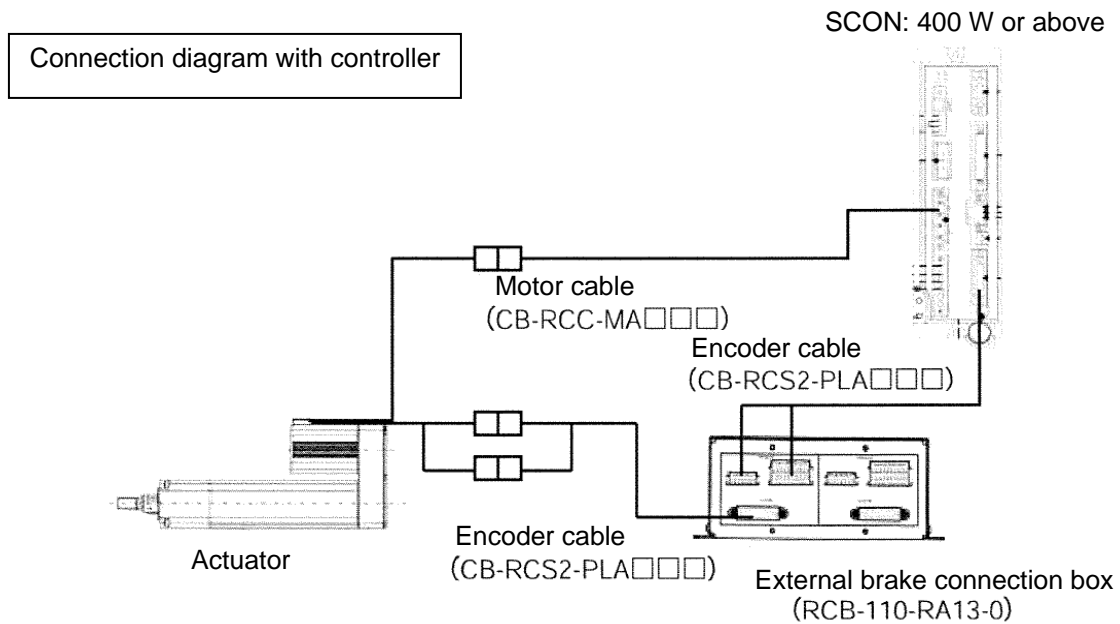
[1] An example of connection with a SCON controller is explained.

Connect the cables according to the example.

In this example, the connectors for actuator 1 and controller 1 are used. It is also possible to use the connectors for actuator 2 and controller 2.

[2] Connect a +24-V power supply to the 24-V power-supply connector on the external brake connection box and input +24-V power.

[3] Turn on the power ON switch. The external brake connection box will be activated.



## 10. Maximum Speed

A maximum speed is specified for this product to prevent resonance of the ball screw shaft while conforming to the speed limit of the motor. Refer to the table below to find the maximum speed of your actuator and operate the actuator at speeds not exceeding the maximum level.

Maximum speed limits

Type	Stroke	Maximum speed
Lead 2.5 (1t)	50 mm	85 mm/sec
	100 mm	120 mm/sec
	150 mm, 200 mm	125 mm/sec
Lead 1.25 (2t)	50 mm, 100 mm, 150 mm, 200 mm	62 mm/sec

**Caution:** If the actuator is used at speeds beyond the maximum level, noise may increase or vibration may generate due to resonance of the ball screw shaft, and such increased noise or vibration may consequently reduce the service life of the product.

If each actuator is used independently, write a program conforming to the maximum speed of the actuator (refer to the table above). If multiple actuators are used in a synchronized operation, write a program conforming to the lowest of the maximum speeds applicable to all synchronized actuators.

In either way, always check the maximum speed of each applicable actuator when writing a program.



## 11. Load Applied to the Actuator

- Make sure the actuator will not receive a load exceeding the value specified in the catalog.
- This actuator can receive a load on its rod.

Use the actuator correctly by observing the condition specified below:

$$M + T \leq 120 \text{ (N-m)}$$

$$\text{Load moment } M = mg \times L_2$$

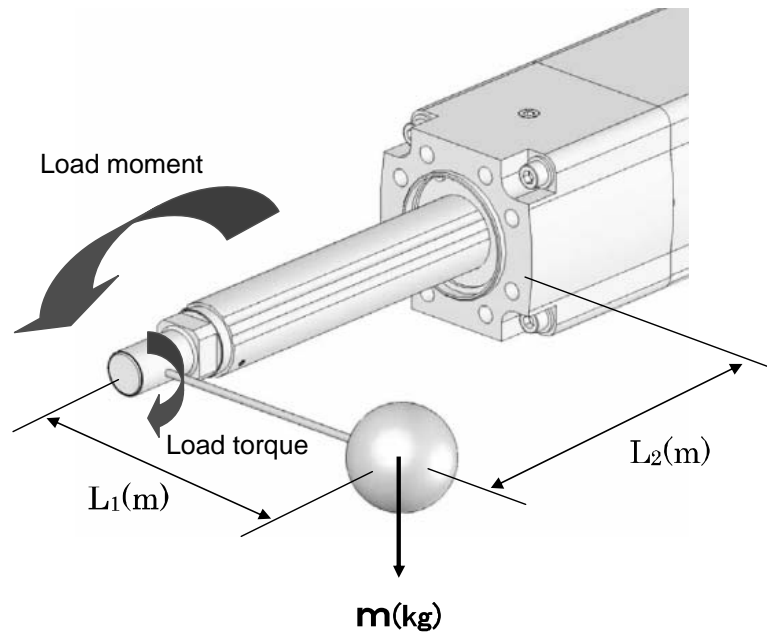
$$\text{Load torque } T = mg \times L_1$$

g: Gravitational acceleration = 9.8

L<sub>1</sub>: Distance from the rod center to the work's center of gravity

L<sub>2</sub>: Distance from the actuator mounting surface to the work's center of gravity + 0.07

If the condition is not satisfied, take an appropriate measure, such as providing an external guide, to prevent the rod from receiving a load.



- Do not allow the rod to receive any load torque exceeding the value calculated above.  
\* Doing so may damage the internal parts of the actuator.

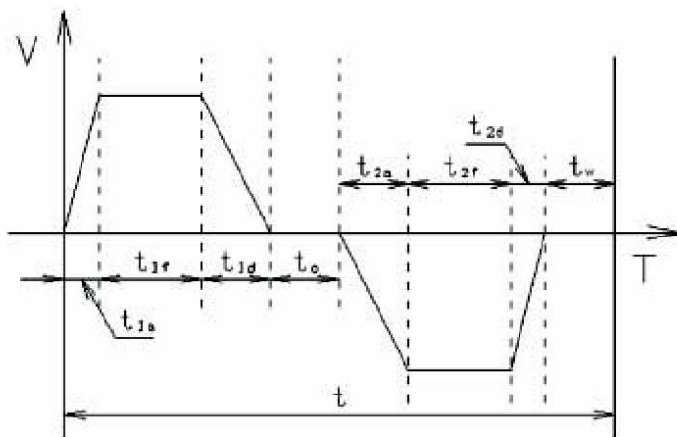
When tightening the nut at the tip of the rod, hold the rod using a monkey wrench, etc.

## 12. Selection Conditions

The following three conditions must be met before the ultra high-thrust actuator can be used:

- Condition [1] The push time does not exceed the specified time.
- Condition [2] The thrust for continuous operation does not exceed the rated thrust of the ultra high-thrust actuator throughout the cycle.
- Condition [3] Push-motion operation is performed only once per cycle.

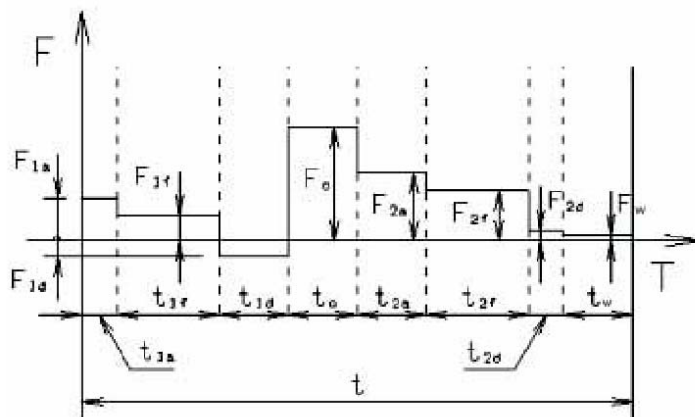
Each condition is explained by using a trapezoid operation pattern as an example.



In the graph on the left:

- $t$  : Operation time per cycle (sec)
- $t_{1a}$ ,  $t_{2a}$  : Acceleration time (sec)
- $t_{1f}$ ,  $t_{2f}$  : Traveling time at constant speed (sec)
- $t_{1d}$ ,  $t_{2d}$  : Deceleration time (sec)
- $t_0$  : Push time (sec)
- $t_w$  : Standby time (sec)

The above operation pattern is expressed differently when the thrust is represented by the vertical axis, as shown below.



In the graph on the left:

- $F_{1a}$ ,  $F_{2a}$  : Thrust required for acceleration (N)
- $F_{1f}$ ,  $F_{2f}$  : Thrust required at constant speed (N)
- $F_{1d}$ ,  $F_{2d}$  : Thrust required for deceleration (N)
- $F_0$  : Push force (N)
- $F_w$  : Thrust required during standby (N)

## 12.1 Selection Procedure

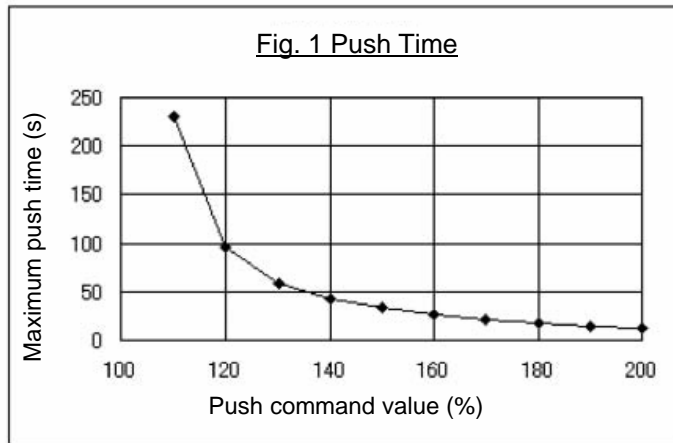
The following explains the procedure to select an actuator for vertical application.

Condition [1]

A maximum push time is specified for each push command value, as shown in the table below. Find the maximum push time for each command by referring to this table, and make sure the push time does not exceed the specified duration. Take note that a failure to adhere to this table may result in actuator problems.

Table 1 Push Times

Push command value (%)	Maximum push time (s)
200	13
190	15
180	18
170	21
160	27
150	33
140	43
130	58
120	95
110	230



Condition [2] Thrust for continuous operation

Confirm that the thrust for continuous operation  $F_t$ , calculated by considering the load and duty, does not exceed the rated thrust of the ultra high-thrust actuator throughout the cycle. Here, remember that push motion operation should not be performed more than once per cycle.

$$F_t = \sqrt{\frac{F_{1a}^2 \cdot t_{1a} + F_{1f}^2 \cdot t_{1f} + F_{1d}^2 \cdot t_{1d} + F_o^2 \cdot t_o + F_{2a}^2 \cdot t_{2a} + F_{2f}^2 \cdot t_{2f} + F_{2d}^2 \cdot t_{2d} + F_w^2 \cdot t_w}{t}}$$

Here,  $F_a/F_d$  represents the force required for acceleration/deceleration and changes according to the operating direction. Calculate the value using the formulas below:

Horizontal application (both acceleration and deceleration)	$F_a = F_d = (M+m) \times d$
Accelerate in downward motion in vertical application	$F_{1a} = (M+m) \times 9.8 - (M+m) \times d$
Move at a constant speed in downward motion in vertical application	$F_{1f} = (M+m) \times 9.8 + a (*1)$
Decelerate in downward motion in vertical application	$F_{1d} = (M+m) \times 9.8 + (M+m) \times d$
Accelerate in upward motion in vertical application	$F_{2a} = (M+m) \times 9.8 + (M+m) \times d$
Move at a constant speed in upward motion in vertical application	$F_{2f} = (M+m) \times 9.8 + a (*1)$
Decelerate in upward motion in vertical application	$F_{2d} = (M+m) \times 9.8 - (M+m) \times d$
Stand by in vertical application	$F_w = (M+m) \times 9.8$

\*1: If an external guide or other similar component is installed, the traveling resistance must be considered.

- M: Mass of moving part (kg)
- m: Loaded mass (kg)
- d: Commanded acceleration/deceleration ( $m/s^2$ )

Mass of moving part: 9 kg

If the calculated thrust for continuous operation  $F_t$  is smaller than the rated thrust, the actuator can be operated.

Rated thrust of a ultra high-thrust actuator with 2.5 (1t) lead: 5100 N

Rated thrust of a ultra high-thrust actuator with 1.25 (2t) lead: 10200 N

The actuator can be operated under operating conditions where both conditions [1] and [2] are satisfied. If either condition cannot be satisfied, take an appropriate countermeasure such as decreasing the push-motion operation time or increasing the standby time to lower the duty.

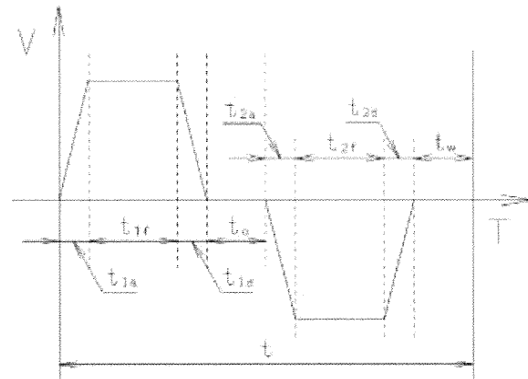
## 12.2 Exercise

Let's check if a selected actuator supports a given operation pattern by using the selection procedure explained above.

★ Operating conditions

- Model: Ultra high-thrust actuator with 1.25 (2t) lead
- Mounting position: Vertical
- Speed: 62 mm/s
- Acceleration/deceleration: 98 mm/s<sup>2</sup> (0.01 G)
- Travel distance: 50 mm
- Loaded mass: 100 kg
- Push command value: 200% (2000 kgf)
- Push time: 3 s
- Standby time: 2 s
- Move 50 mm downward, perform push-motion operation, move 50 mm upward, and stand by for 2 sec. The operating conditions for upward and downward movements are the same.

\* 1 G = 9.8 m/s<sup>2</sup>



The graph on the right illustrates the above operation pattern.

Now, calculate the necessary values by following the selection procedure.

Condition [1] Check the push-motion operation time.

From Table 1 on p. 15, the push time is 3 seconds as opposed to the maximum push time of 13 seconds corresponding to the push command value of 200%. Accordingly, the push time condition is satisfied.

Condition [2] Calculate the thrust for continuous operation.

Assign the above operation pattern to the aforementioned formula to calculate thrust for continuous operation.

$$F_t = \sqrt{\frac{F_{1a}^2 \cdot t_{1a} + F_{1f}^2 \cdot t_{1f} + F_{1d}^2 \cdot t_{1d} + F_o^2 \cdot t_o + F_{2a}^2 \cdot t_{2a} + F_{2f}^2 \cdot t_{2f} + F_{2d}^2 \cdot t_{2d} + F_w^2 \cdot t_w}{t}}$$

Here,

$$F_{1a}, F_{2d} = (M + m) \times 9.8 - (M + m) \times d = 1058 \text{ N}$$

$$F_{1f}, F_{2f} = (M + m) \times 9.8 = 1068 \text{ N}$$

$$F_{1d}, F_{2a} = (M + m) \times 9.8 + (M + m) \times d = 1079 \text{ N}$$

$$F_o = \text{Push command value } 200\% (2000 \text{ kgf}) = 19600 \text{ N}$$

$$F_w = (M + m) \times 9.8 = 1068 \text{ N}$$

$$t_{1a} = t_{2a} = t_{1d} = t_{2d} = \text{Speed } 62 \text{ mm/s} \div \text{Acceleration/deceleration } 98 \text{ mm/s}^2 = 0.632 \text{ s}$$

$$t_{1f} = t_{2f} = (\text{Travel distance } 50 \text{ mm} - (\text{Travel distance during acceleration } 19.60 \text{ mm} + \text{Travel distance during deceleration } 19.60 \text{ mm})) \div \text{Speed } 62 \text{ mm/s} = 0.174 \text{ s}$$

$$\text{Travel distance during acceleration (deceleration)} = \text{Acceleration (deceleration) rate } 98 \text{ mm/s}^2 \times$$

$$(\text{Acceleration (deceleration) time } (t_{1a}, 2a, 1d, 2d) 0.632 \text{ s})^2 \div 2 = 19.60 \text{ mm}$$

$$t_o = 3 \text{ s}, t_w = 2 \text{ s}, t = 7.88 \text{ s}$$

From the above, the following result is obtained:

$$F_w = 12113 \text{ N}$$

Since this is greater than the rated thrust of 10200 N specified for the ultra high-thrust actuator with 1.25 (2t) lead, the actuator cannot be operated based on this operation pattern.

Now, the standby time is increased (duty is lowered) as a countermeasure.

In this example, calculations are repeated by assuming  $t_1 = 6.12 \text{ s}$  ( $t = 12 \text{ s}$ ). This time, the following result is obtained:

$$F_w = 9814 \text{ N}$$

The actuator can be operated.

## 13. Maintenance

### 13.1 Maintenance Schedule

Perform maintenance work according to the schedule below. The schedule is set assuming eight hours of operation a day. When the operation time is long such as 24-hour operation, shorten the maintenance intervals as needed.

	Visual inspection	Grease supply	
Start of operation	○		
After 1 month of operation	○		
After 3 months of operation	○	○ (Rod (ball spline) slide surface)	*1
Every 3 months thereafter	○	○ (Rod (ball spline) slide surface)	*1
After 3 years of operation or 5000 km travel distance	○		
Every 1 year thereafter	○		

\*1 Apply the grease to the rod (ball spline) slide surface when dry surface is observed at the start of operation or every three months of operation.

### 13.2 Visual Inspection of the Machine Exterior

Check the following when doing the visual inspection.

Body	Loose mounting bolts?
Cables	Damage to cables or connection to connector box?
General	Unusual noise or vibrations?

### 13.3 Cleaning

- Clean the exterior as needed.
- Wipe off dirt with a soft cloth.
- Do not use strong compressed air on the actuator, as it may force dust into the crevices.
- Do not use petroleum-based solvents, as they may damage resin or coated surfaces.
- If the unit is badly soiled, apply a neutral detergent or alcohol to a soft cloth and wipe lightly.

## 13.4 Greasing the Rod (Ball Spline)

### (1) Applicable grease

Showa Shell Sekiyu
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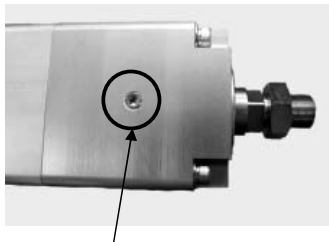
Albania EP Grease 2
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<b>⚠ Warning:</b> Never use fluorine grease. Fluorine grease chemically reacts with lithium grease to cause damage on the machine.
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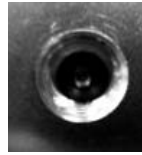
### (2) How to apply grease

Before applying grease, turn off the actuator power.

- 1) Use an Allen wrench of 6 mm across flats to remove the tapered plug with hexagonal hole installed at the grease feed port. When the tapered plug has been removed, the grease nipple appears.



Tapered plug with hexagonal hole installed at grease feed port



Grease nipple

- 2) Insert the grease gun into the grease nipple and add grease.  
\* Use a grease gun corresponding to the diameter of the grease nipple.



Nipple diameter
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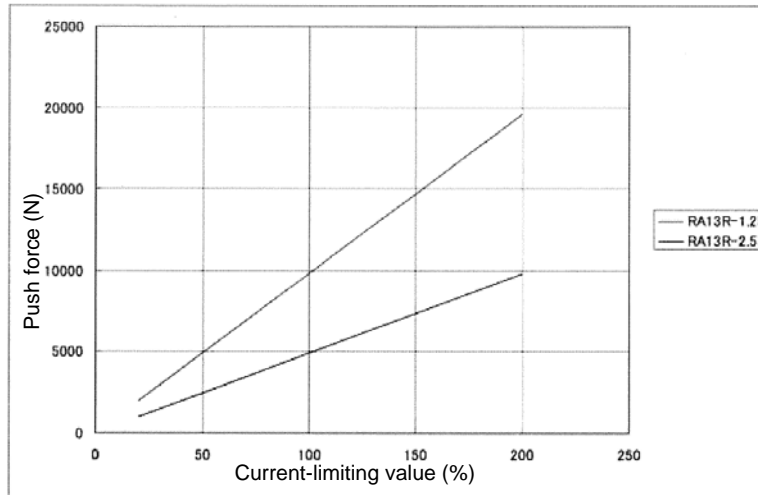
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- 3) After a sufficient amount of grease has been added, close the grease feed port with the tapered plug with hexagonal hole.
- 4) Turn on the controller power and retract/extend the rod repeatedly via jogging motion, etc., to spread the grease evenly over the entire surface.



## 14. Relationship of Load and Weight

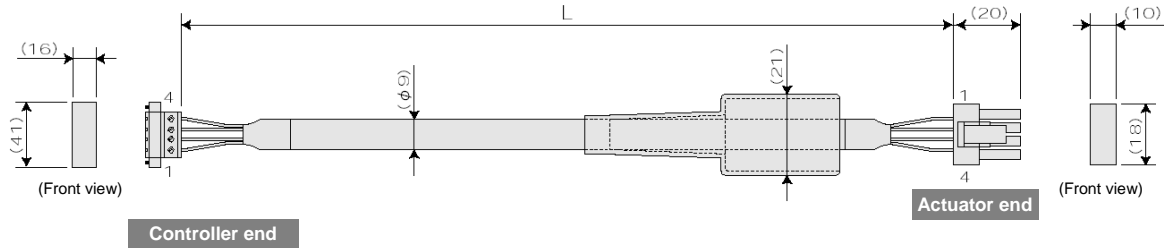
The push force to be applied during push-motion operation can be changed freely by changing the current-limiting value on the controller.



**Caution:** This diagram of push force and current-limiting value is provided as a reference. Actual values may vary slightly from the diagram.  
Keep the current-limiting value at 20% or above, because any lower setting may cause the push force to fluctuate.  
The traveling speed is fixed to 10 mm/s during push-motion operation.  
This diagram assumes a push speed of 10 mm/s. Take note that the push force may decrease when a different push speed is used.  
Depending on the operating conditions, the push force may also decrease when the motor temperature rises.

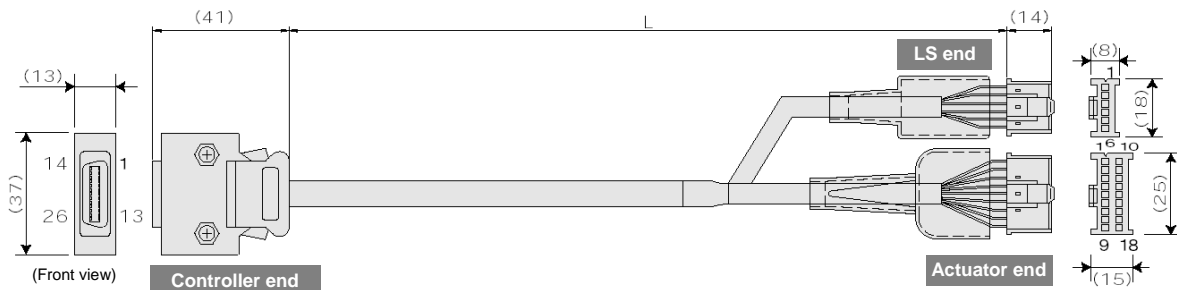
## 15. Cable Drawings

- [1] Motor cable/motor robot cable  
Model: CB-RCC-MA□□□□/CB-RCC-MA□□□□-RB



Wire size	Color	Signal	No.	No.	Signal	Color	Wire size
0.75sq	Green	PE	1	1	U	Red	0.75sq (crimped)
	Red	U	2	2	V	White	
	White	V	3	3	W	Black	
	Black	W	4	4	PE	Green	

- [2] Encoder cable/encoder robot cable  
Model: CB-RCS2-PLA□□□□/CB-RCS2-PLA□□□□



Wire size	Color	Signal	No.	No.	Signal	Color	Wire size
AWG26 (soldered)	—	—	10	1	E24V	White/blue	AWG26 (crimped)
	White/orange	E24V	12	2	OV	White/yellow	
	White/green	OV	13	3	LS	White/red	
	Brown/blue	LS	26	4	CLEP	White/black	
	Brown/yellow	CLEP	25	5	OT	White/purple	
	Brown/red	OT	24	6	RSV	White/gray	
	Brown/black	RSV	23	7	—	—	AWG26 (crimped)
	—	—	9	8	—	—	
	—	—	18	9	FG	Drain	
	—	—	19	10	SD	Orange	
	White/blue	A+	1	11	SD	Green	
	White/yellow	A-	2	12	BAT+	Purple	
	White/red	B+	3	13	BAT-	Gray	
	White/black	B-	4	14	VCC	Red	
	White/purple	Z+	5	15	GND	Black	
	White/gray	Z-	6	16	—	—	
	Orange	SRD+	7	17	BK-	Blue	
	Green	SRD-	8	18	BK+	Yellow	
Purple	BAT+	14					
Gray	BAT-	15					
Red	VCC	16					
Black	GND	17					
Blue	BKR-	20					
Yellow	BKR+	21					
—	—	22					

Clamp the shield to the hood.

Drain wire or braided shield wire

("White/blue" in the "Color" field indicates that the cable is white and the insulator is blue.)

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