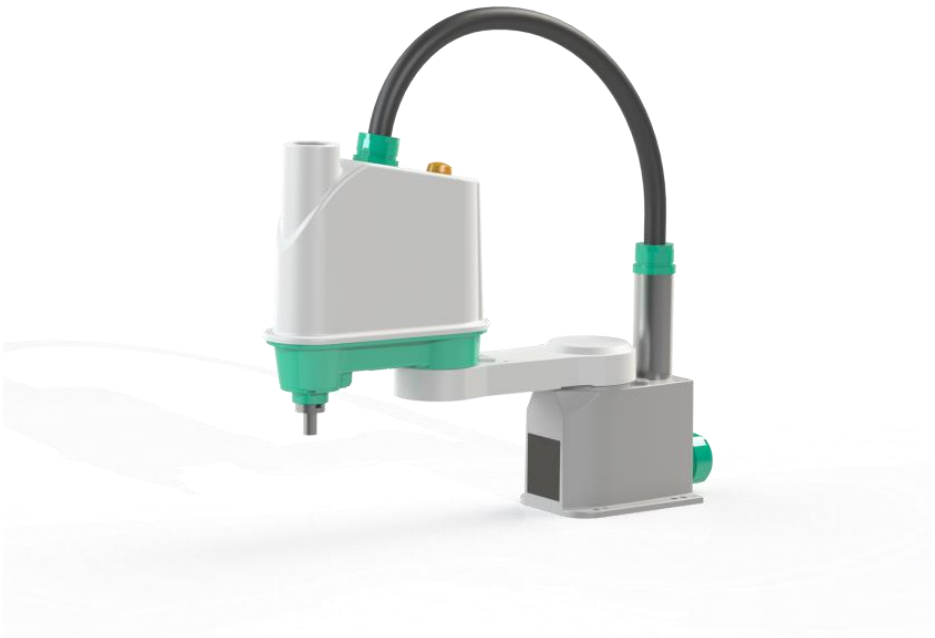
CKD

SCARA Robot

KHE-400 Robot Manual

INSTRUCTION MANUAL

SM-A20045-A



- Read this Instruction Manual before using the product.
- Read the safety notes carefully.
- Keep this Instruction Manual in a safe and convenient place for future reference.

CKD Corporation

Introduction

Thank you very much for your purchase of CKD's robot system.
This manual describes the basic specifications of the industrial robot, and how to unpack and install the robot, how to connect wiring and piping, how to install the hand, and how to maintain and inspect the robot.
Read this manual before unpacking the product.
Before beginning the work according to this manual, read through the Safety Manual so that you can understand the safety measures.

This manual has the following chapters.

Specifications
Section 1: Specifications
This section describes the basic specifications and names of respective units of the robot.

Installation
Section 2: Unpacking and Transportation
This section describes how to unpack the robot and how to transport it to the installation site.
This section also describes precautions for temporarily storing the unpacked robot.

Section 3: Installation of the Robot
This section describes the installation environment, required space, and installation procedure for the robot.

Sections 4 and 5: Setting of the Hand
These sections describe how to install the hand on the robot arm and how to wire and pipe the hand.
Lastly, these sections describe the permissible load conditions of the hand.

Maintenance
Sections 6 and 7: Maintenance
These sections describe how to maintain respective units of the robot.

Section 8: Zero Setting and Position Detector Error
This section describes the zero setting procedure for the robot and the corrective action if the position detector error occurs.

Section 9: Replacement Parts
This section describes replacement parts of the robot.

Contents

Use Range

This product is the horizontally articulated type industrial robot in which the manipulator has two horizontally rotating joints and the mechanical interface on its tip moves vertically and rotates horizontally.
The product has been developed with intention of adapting it to automation of wide range of work including conveying work such as movement and alignment of workpieces and assembly work such as insertion of parts and screw tightening.
The customer should also use this product with the aim to adapt it to automation of these work and incorporate it to the automation equipment.

This product is not intended to apply it to work that contacts a human (such as work related to medical care and nursing care), incorporate it to the equipment that supports human life (such as life support device and incubator), incorporate it to the equipment on which a human rides (including transport equipment such as car, aerospace equipment such as airplane, and game equipment such as roller coaster), and incorporate it to the equipment that protects human life and human body (such as safety device).
This product is not intended to incorporate it to the equipment aimed to control large quantity of heat (such as nuclear power controller and incinerator controller).
This product is prohibited from being used to apply it to work or incorporate it to the equipment that is likely to threaten human life and harm a human body directly due to a failure or malfunction. If this product is used, it will be guaranteed under customer's responsibility.

Use Method

The use conditions for the KHE series robot are described. If the product is used in the state that differs from the conditions, unexpected risk may occur. Abide by the conditions for use.

1. Main Specifications of Product: See Specifications "1.4 Specifications Table" and Installation "3.1 Installation Environment."

2. Restrictions on Use: Tables 1 and 2 give "Restricted Specification Sheet" indicating restrictions on use.

Table 1 Restricted Specification Sheet (1)

1. Purpose and application of using product (restrictions on use)	
1) Intended use	Allow the robot to achieve operation along with the purposes (article conveyance, assembly, inspection, machining, etc.). (1) During teaching and adjustment operation −Operation is likely to be performed by turning on the servo power within the movable range of the robot. −A person who observes teaching and operation checking worker as a co-worker is arranged outside the movable range. (1) Teach the position where the robot operates. (2) Create the operation sequence (program, etc.). (3) Transfer and check signal and data with the external equipment. (4) Check operation at low speed (250 mm/sec or less). (2) During operation −Danger prevention measures that prevent contact with the robot (installation of the fence or enclosure) are taken to keep a person away from the operating robot. −When the operating robot is approached, measures shall be taken to turn off the servo power. (1) Start the robot. (2) Perform operation along with the purpose at the specified speed. (3) Stop the robot. (3) During maintenance and inspection −Contents performed within the movable range of the robot when the primary power is off (1) Check the bolts for looseness and backlash and re-tighten them. (2) Check the cable clamp for looseness. (3) Inspect damage. (4) Clean dust. (5) Inspect and apply antirust agent. (6) Check the timing belt for looseness and crack. (7) Check the cable and air tube for wear. (8) Check the operation when each axis is pushed and moved by hand. (9) Replace the consumable parts for the robot and controller. (10) Replace the battery for memory in the controller. −Contents performed within the movable range of the robot when the primary power is on (1) Check the grease state and apply grease (when the servo power is off). (2) Push each axis by hand and check it for backlash (when the servo power is on). (3) Check abnormal vibration and sound during operation (when the servo power is on). (4) Check the teaching point for misalignment (when the servo power is on). (5) Replace the battery for robot position detector (when the servo power is off).

Table 2 Restricted Specification Sheet (2)

2) Predictable misuse	−Use for work which applies excessive impact to the robot or to which excessive impact is applied by the robot −Modification of robot body, controller, and optional parts and energization with these covers removed −Operation in other than the specified installation state (floor, suspension, and wall-mounted) −Operation on the frame that does not satisfy the specified strength −Operation in other than the specified environment		
3) Unexpected start	−Malfunction caused by excessive noise −Robot start caused by start signal unexpectedly sent from the peripheral equipment to the robot −Unintended start caused by abnormal communication data −Malfunction caused by voltage fluctuation		
2. Replacement of product components (restrictions on time)			
1) Mechanical restriction 2) Electrical restriction	Replace consumable parts as required or periodically through daily inspection, regular inspection (every 3 and 6 months and every year) and overhaul (every 5 years).		
3 Movable range of product (restriction on space)			
1) Operating range	Axis 1	Conforms to 1.4 Specifications Table .	
	Axis 2	Conforms to 1.4 Specifications Table .	
	Axis 3	Conforms to 1.4 Specifications Table .	
	Axis 4	Conforms to 1.4 Specifications Table .	
	Additional axis	Conforms to individual specifications.	
	—	—	
	—	—	
2) Interface	−The product shall be installed at a location suitable for outer shape and operating range. −Space required for maintenance and inspection shall be secured.		
3) Work environment	−Danger prevention measures that prevent contact with the robot (installation of the fence or enclosure) shall be taken. −Space shall be secured to prevent a person from being caught between the robot and the fence or AY15enclosure.		
4. Life cycle of product			
During the life cycle of assembly, shipment test, transportation, installation, teaching, operation, maintenance and disposal, risk assessment is carried out for “installation” stage (transportation and installation), “use” stage (teaching, operation, and maintenance) and disposal.			
5. Person who approaches the machine			
Target	Knowledge, experience, and condition		
1) Transportation and install	Knowledge: Person who has understood the instruction manual		
	Experience: —		
	Condition: Qualified person on forklift or crane (as required)		
2) Teaching/adjustment operation worker (including co-worker)	Knowledge: Person who has understood the instruction manual		
	Experience: Person who has acquired the operation of the robot to be used		
	Condition: Person who has received special training pertaining to the operation such as teaching of the industrial robot and to whom work has been permitted by the employer		
3) Operation worker (operator)	Knowledge: Person who has understood the instruction manual		
	Experience: Person who has understood the work regulation		
	Condition: —		
4) Maintenance and inspection worker	Knowledge: Person who has understood the instruction manual		
	Experience: Person who has acquired the operation of the robot to be used and person who has acquired maintenance work of the target robot		
	Condition: Person who has received special training pertaining to the operation such as inspection of the industrial robot and to whom work has been permitted by the employer		
5) Disposal worker	Knowledge: Person who has understood the instruction manual and the disposal method for each local government		
	Experience: —		
	Condition: —		
6. Other			

Warranty

We conduct a strict tests and inspections before delivery to ensure that the product satisfies our performance standards.
We provide warranty to cover defects of the product based on the following prerequisites.

1. Warranty period The warranty period of the product is either of the following, whichever is earlier.
   1) 18 months after delivery from our factory
   2) 12 months after installation at your site
   3) Operating time of 2400 hours.

2. Warranty scope
   1) We provide warranty for the product. Note that only the specifications and functions defined in the product specifications, catalog, and instruction manual are covered by the warranty. Any secondary or incidental damages caused by failure of the product are not covered by the warranty in any circumstances.
   2) We provide repair of a faulty product for free only if the product has been handled and used according to the instruction manual that comes with the product.
      Any repairing after the warranty period passes will be charged.

3. Disclaimer The warranty shall not apply to the following cases.
   a) Any failure or damage arising from your careless use or misuse that is not defined in the instruction manual.
   b) Any failure caused by aging or normal wear and tear (discoloration, deterioration of consumables[*1)].
   c) Any failure regarding sensuous phenomena such as noise not affecting the functions
   d) When any modification or disassembly without our consent is confirmed
   e) Any failure or damage arising from insufficient maintenance and inspection or inappropriate repair
   f) Any failure or damage due to act of God, fires, and other force majeure
   g) Internal data such as programs and points created or modified by users
   h) When a product purchased in Japan is taken abroad

4. Precautions
   1) CKD shall not guarantee the standard performance of the product if you use the product beyond the specifications.
   2) If the customer did not observe the "DANGER," "WARNING," and "CAUTION" described in this instruction manual, CKD will not assume the responsibility for any consequential accident resulting in injury or death, damage or trouble.
   3) "DANGER," "WARNING," "CAUTION" and other descriptions stipulated in this instruction manual are only those which can be assumed by CKD without predicting all events in all situations. Please no that the range is limited.

(*1) Consumable parts refer to the replacement parts for maintenance as listed in instruction Manual "9.2 List of Replacement Parts – Robot."

Standards, laws and regulations regarding safety of industrial robots

The international industrial standard ISO/DIS 12100 "Safety of machinery" defines measures for reducing risks regarding machinery.

Step 1: Fundamental safe design measures - Restrictions on force, speed, and energy

Step 2: Safety protection - Installation of protective fences, etc.
Additional protection measures - Installation of emergency stop devices

Step 3: Information for use - Warning labels, alerts, instruction manuals

Based on the above, the ISO/IEC defines the "Guide 51" that groups various standards in a hierarchal structure. Safety standards for industrial robots are standardized as separate safety standards for machinery in layer C.

- ISO 10218, ISO 10218-1

After risk assessment is carried out, provision of residual risk information to the user is standardized.

- IEC 82079-1

Comply with the standards, laws and regulations in the countries where you use industrial robots.

Safety Precautions

This manual contains important information for the safe use of the robot body and the prevention of injury to the operator and others and the prevention of damage to property.
Read and understand the meanings of the following indications and symbols first, and observe these precautions.

[Meanings of Indications]

Indication	Meaning
⚠ DANGER	Indicates the imminent danger that incorrect operation could cause death or serious injury.
⚠ WARNING	Indicates the danger that incorrect operation could cause death or serious injury.
⚠ CAUTION	Indicates the possibility that incorrect operation could cause injury[1)] to operator or damage to the property[2)].

1) Injury indicates injuries such as wounds, burns, and electric shock that do not require hospitalization or long-term outpatient treatment.
2) Damage to property indicates extensive damage related to the destruction of assets or materials.

[Meanings of symbols]

Symbol	Meaning
	Indicates a prohibited action. The specific content of the prohibition is shown pictorially or in text form inside the symbol or nearby it.
	Indicates a required action. The specific content of the required action is shown pictorially or in text form inside the symbol or nearby it.
	Indicates a danger and precaution. The specific content of the precaution is shown pictorially or in text form inside the symbol or nearby it.

⚠ CAUTION
• To install and operate the robot safely, read and understand the separate Instruction Manual “Safety Manual” in advance.

[Installation]

Strictly observe the following to use the robot safely.

⚠ DANGER	
 Prohibited	• Do not run the equipment if it is damaged or parts are missing. Otherwise, electric shock, fire, or malfunction may result. • Do not install the equipment in a place where liquid such as water is applied. Otherwise, electric shock, fire, or malfunction may result. • Do not place a flammable material near the equipment. Fire may result if the equipment ignites due to failure.
 Required	• Always secure the robot with the attached clamp before transporting the robot. Failure to do so could lead to injuries if the arm moves when the robot is lifted. • Install the equipment before wiring. Wiring before installation may cause electric shock and injury. • Use the power supply voltage and capacity specified by CKD. Otherwise, equipment failure or fire may result. • Use the power cable specified by CKD. Using cables not specified by CKD may cause fire or malfunction. • Ensure that the equipment is grounded by a grounding wire. Otherwise, electric shock or fire may result due to malfunction or electric leakage. Malfunction due to noise may also result.

⚠ CAUTION	
 Prohibited	• Never lift the robot by the arm 2 cover. Doing so will apply an excessive force to the mechanism section of the robot body and could lead to faults.
 Required	• When storing the robot, secure it to the base. The robot will be unstable if just set down without securing it, and it could tilt over.
 Caution	• When operating the robot after long-hour stop at a low temperature (10℃ or less), be sure to perform a continuous operation at a low speed (approximately 20% of the maximum speed) for a few minutes. Otherwise, a motor overload error may occur due to solidified grease.

[Maintenance and inspection]

Strictly observe the following in order to use the controller safely.

⚠ DANGER	
 Prohibited	• Do not burn, disassemble, or recharge the battery. Otherwise it may blow out.
 Required	• Before conducting maintenance and inspection, be sure to disconnect the power plug of the controller from the power outlet. • When disposing of the battery, observe the customer-defined rules.

⚠ CAUTION	
 Prohibited	• Do not replace or modify parts that are not stated in the instruction manual. Performance degradation, failure or accident may result.
 Required	• Use replacement parts specified by CKD. • Regularly conduct maintenance and inspection. Otherwise, equipment failure or accident may result.
 Caution	• The Axis 4 motor of the KHE series robot is not provided with a brake. At servo OFF, therefore, the Axis 4 may rotate due to the dead weight of the tool and hand, offset condition or touch by hand. Once the Axis 4 rotates, the Axis 3 will move up or down. Be careful not to have your hand or leg caught in it. • A brake release switch is provided at the base rear. If the brake release switch is pressed while a heavy load such as a hand or workpiece is mounted on the Axis 3, the Axis 3 will drop. Be careful not to have your hand or leg caught in it.

Specifications

This part describes the basic specifications, name of each part, coordinate system and external dimensions of the KHE series robot.

1.Specifications

1.1 Name of Each Part

Fig. 1.1 shows the name of each part of the robot.

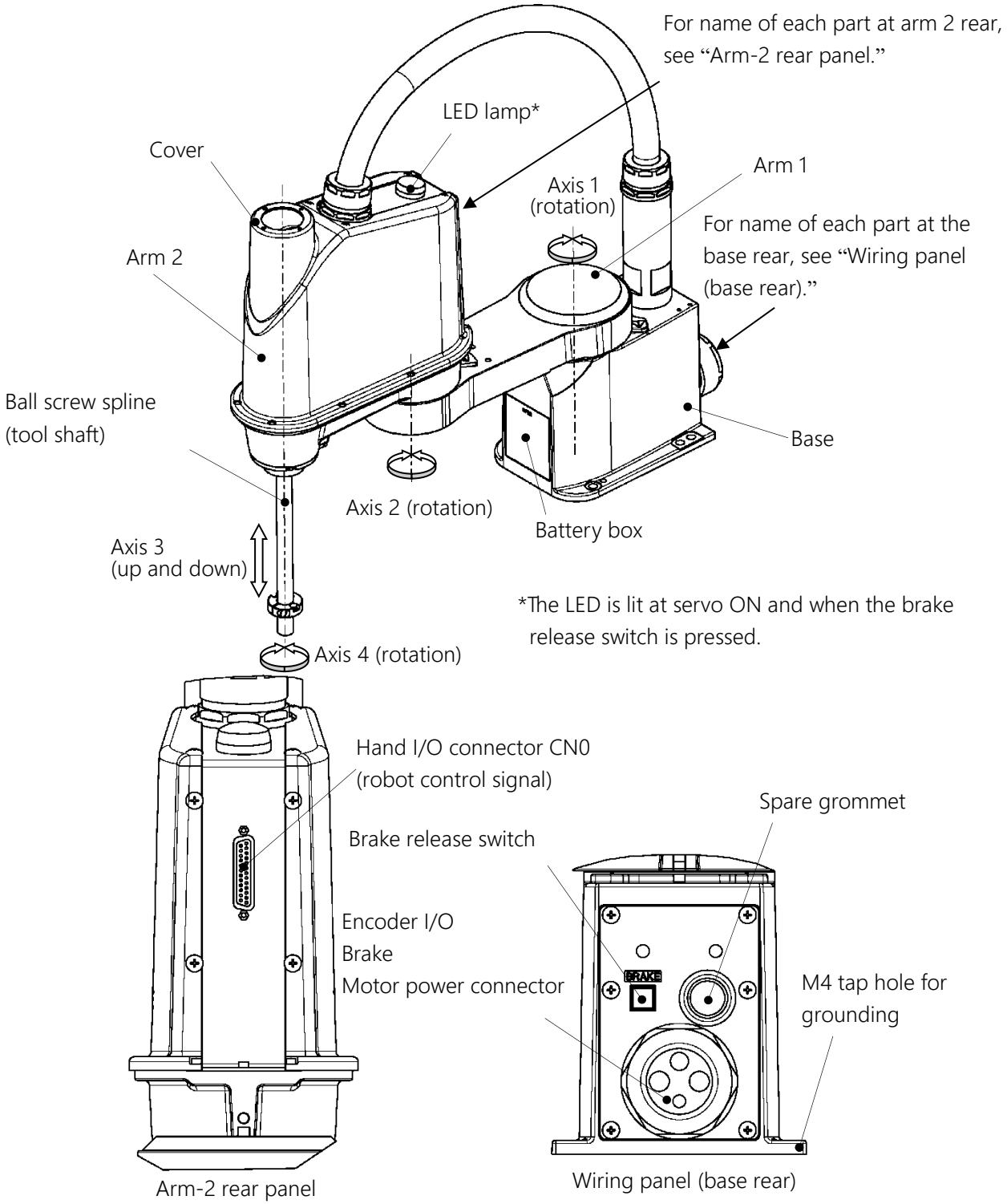


Fig. 1.1 Name of each part

1.2 Coordinate System

The robot's joint angle or stroke origin (0° or 0 mm position) is factory-calibrated according to the reference planes. Fig. 1.2 shows the base coordinate system and origin of each axis joint angle.

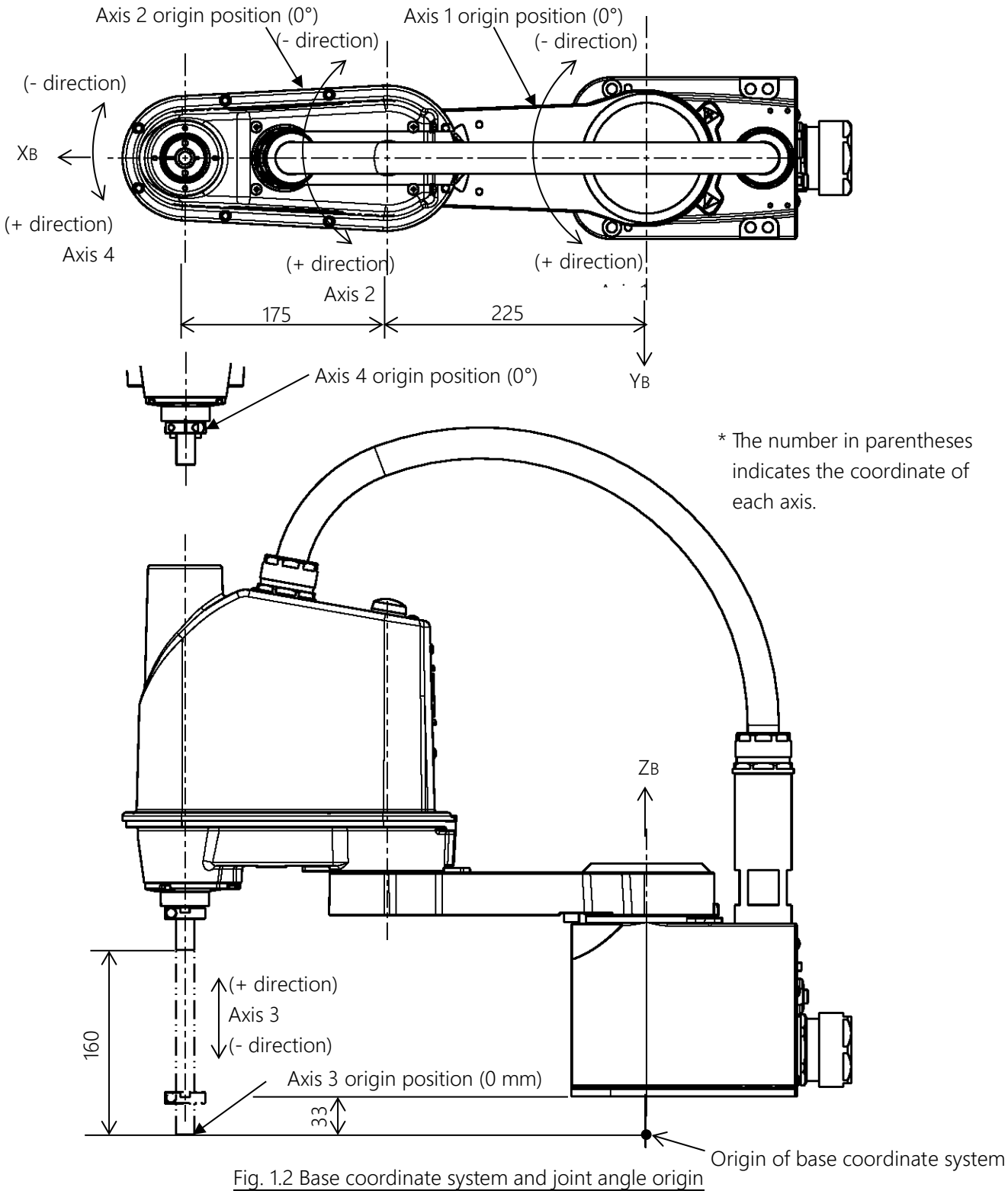


Fig. 1.2 Base coordinate system and joint angle origin

1.3 External Dimensions

Fig. 1.3 refers to the external dimensions of the KHE-400.

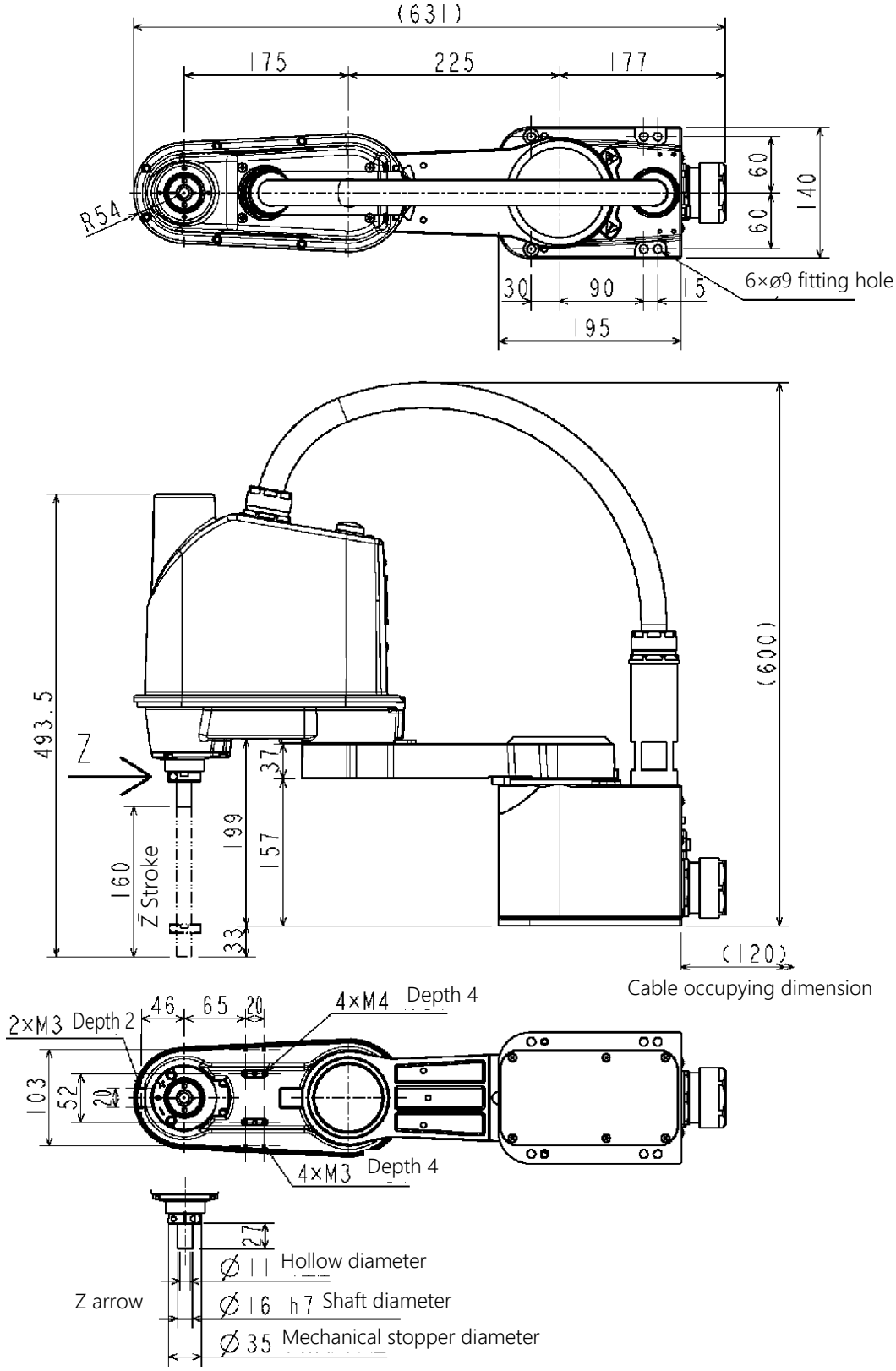


Fig. 1.3 External dimensions of the robot (KHE-400)

1.4 Specifications Table

Item		Specifications
Structure		Horizontally articulated type SCARA robot
Model		KHE-400
Applicable controller		KSL3000
Mass of robot body		15 kg
Number of controlled axes		Four (4)
Arm length		400 mm (225 mm + 175 mm)
Motor capacity/current limit	Axis 1	400 W / 20.3 Ao-p
	Axis 2	200 W / 11.7 Ao-p
	Axis 3	100 W / 6.60 Ao-p
	Axis 4	100 W / 6.1 Ao-p
Operating range	Axis 1	±130 deg
	Axis 2	±145 deg
	Axis 3	0 to 160 mm
	Axis 4	±360 deg
Maximum speed *1	Axis 1	672 deg/s
	Axis 2	780 deg/s
	Axis 3	1120 mm/s
	Axis 4	1800 deg/s
	Composite speed of axes 1 and 2	7.0 m/s
Rated payload mass*1		1 kg
Maximum payload mass*1		5 kg
Permissible load inertia*1		0.06 kg・m^2
Repeatability*2	Composite speed of axes 1 and 2	±0.01 mm
	Axis 3	±0.01 mm
	Axis 4	±0.007 deg
Cycle time (when payload mass is 2 kg)*3		0.39 sec
Drive system		AC servo motor
Position detection method		Absolute
Wiring for hand		Input: 8, output: 8
Paint color*4 Material color*4		Arm 2: PANTONE 293C or equivalent Base and arm 1: White AN-90 or equivalent Arm cover: White AN-90 or equivalent
Noise level*5		68 dB (A)
Power supply capacity*6		2.6 kVA

*1: The speed and acceleration are limited in accordance with the operation pattern, the load mass, and the offset value.
*2: Repeatability in one direction at a constant ambient temperature of 20°C. It is not absolute positioning accuracy. As for X-Y and C, they represent values at the upper limit of Z. Trajectory accuracy is not guaranteed.
*3: Continuous operation with standard cycle operation pattern and exceeding the effective load ratio cannot be performed.
During shuttle for rough positioning in horizontal direction of 300 mm and vertical direction of 25 mm.
*4: The color may differ according to each production lot. Be aware that there is no problem in the very nature of the product quality.

*5: The measurement conditions are as follows.

Operating condition: Rated load, concurrent operation of axes 1 and 2, maximum speed, and maximum acceleration

Measurement position: Height of 1.6 m from the robot installation surface at a distance of 1 m from four front, rear, right and left directions of the robot

*6: The measurement conditions are as follows.

Operating condition: Rated load and 2 kg, concurrent operation of all axes, maximum speed, and maximum acceleration

Measuring instrument: Power analyzer (POWER ANALYZER 3390)

⚠ CAUTION

- Micro vibration may occur on the robot tip depending on the posture of the robot. If micro vibration occurs, decrease the speed and decelerate the robot.
- When moving axes 1, 2 and 4, do so by raising the Z axis (axis 3) as much as possible.
  If axes 1, 2 and 4 are moved while the Z axis is down, it may damage the ball screw spline (the shaft of the Z axis) early.
  If you must move axis 1, 2 or 4 while lowering the Z axis, adjust the operating speed and acceleration/deceleration using the SPEED instruction or the ACCEL/DECEL instruction in order to prevent the ball screw spline from vibrating. When moving axes 1, 2 and 4 while the Z axis is down, be extra careful not to make contact with obstacles.
- Even if axes 1, 2 and 4 are moved at low speed, the ball screw spline (the shaft of the Z axis) may be damaged before alarm is generated.

Installation

This part describes information you should know before unpacking, transporting, installing, and operating the robot.

2. Unpacking and Transportation

The worker should receive safety training defined by each country's laws and regulations. Be aware that the failure and accident resulting from the work done by the customer will not be under our warranty.

Recommended protector:

Type and name	Protection part and use	Recommended example
Helmet	Protection part: Head Use: Protect from a falling object. Protect from collision with the arm.	
Safety glasses	Protection part: Eyes Use: Protect from a flying object. Protect from collision with the arm.	
Protective gloves	Protection part: Hands and fingers Use: Protect hands and fingers when caught in the machine. Prevent a carried object from dropping.	
Protective shoes	Protection part: Feet and toes Use: Protect from a falling object.	

2.1 Unpacking

The robot is shipped in corrugated cardboards. Fig. 2.1 shows the packing state. Open the packages in a location easily accessible, where the equipment is to be installed. Take careful precautions not to damage the robot. After opening the packages, make sure that all the accessories are present and that nothing has been damaged during transport. For robot and controller accessories, see the accessory list packed with the controller.

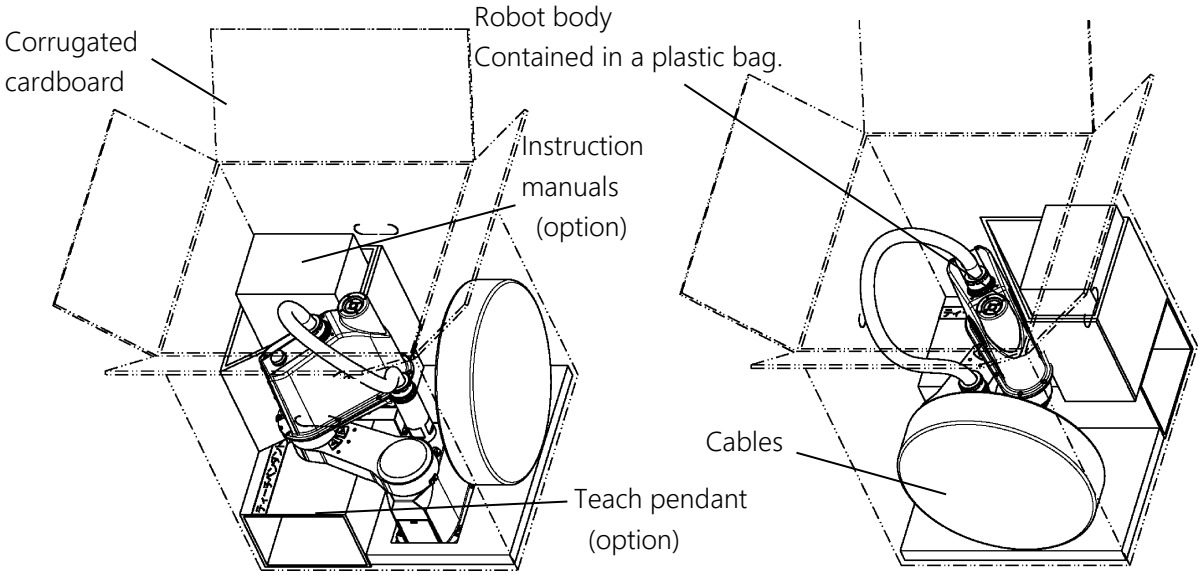


Fig. 2.1 Packaging state (KHE-400)

Table 2.1 Size and Mass

Packing size	480 mm (W) × 670 mm (H) × 540 mm (D)
Packing mass	20 kg

⚠ CAUTION

- If any parts of the equipment are found damaged or any accessories are missing after the shipment containing the equipment and controller have reached your office, DO NOT install and operate them. Otherwise, the equipment will malfunction. Contact CKD immediately.
- Dispose of the wooden pallet, corrugated cardboards, polyethylene shipping bags and cushion material according to the customer's in-house regulations.

2.2 Transportation

Move the robot very carefully. Make sure that no excessive impact or vibration is exerted on the equipment. If the equipment is to be subject to vibration over a long period, be sure to tighten all the clamp and base set bolts completely. If the equipment is to be moved to a location some distance from where it was unpacked, reposition the cushions as they were and put the equipment back into the wooden frame or corrugated cardboards.

2.3 Mass and Dimensions

Fig. 2.2 shows the mass and external dimensions of the robot.

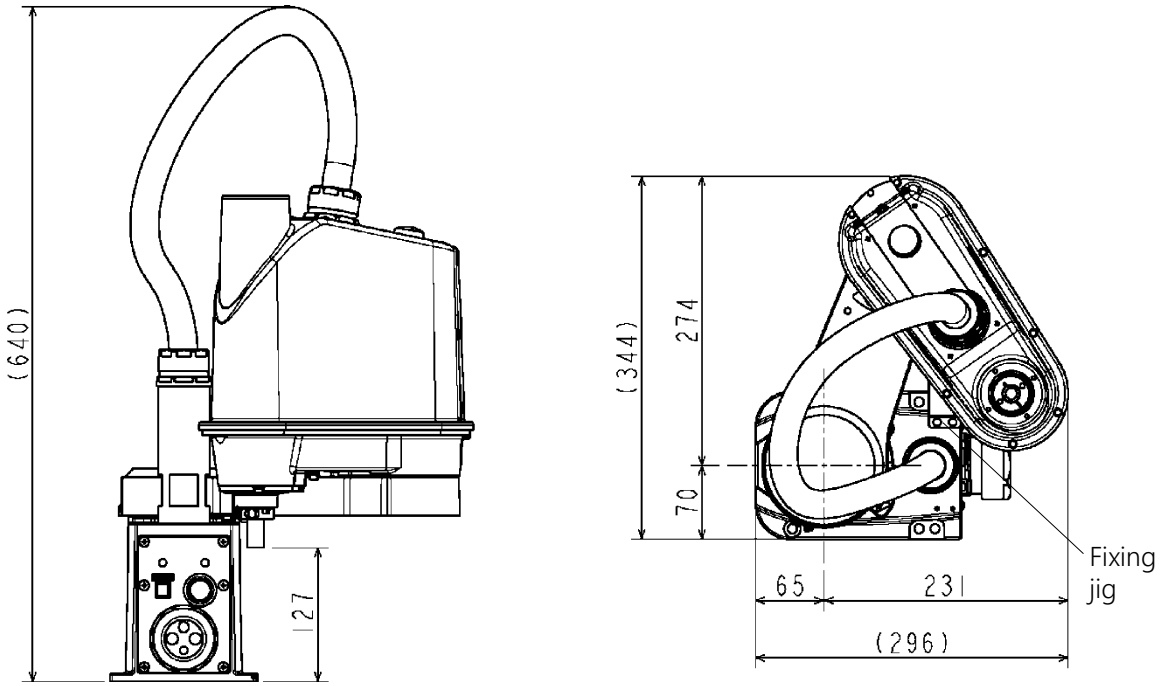


Fig. 2.2 Outer dimensions at transport (KHE-400)

2.4 Transporting the Robot

In principle, the robot should be transported in the state shown in Fig. 2.3 above.
Fold back and secure the arm with the attached clamp. (The equipment is shipped in this posture. After you have unpacked the shipment, you should move it as it is.) At this time, be careful not to impose a large force on the spline shaft. The KHE-400 robot cannot be lifted up and transported.

⚠ CAUTION

- Be sure to secure the arm with the attached clamp before transporting the robot.

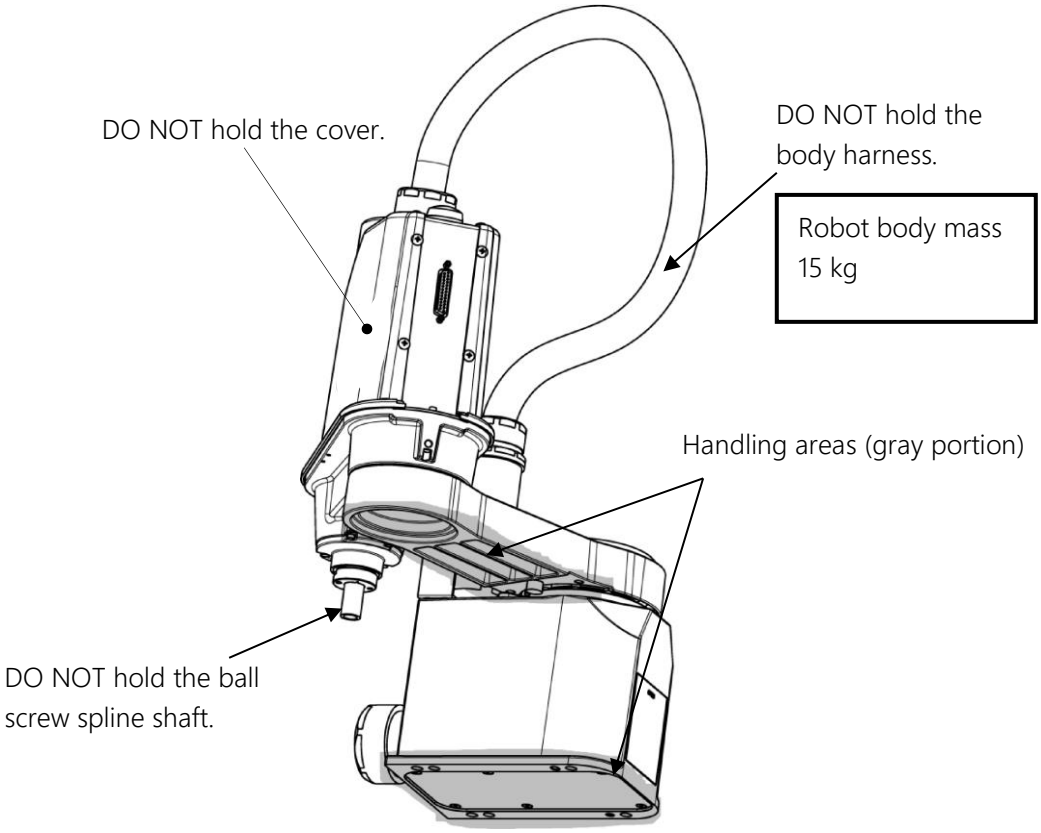


Fig. 2.3 Handling areas of the robot (KHE-400)

After the installation, remove the clamp used for transport.

⚠ CAUTION

- When lifting up the robot by workers, hold the gray portions by hands as shown in Fig. 2.3.
  If the arm 2 cover, body harness, or ball screw spline shaft is held by hands, an unusually large force is exerted, resulting in a malfunction.
- When carrying the robot by workers, take careful precautions to prevent their hand or leg from being caught in the equipment.
- The work should be performed by two (2) or more workers.
- NEVER touch the ball screw spline shaft by bare hands.
  Touching it by bare hands leads to early rust development. Be sure to wear the gloves.

2.5 Storage

Avoid storing the robot and controller for long periods of time after unpacking them.
If this is unavoidable, however, strictly observe the following precautions for storage.

2.5.1 Storage Precautions for the Robot

⚠ CAUTION

- Secure the base completely to prevent the robot from falling over.
  When placed directly on the floor, the robot is unstable and will fall over.
- Keep the robot away from direct sunlight, high temperature and high humidity.
  The resin covers and timing belts may deteriorate.
- Seal the equipment in a vinyl bag to prevent rust development and contaminant. Put a desiccant in the bag to absorb moisture.
  As the ball screw spline shaft is susceptible to rust development, coat it with corrosion inhibitor or grease the entire ball screw spline shaft.
  For the application method, see "7.6.3 Greasing Up the Ball Screw Spline Unit and Applying Corrosion Inhibitor."
- Before the use, apply the grease to the ball screw spline shaft.
- Before starting an operation, perform running completely.
- During storage, the life of the backup batteries will shorten. It is recommended to replace the batteries at the time of operation. (See "8.3 Replacing Position Detector (or Encoder) Batteries.")

3. Installation of the Robot

The worker should receive safety training defined by each country's laws and regulations.
Be aware that the failure and accident resulting from the work done by the customer will not be under our warranty.

Recommended protector:

Type and name	Protection part and use	Recommended example
Helmet	Protection part: Head Use: Protect from a falling object. Protect from collision with the arm.	
Safety glasses	Protection part: Eyes Use: Protect from a flying object. Protect from collision with the arm.	
Protective gloves	Protection part: Hands and fingers Use: Protect hands and fingers when caught in the machine. Prevent a carried object from dropping.	
Protective shoes	Protection part: Feet and toes Use: Protect from a falling object.	

3.1 Installation Environment

Table 3.1 shows the environmental conditions for the location in which the robot are to be installed.

Table 3.1 Environmental conditions for robot

Item	Specifications
Temperature	In operation: 0 to 40°C In storage: -10°C to 50°C
Humidity	20 to 80% (Non-condensing) DO NOT install the equipment where it may be subject to fluids such as water.
Altitude	1000 m or less
Vibration	In operation: 0.98 m/s^2 or less
Dust	No inductive dust should exist. Consult with CKD first if you wish to use the robot and controller in a dusty environment.
Gas	No corrosive or combustible gas should exist.
IP (Ingress Protection) rating	Equivalent to IEC60529 IP10 (robot side), and equivalent to IP20 (for the controller)
Overvoltage category	IEC60664-1 Class III

Item	Specifications
Protection against electric shock	IEC61140 Class I
Pollution degree	IEC60664-1 Pollution Degree 3
Sunlight	The robot and controller should not be exposed to direct sunlight.
Power noise	A heavy noise source should not exist nearby.
Magnetic field	A heavy magnetic field source should not exist nearby.
Other ambient environmental requirements	No iron powder, no oil, no salt content, and no organic solvent. No water splash on the robot/controller.

⚠ DANGER

- Do not place the robot or controller near combustible.
  Doing so could lead to fires if it ignites due to a fault, etc.

⚠ CAUTION

- In the case where batteries for detecting the motor position are of alkaline type (standard type), the batteries can overheat, leak battery fluid, or rupture when used under high temperatures. Also, high temperature can reduce the performance and lifespan of the battery.
  If using the robot under high temperatures, please consult with the CKD sales office.
- If the robot is operated at high speed when started in a low-temperature environment, the torque increases, and an error can occur.
  In a low-temperature environment, be sure to operate the robot at low speed in continuous operation mode for several minutes after starting it, which softens the grease. Then, change to high-speed operation.

3.2 Installation

Before the robot can be installed, the installation layout must be studied in consideration of the working envelope, the coordinate system, and the maintenance clearance.

3.2.1 Installing the Robot

The robot is secured by using the mounting holes on the base (four (4) places).
Use attached hexagon socket head cap screws M8×20.
Table 3.2 lists the load on the frame during horizontal movement, and Fig. 3.1 shows the robot installation method. The pinholes are provided on the base unit. If the robot position is to be aligned in the base coordinate system or the robot must be replaced, the robot can be positioned by the pinholes.

⚠ CAUTION

- The robot will suddenly accelerate and decelerate during operation. When installing it on a frame, make sure that the frame has sufficient strength and rigidity.
  If the robot is installed on a frame that does not have sufficient rigidity, vibration will occur while the robot is operating, and could lead to faults.
  When installing the painted workpiece conveyor on the floor, secure the robot with anchor bolts, etc.
- Install the robot on a level place.
  Failure to do so could lead to a drop in performance or faults.
- Secure the frame to the external area (floor or wall), and do not move it.

Table 3.2 Load on the frame during horizontal movement

Model	Load on the frame during horizontal movement (Nm)	Robot body mass (kg)
KHE-400	150	15

*This value is a reference value. When designing the frame, consider safety factor.

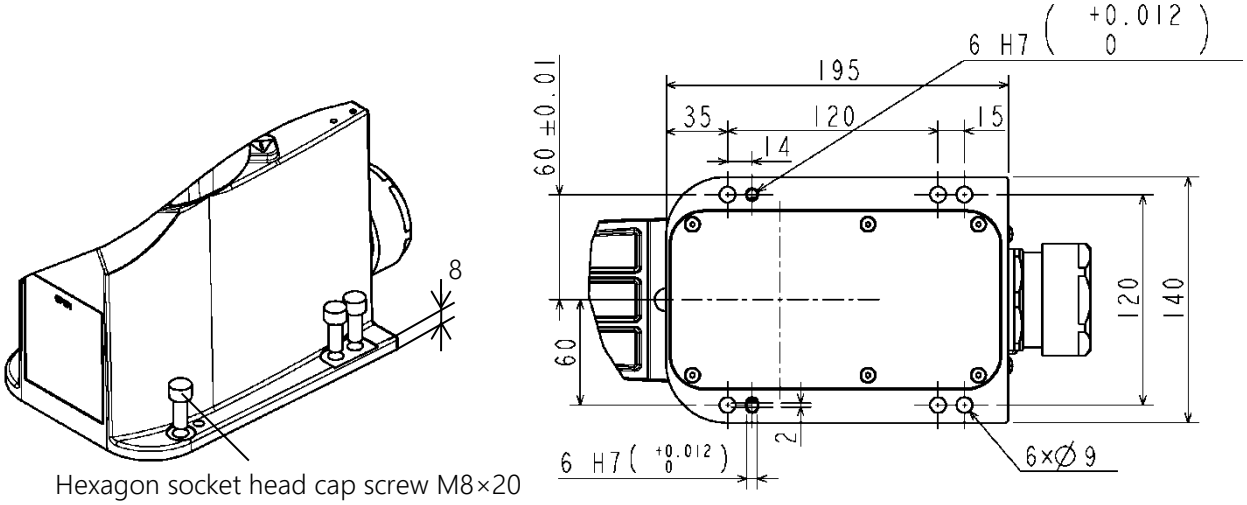


Fig. 3.1 Setting method (KHE-400)

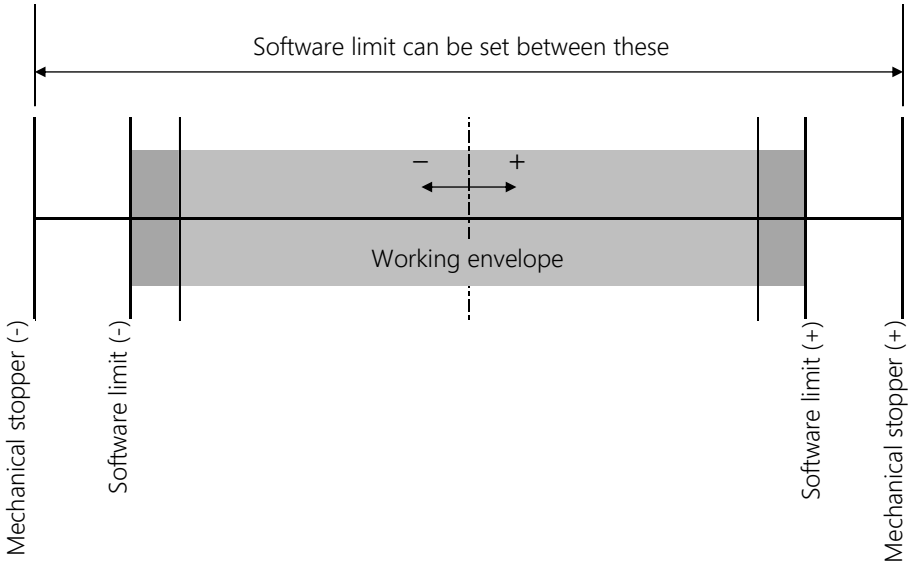
3.2.2 Operating Range

Fig. 3.2 shows the operating range.

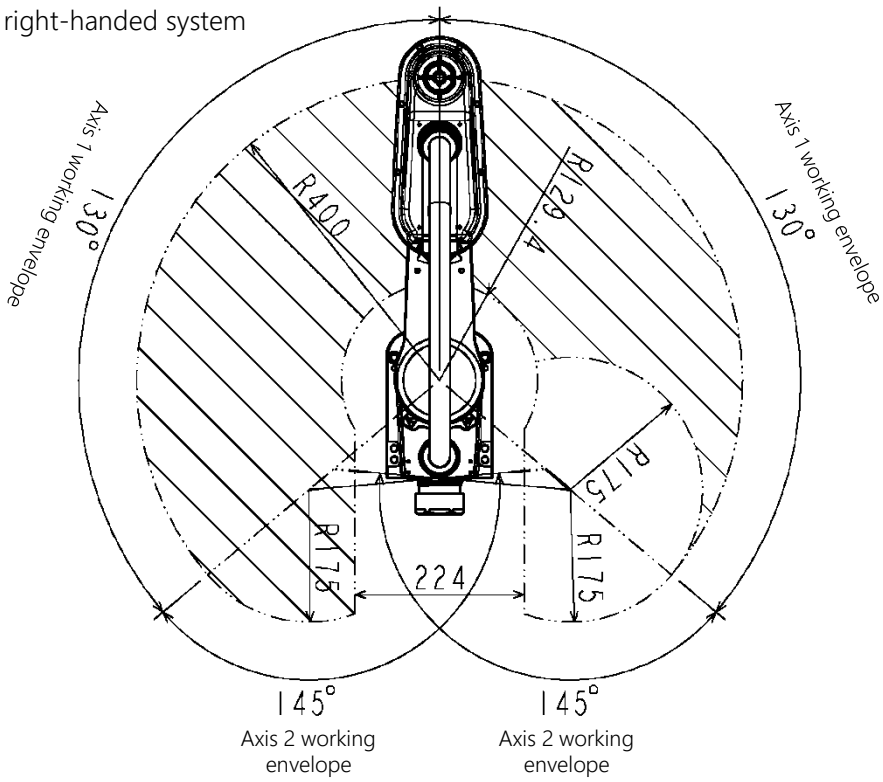
Each axis can operate within the working envelope. To prevent the equipment from moving out of the working envelope by misoperation, the robot is equipped with mechanical stoppers outside the working envelope.

Additionally, there are software limits that the user can set up.

For details, refer to the User Parameters Instruction Manual provided separately.



For right-handed system



For left-handed system

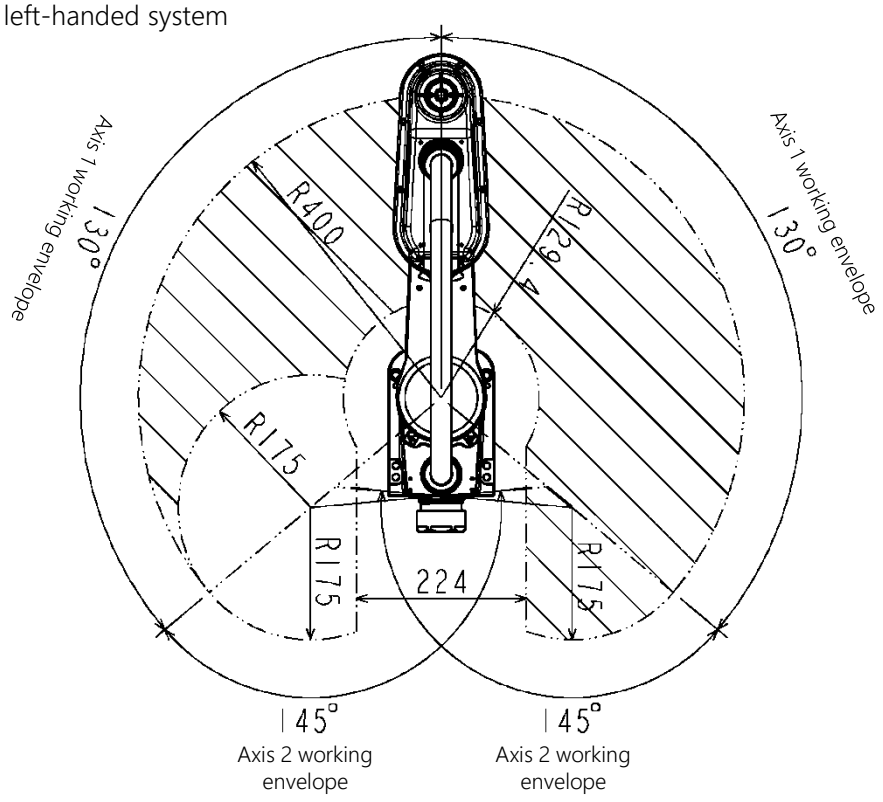


Fig. 3.2 Operating range

3.2.3 Changing axis-1 and 2 working envelope

The robot is equipped with the mechanical stoppers to restrict the working envelop of each axis mechanically. Changing the mechanical working envelope of the robot by changing this mechanical stoppers refers to "working envelope change."
This section explains how to change axis-1 and 2 working envelope of the robot.

For how to change the axis-3 working envelope, see "3.2.4 Changing axis-3 working envelope." Unlike other working axes, the working envelope of axis 4 is restricted by only software limit instead of mechanical stoppers. Therefore for change of axis-4 working envelope, see "3.2.5 Changing software limit."

⚠ CAUTION

- If a working envelope is to be changed, design and manufacture mechanical stoppers in accordance with your operating conditions, referring to this manual.
- If a working envelope is changed after the mechanical stoppers, be sure to change the software limits in order to prevent the robot from coming into contact with the mechanical stoppers during operation.
- The mechanical stoppers are not to strictly limit the movable range of the robot. Do not go into the robot's working envelope when you turn on the robot.
- If the robot collides with a mechanical stopper, the robot will stop recognizing the collision, but the mechanical stopper may be damaged. Do not use the mechanical stopper any more.
- The mechanical stopper reference drawings in this manual do not satisfy your operating conditions. Design, manufacture, and mount mechanical stoppers in accordance with your operating conditions such as the working envelope.
- A failure of the robot arising from mechanical stoppers is excluded from the warranty.
- If mechanical stoppers are changed, the function described in "8.9.1 [4] How to Restore Data by HOME3 or HOME4" is disabled.

As shown in Fig. 3.3 and Fig. 3.6, the working envelope can be changed by changing the position of mechanical stoppers.

Table 3.3 Working envelope before and after change

		Before change	After change
Axis-1 working envelope	+ direction	130°	95°
	- direction	130°	95°
Axis-2 working envelope	+ direction	145°	120°
	- direction	145°	145°

Install hexagon socket head cap screws (M8×12) into the outside tap hole.

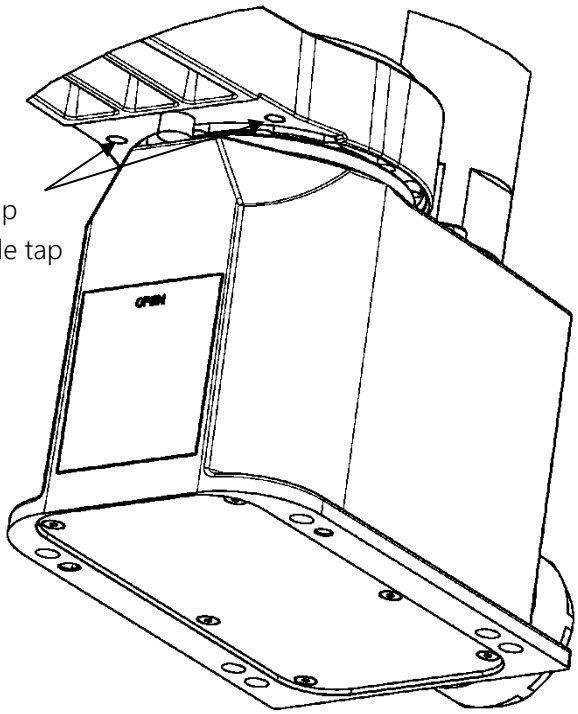


Fig. 3.3 Example of changing axis-1 working envelope

When the axis-2 working envelope is changed, it can be set to any working envelope by changing the shapes of mechanical stoppers. Fig. 3.4 shows the mounting position of the axis-2 mechanical stoppers, and Fig. 3.5 shows the example of changing the axis-2 mechanical stopper. The customer should design and manufacture the mechanical stoppers as required.

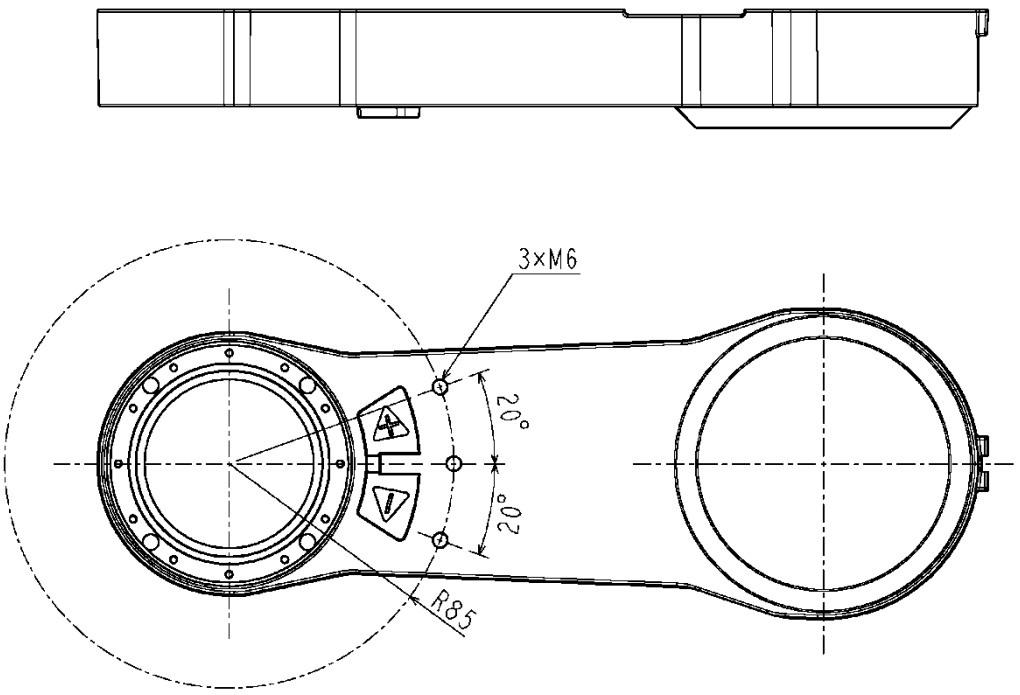


Fig. 3.4 Mounting position of axis-2 mechanical stopper

Example of changing axis-2 mechanical stopper
Set working envelope: 120°, -145°

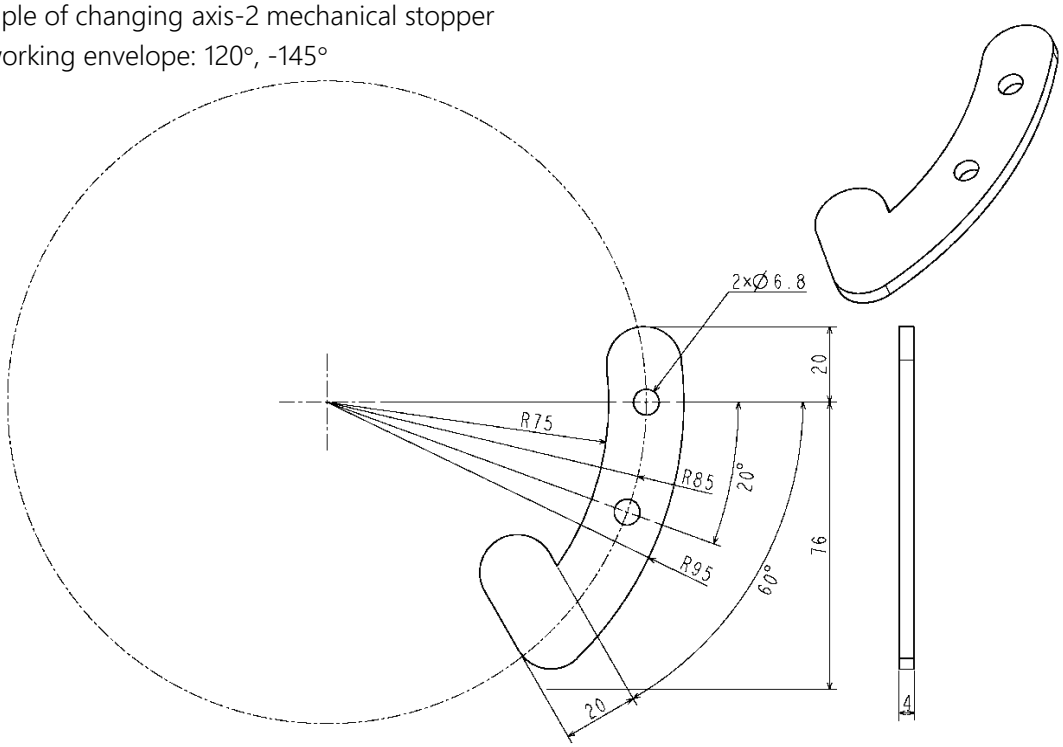


Fig. 3.5 Example of changing axis-2 mechanical stopper

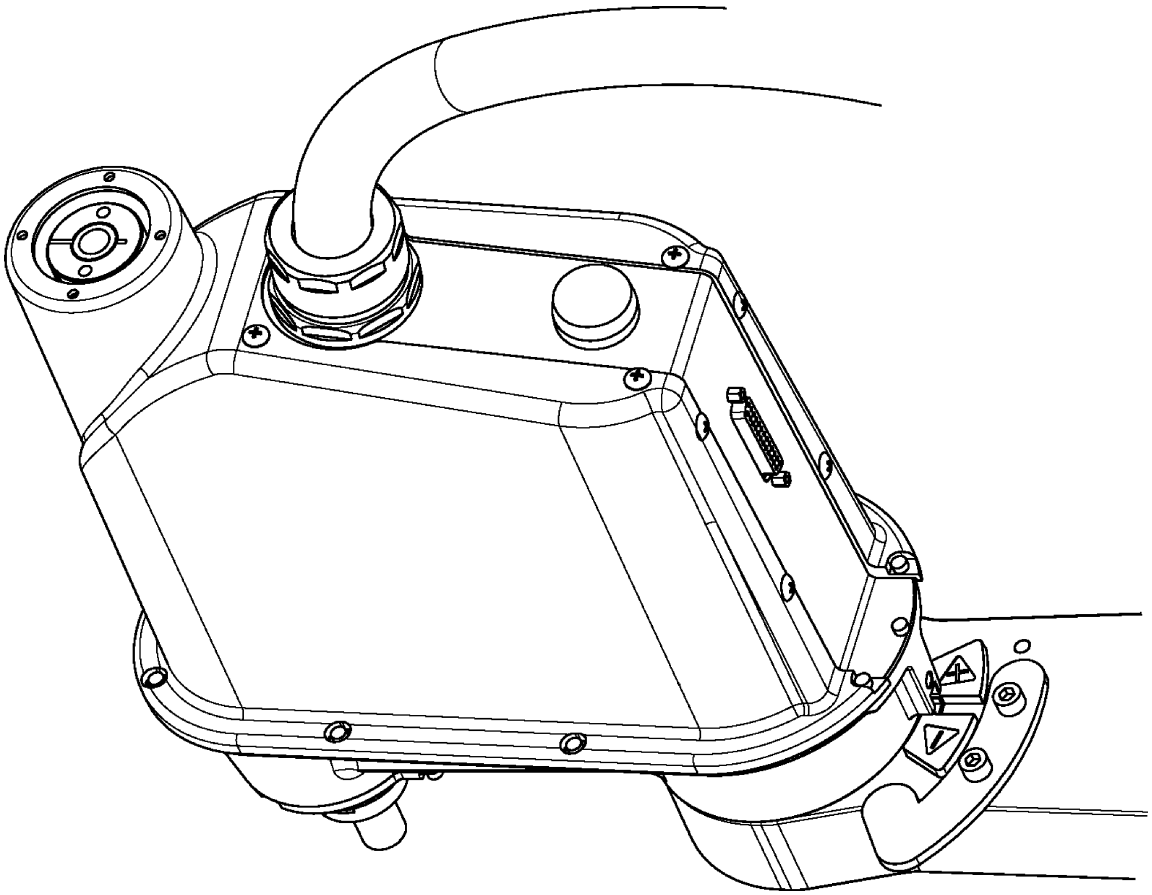


Fig. 3.6 Example of changing axis-2 working envelope

If a working envelope is changed, user parameter must be changed.
For how to change the software limit, see "3.2.5 Changing software limit."

3.2.4 Changing axis-3 working envelope

The robot is shipped while the software limits and mechanical stoppers are factory-set for Z stroke of axis 3 to travel between 0 to 160 mm. Fig. 3.7 shows the factory-set working envelope.

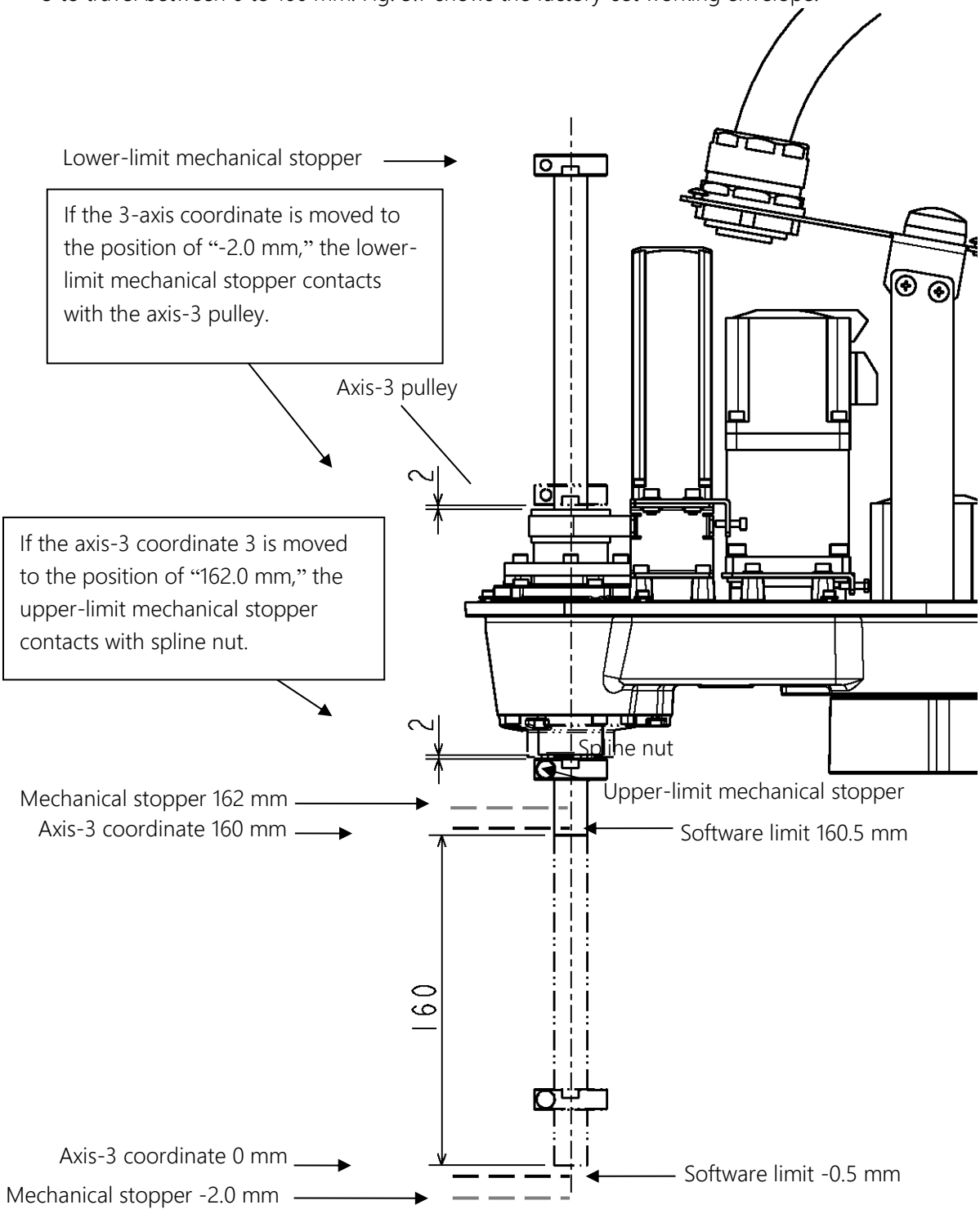


Fig. 3.7 Factory-set axis-3 working envelope

1) Remove the arm-2 cover. For how to remove the cover, see "7.3.1 Arm-2 ."

2) Loosen mechanical stopper set bolts, move the mechanical stoppers to any position, and then secure them again.
When securing mechanical stoppers, be sure to apply screw locking adhesive (LOCTITE 242 medium strength) to the set bolts.

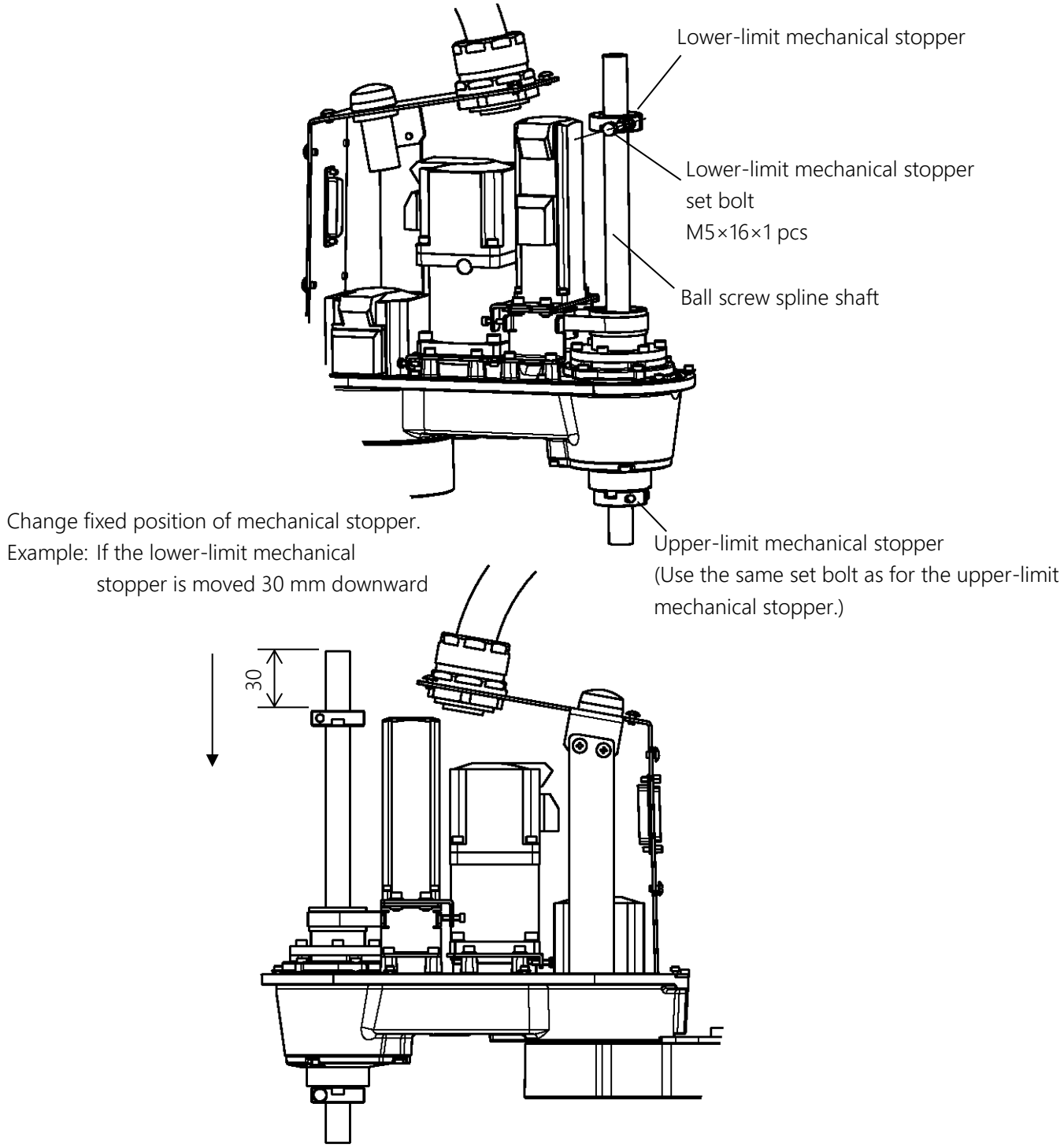


Fig. 3.8 Changing axis-3 working envelope

3) If the mechanical stopper is changed, be sure to change the software limit. As for the change of software limits, see "3.2.5 Changing software limit" and Fig. 3.10. After the software limit is changed, move axis 3 up and down by hand while pressing the axis-3 brake release switch and make sure that the software limit is set correctly.

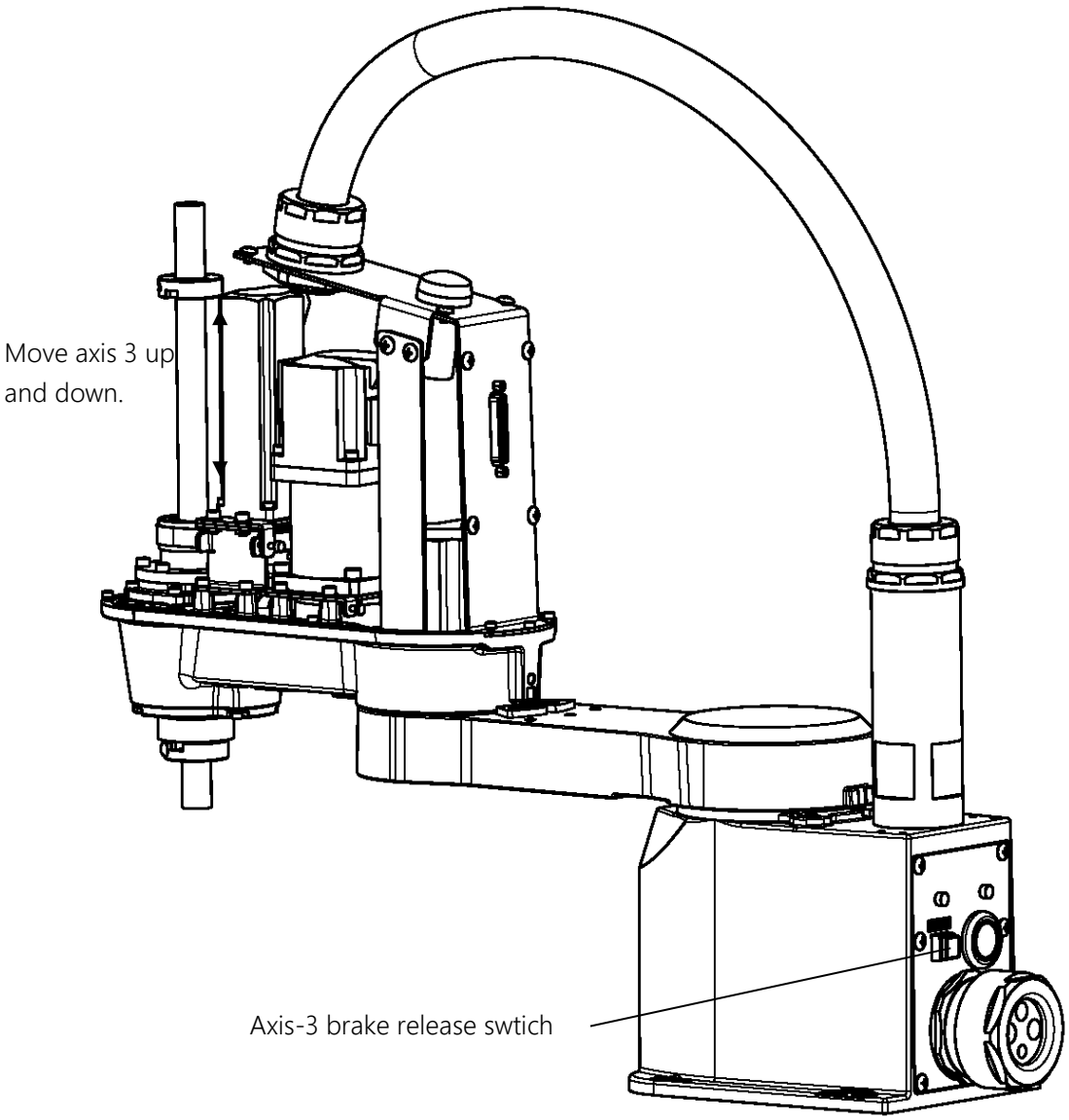


Fig. 3.9 Changing and checking the axis-3 software limit

Fig. 3.10 Example of changing axis-3 working envelope shows the working envelope setting if the lower-limit mechanical stopper is moved 30mm downward.

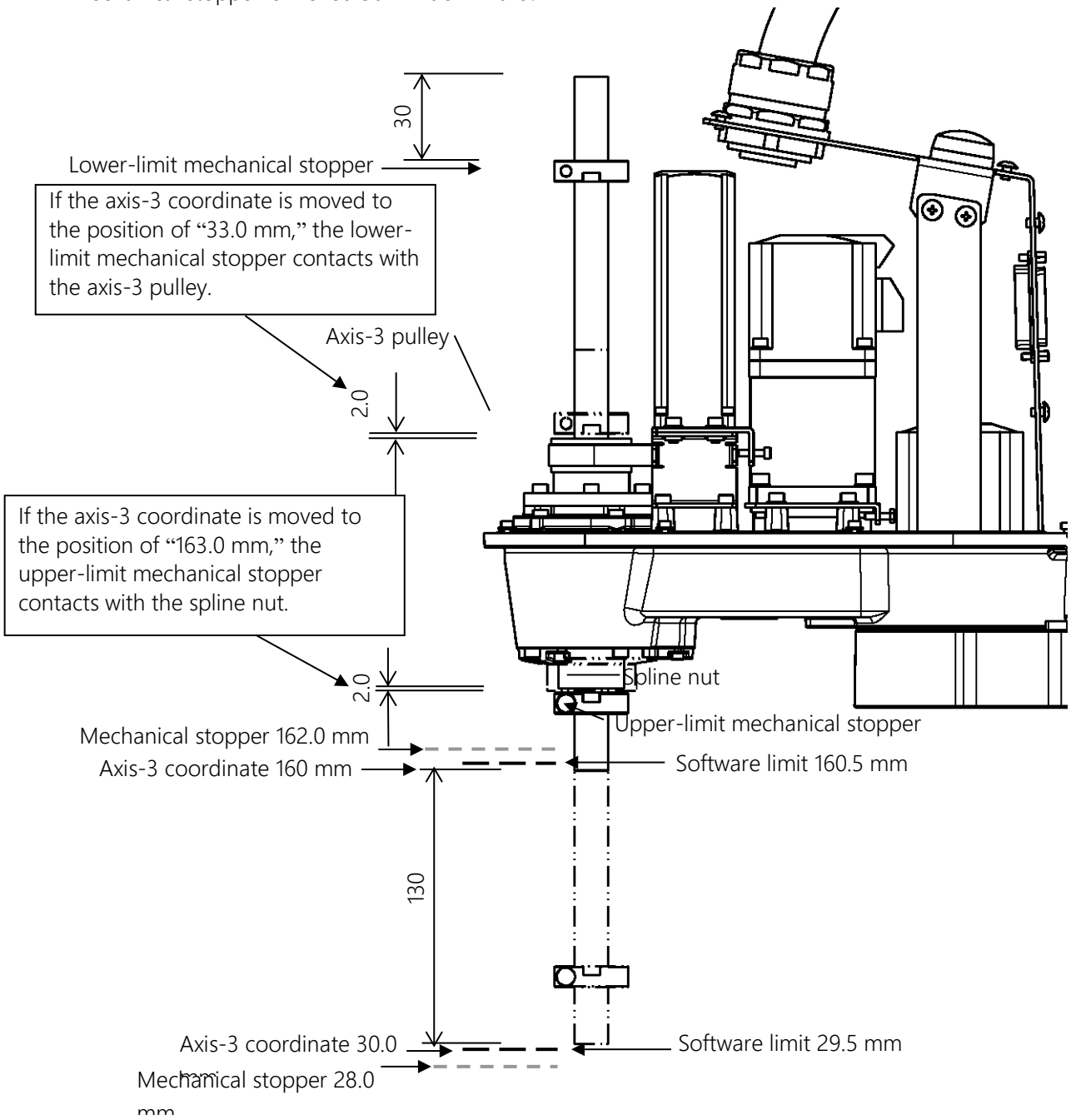


Fig. 3.10 Example of changing axis-3 working envelope

4) Mount the arm-2 cover. For how to mount the cover, see "7.3.1 Arm-2 Cover."

⚠ CAUTION

- To change the working envelope, use the lower-limit mechanical stopper. If the upper-limit mechanical stopper is used to change the working envelope, the state becomes the same as that in which the Z-axis is in low position. Moving Axis 1, 2, or 4 in such state can lead to premature damage to the ball screw spline.

3.2.5 Changing software limit

If the mechanical stopper is changed, be sure to change the software limit as well.
There are the following two methods for changing the software limit.

[1] Operate the teach pendant to use utility mode "J-LIM" for change.
For details, refer to the description of 10.8 "Joint limit setting [J-LIM]" in Section 10 "Utility" in "Operation Manual" Instruction Manual provided separately.

[2] Change the setting value of "user parameter file (file name: USER.PAR)."
There are software limits that the customer can set up. For details, refer to the description of "[U14] SOFTWARE LIMIT" in "User Parameters" Instruction Manual provided separately.

When the software limit is changed using the above two types of methods, the software limit value set in the factory-set "user parameter file (file name: USER.PAR) is changed and saved.
Therefore, before changing the software limit, be sure to back up the "user parameter file" so that the software limit value set in the factory-set user parameter file can be identified.

If the software limit is changed using the method in [2], be sure to turn off the power and then turn it on. Otherwise, the user parameter change is not reflected.

4. Setting Hand

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations.
Be aware that failure and accident resulting from the work done by the customer will not be under our warranty.

Recommended protector:

Type and name	Protection part and use	Recommended example
Helmet	Protection part: Head Use: Protect from a falling object. Protect from collision with the arm.	
Safety glasses	Protection part: Eyes Use: Protect from a flying object. Protect from collision with the arm.	
Protective gloves	Protection part: Hands and fingers Use: Protect hands and fingers when caught in the machine. Prevent a carried object from dropping.	
Protective shoes	Protection part: Feet and toes Use: Protect from a falling object.	

4.1 Mounting hand

The hand is to be mounted on the lower end of the shaft or the tool flange. Fig. 4.1 shows the dimensions of the lower end of shaft and the tool flange. If the hand is mounted on the tool flange, the tool is centered with the φ12H7 mating section. The hand direction is adjusted by means of the 4 x 4 keys and secured with four (4) M4 bolts. The tool flange is optional.

⚠ CAUTION

- To provide a chuck on the hand, install wiring and air piping to prevent a workpiece from being released when the power is turned off. Otherwise, when the emergency stop switch is pressed, a workpiece is released to result in damage to the robot, workpiece, etc.

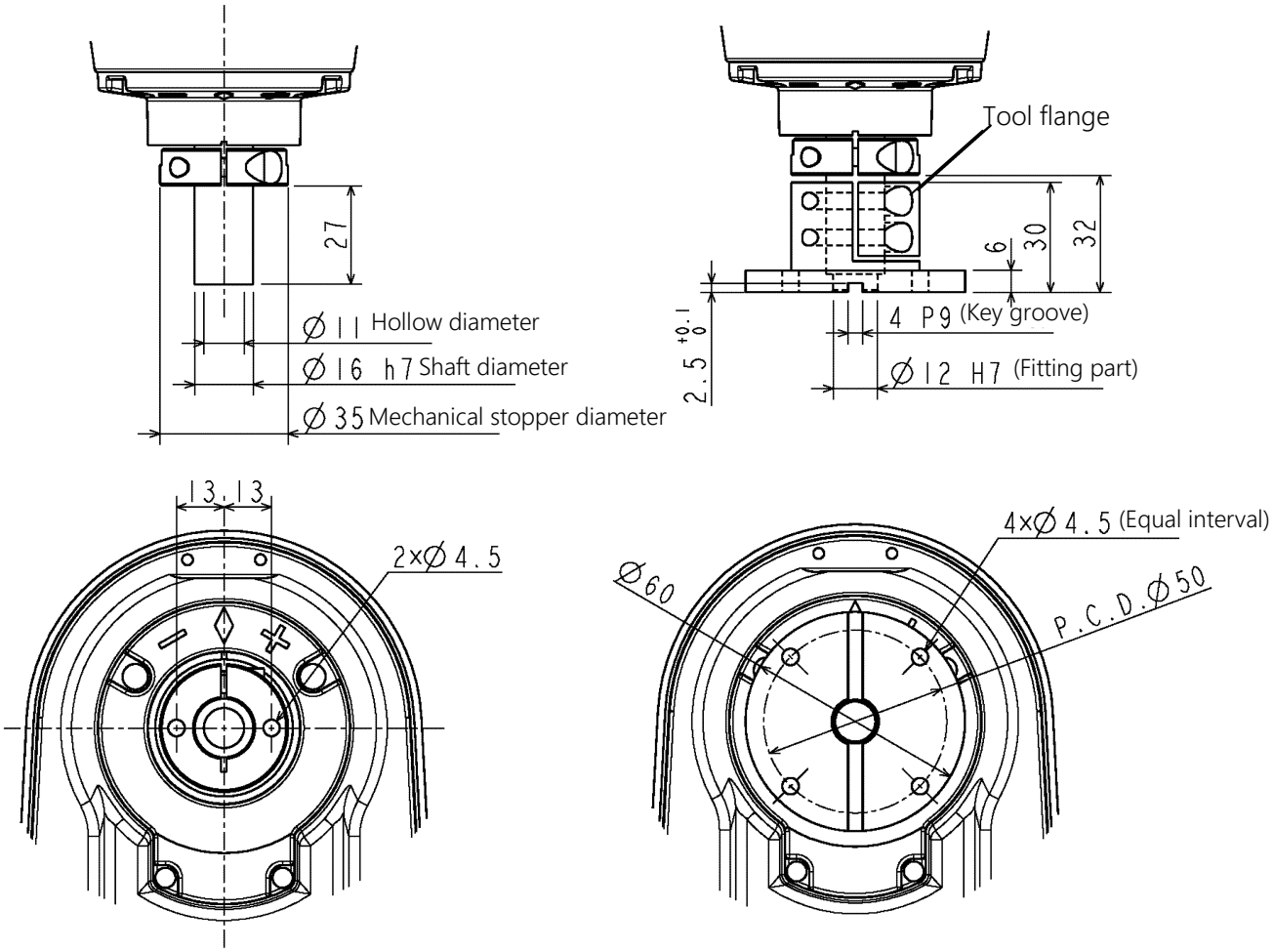


Fig. 4.1 Hand mounting dimensions

4.2 Mounting camera and air valve

The screw holes are formed in the arm 2 bottom and base as shown in Fig. 4.2. When a camera or air valve is mounted on the arm, these screw holes are used. Fig. 4.3 shows the mounting example.

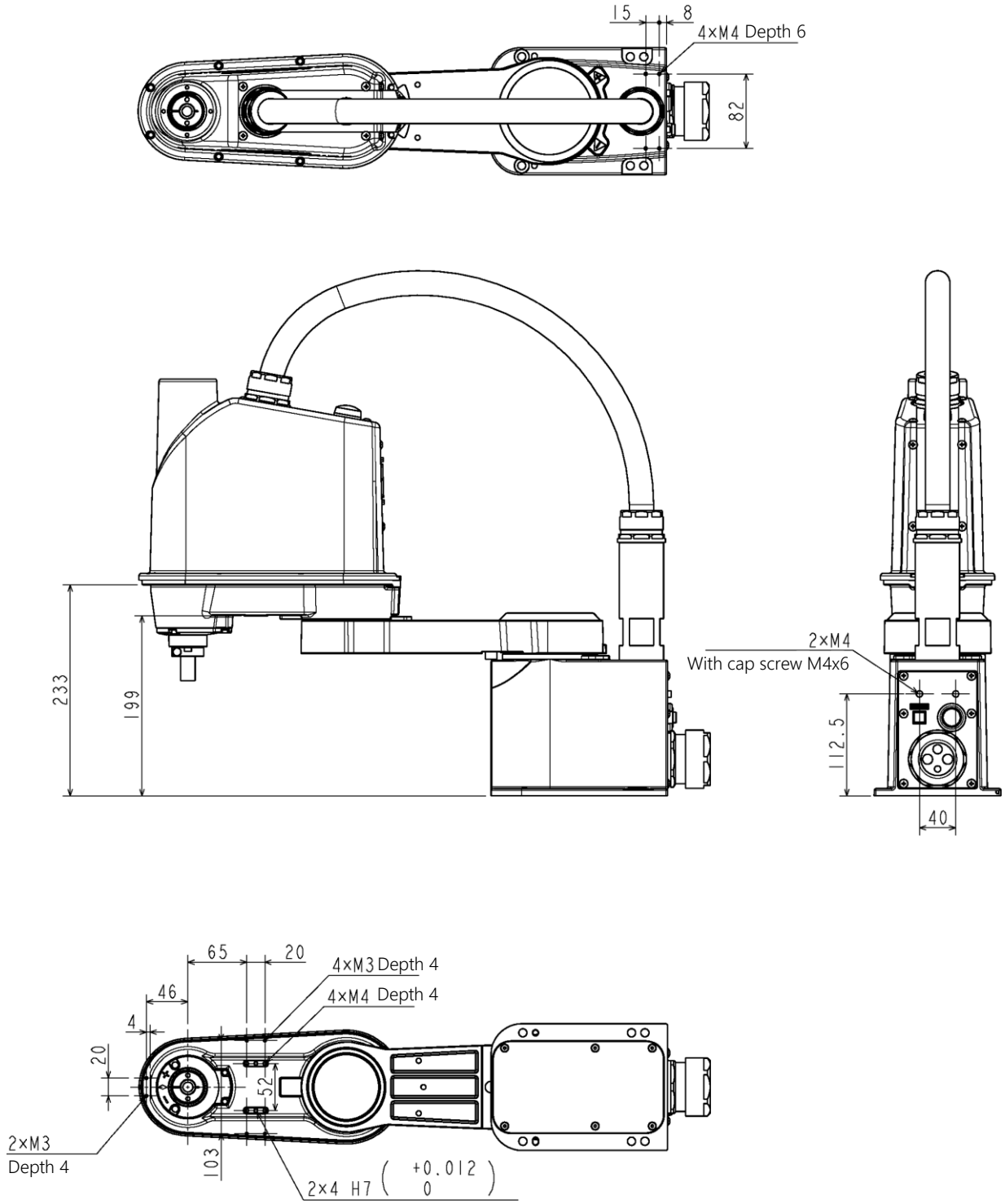


Fig. 4.2 Service tap dimensions

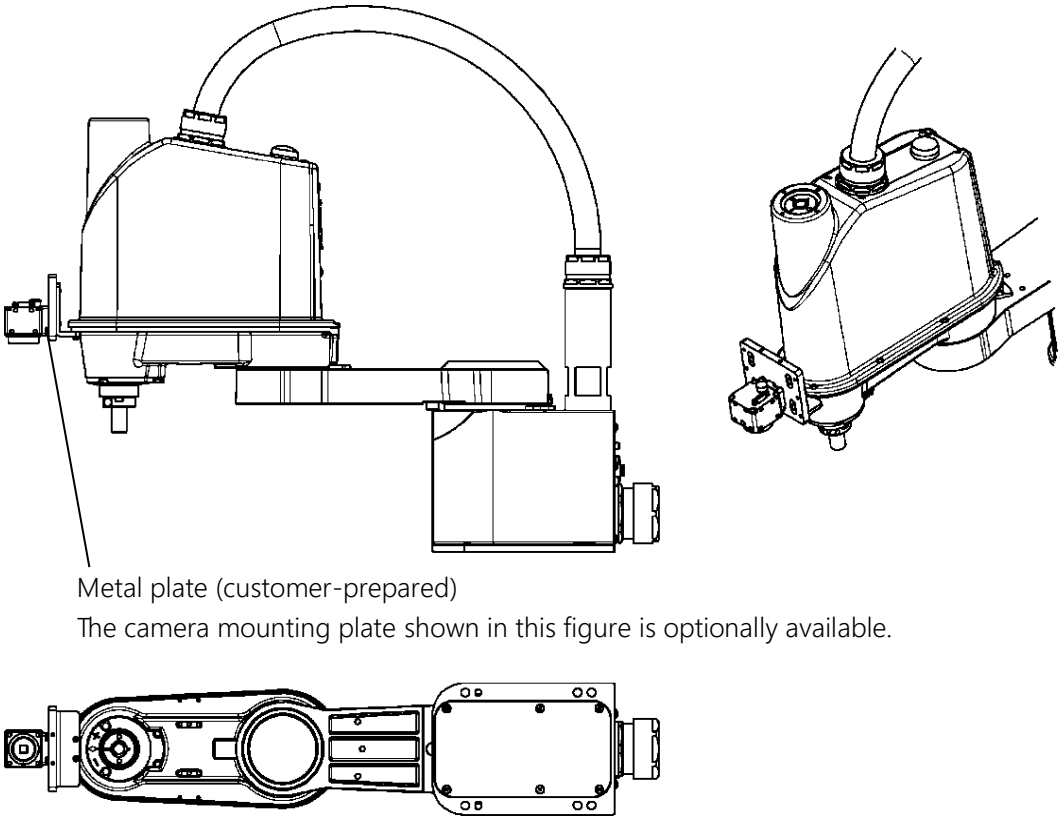


Fig. 4.3 Example of mounting the camera

Table 4.1 lists the manufacturers of the optional camera mounting plate.

Table 4.1 Camera mounting plate (optional)

Manufacturer	Product name	Maker model Example	000 Dwg. No.	Unit code
Keyence	Camera mounting bracket	CV-S035CH/CV-S035MH	L15388G01	Y610D0650
		CV-S200CH/CV-S200MH		
		CA-HX200C/CA-HX200M		
		CA-HX500C/CA-HX500M		
OMRON		FH-SC/FH-SM	L15388G02	Y610D0660
		FH-SC02/FH-SM02		
		FH-SC04/FH-SM04		
		FH-SM05R/FH-SC05R		
Panasonic		ANPVC2040	L15388G03	Y610D0670
		ANPVC1040		
		ANPVC5030		
		ANPVC1470		
Basler		GigE Vision air sensor Ace series	L15388G04	Y610D0680

4.3 Hand air piping

The hand air piping should be installed by the customer. Fig. 4.4 shows an example of installing hand air piping for reference.

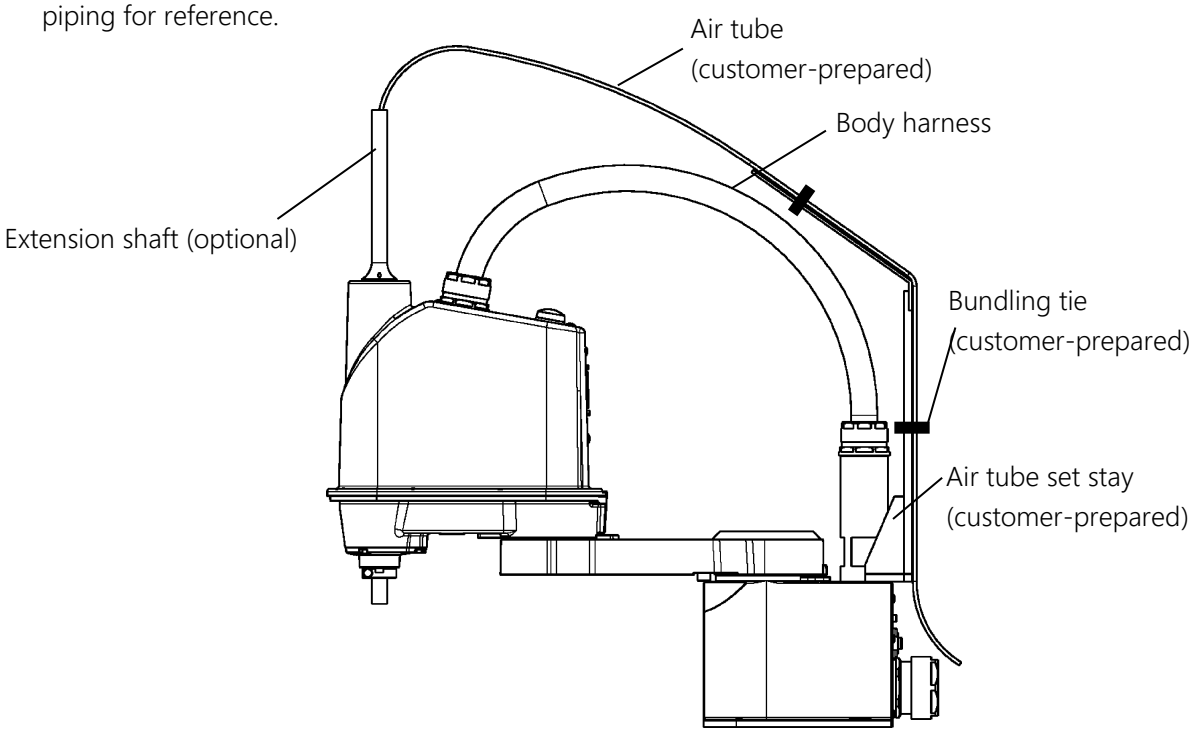


Fig. 4.4 Example of hand air piping and wiring

Table 4.2 Extension shaft (optional)

Product name	Type	Shibaura Dwg. No.	Unit code
Extension shaft		L19080G01	Y610D05Z0

⚠ CAUTION

- The air tube is a consumable product. Check the state by periodic inspection, and replace the air tube if it is damaged.
- The solenoid valve air tubes should be prepared by the customer.
- Fig. 4.4 shows a piping example. Note that the damaged air tube is not under our warranty.
- Wiring together with the body harness imposes forcible force on the body harness, which can lead to break.

4.4 Permissible load conditions and program setting

This section describes the permissible load conditions of the robot and how to set up the program according to the load.

4.4.1 Permissible load conditions

The robot load conditions are defined by the hand mass, moment of inertia and offset value of hand gravity center from the hand shaft center as shown in Fig. 4.5.
The permissible load conditions are listed in Table 4.3.

Table 4.3 Permissible load conditions

Conditions	Permissible values
Mass	Up to 5 kg (rated 1 kg)
Load inertia	Up to 0.06 kg·m^2
Offset value of load gravity center	Up to 100 mm

⚠ CAUTION

- NEVER operate the robot under the load conditions exceeding the permissible values. Otherwise, the robot life and safety cannot be guaranteed.

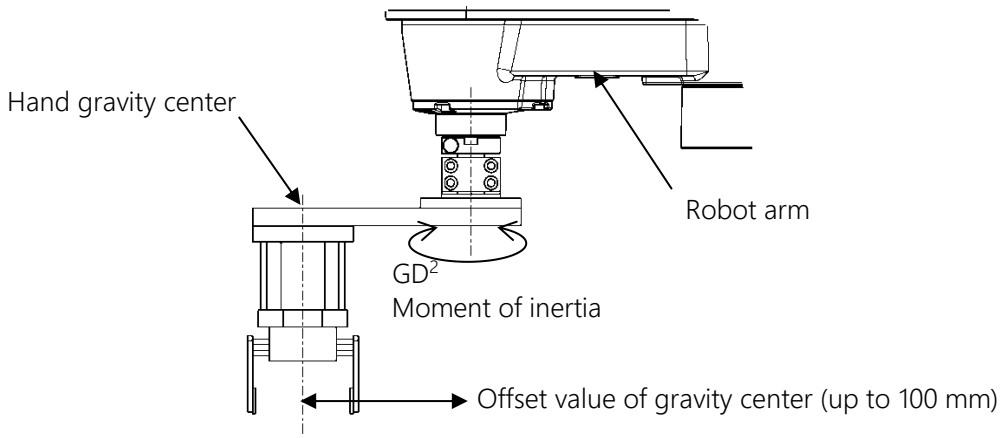


Fig. 4.5 Robot tool

4.4.2 Load conditions and program setting

This robot can automatically change the maximum speed, acceleration/deceleration and servo gain by using the PAYLOAD command in the program according to the load conditions.
Be sure to use the PAYLOAD command.
The specific method for using this function is explained below.

PAYLOAD command format

The PAYLOAD command format is written as shown below if the tool mass is M kg and the gravity center offset is L mm.

```
PAYLOAD= {M, L}
   M: Load mass     (kg)
   L  : Gravity center offset (mm)
```

The PAYLOAD command has the following functions.
The maximum speed and acceleration/deceleration of each robot axis are automatically changed according to the set load conditions.
The servo gain of each robot axis is automatically changed according to the set load conditions.

Program examples

Basic program examples using the PAYLOAD command are shown below.
For further information, refer to the Robot Language Manual Instruction Manual.

(Program example 1)
The robot is moved under the load conditions of 5 kg load mass and 100 mm gravity center offset.

```
PROGRAM SAMPLE
   SPEED= 100
   PAYLOAD={5,100}
   MOVE P1
   MOVE P2
   STOP
END
```

(Program example 2)
Assume that the hand mass becomes 5 kg and the gravity center offset becomes 50 mm when the workpiece is grasped at the hand mass of 3 kg and the gravity center offset of 30 mm.
Pick-and-place operation is executed under the above conditions.

```
PROGRAM SAMPLE
   PAYLOAD={3,30}
   ACCUR=COARSE
   ENABLE NOWAIT
   RESET DOUT
   MOVE P0
   DOUT(1)
   WAIT DIN(1)
LOOP:
   MOVE P1+POINT(0,0,100)
   IF DIN(-1)THEN GOTO FIN
   MOVE P1
   WAIT MOTION>=100
   DOUT(213)
   DELAY 1
   PAYLOAD={5,50}
   MOVE P1+POINT(0,0,100)
   MOVE P2+POINT(0,0,100)
   MOVE P2
   WAIT MOTION>=100
   DOUT(-213)
   DELAY 1
   PAYLOAD={3,30}
   MOVE P2+POINT(0,0,100)
   GOTO LOOP
FIN:
   MOVE P0
   DOUT(1)
   STOP
END
```

Setting of PAYLOAD command

In the default state, or when the PAYLOAD command is not used, the maximum speed and acceleration/deceleration are set to 100% and the servo gain is set to the value under the minimum load.

See "4.4.3 Setting maximum speed and robot acceleration/deceleration for load conditions."

⚠ CAUTION

- Be sure to use the PAYLOAD command.
- Unless the PAYLOAD command is used, malfunction is caused or the life of the mechanisms is shortened. In the worst case, the mechanism will be damaged.
- Even when the PAYLOAD command is used, adjust the speed by using the SPEED or DECEL command while confirming the behavior of workpieces to be handled.
- Micro vibration may occur depending on the posture of the robot. If micro vibration occurs, decrease the speed and decelerate the robot.

⚠ CAUTION

- The load moment of inertia should be with the tolerances given in Table 4.3.
- Even if there is no offset of load gravity center, when the moment of inertia is large, the robot may vibrate.
  When this happens, figure out the virtual gravity center offset (L mm) from the following equation, using the moment of inertia (J kg・m^2) and mass (M kg).
  $L=\sqrt{(J\times10^6/M)}$
  Then, designate the following command.
  PAYLOAD={M,L}

⚠ CAUTION

- When guiding manually, the robot may vibrate if the load mass or gravity center offset is large.
  This is because the servo gain is not appropriate.
  When this happens, refer to 10.16 "PAYLOAD setting before manual guiding" in Operation Manual to set PAYLOAD in manual mode. The servo gain is changed then to the value which meets the load conditions.

Weight of load mounted on the arm

If the camera or air valve is mounted on the arm, the weight of the load is converted to the equivalent weight of the shaft and is added to the load weight and set the PAYLOAD command.

Equvalent weight equation

If load is mounted on the tip from the axis-3 center: $W_M=M(A_{M2})^2/(A_2)^2$

If load is mounted between axis-1 center and axis-3 center: $W_M=M(A_{M1})^2/(A_1+A_2)^2$

W_M:Equivalent weight
M :Camera weight
A_1 :Arm-1 length
A_2 :Arm-2 length
A_{M1}:Distance from axis-1 rotation center to gravity center of camera
A_{M2}:Distance from axis-2 rotation center to gravity center of camera

Fig. 4.6 and Fig. 4.7 show the examples.

Example: If the camera of 1 kg is mounted on the arm-2 tip and the hand of 2 kg is mounted on the shaft tip

Equivalent weight (W_M) of the camera mounted on the arm-2 tip is
$W_M=1\times245^2/175^2=1.96$
Thus, the total load mass
$W+W_M=2+1.96=3.96$
is rounded up to become 4 kg.

Set "4" in the PAYLOAD command.

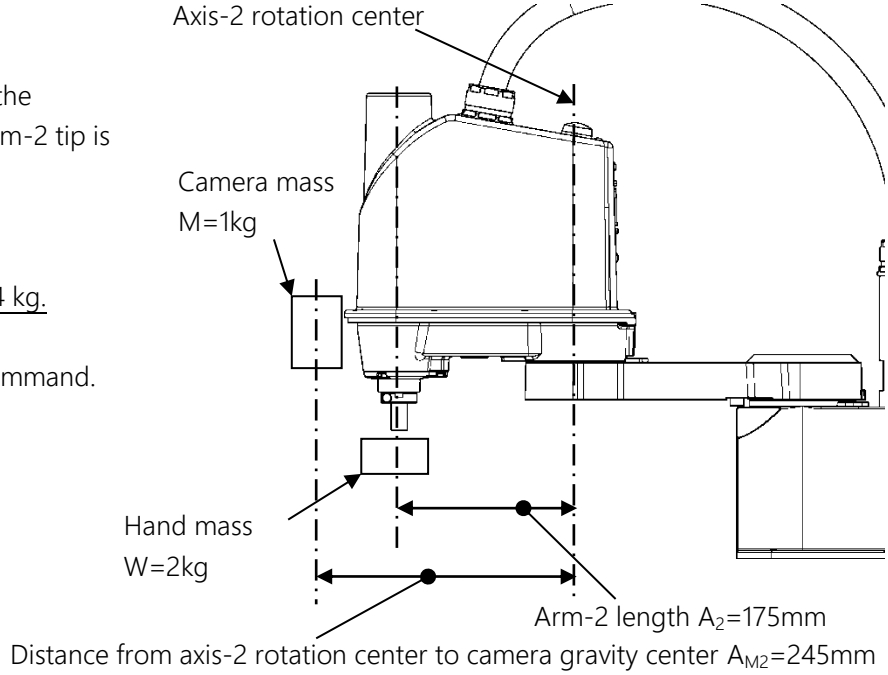


Fig. 4.6 Mounting on the tip from axis-3 center

Example) With solenoid valve of 1 kg mounted in the middle of Arm-2 and hand of 2 kg in the tip of shaft

Equivalent weight W_M of the solenoid valve mounted between axis-1 rotation center and the axis-3 rotation center is

$W_M=1\times300^2/(175+225)^2=0.5625$

Thus, the total load mass

$W+W_M=2+0.5625=2.5625$

is rounded up to become 2.6 kg.

Set "2.6" in the PAYLOAD command.

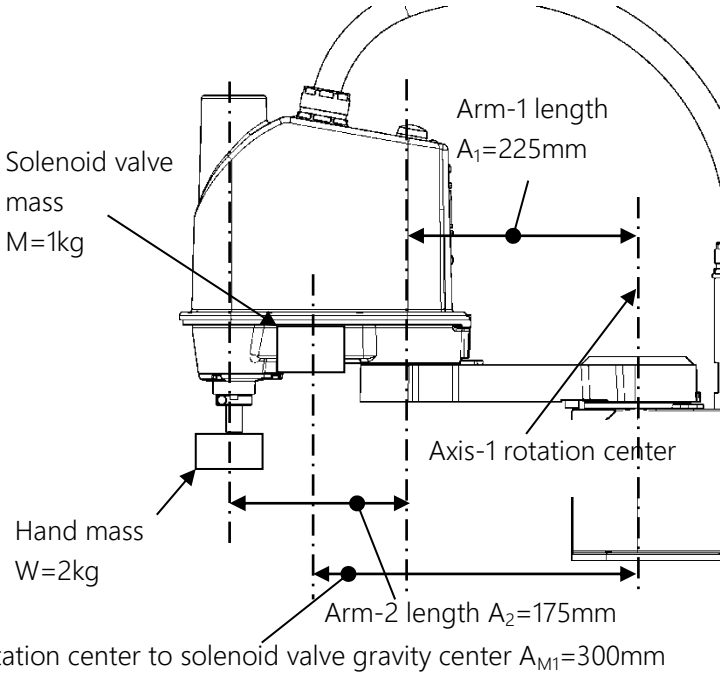
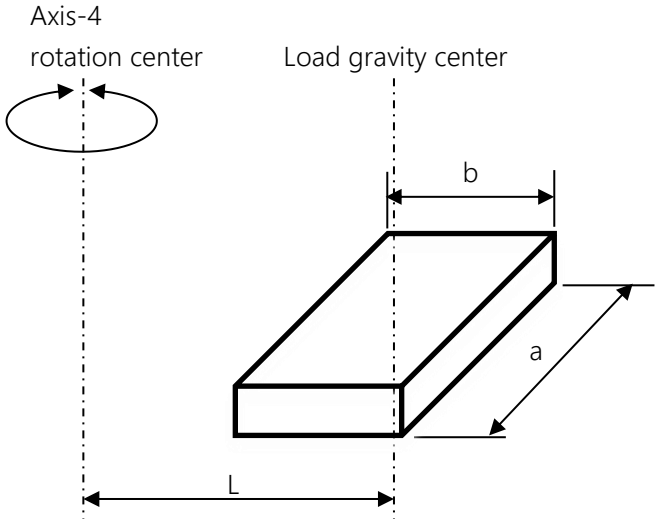


Fig. 4.7 Mounting between axis-1 rotation center and axis-3 center

Calculating moment of inertia

The simplified model of the robot and load is used to show an example of equation of load moment of inertia below.

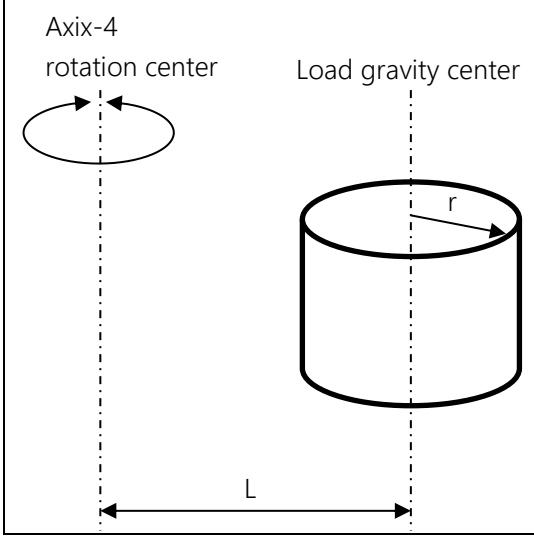
1) If the load shape is rectangular



L: Distance from axis-4 center to load gravity center (m)
a: Load width (m)
b: Load length (m)
M: Load mass (kg)
J: Moment of inertia(kg·m^2)

$J=\{M(a^2+b^2)/12\}+ML^2$

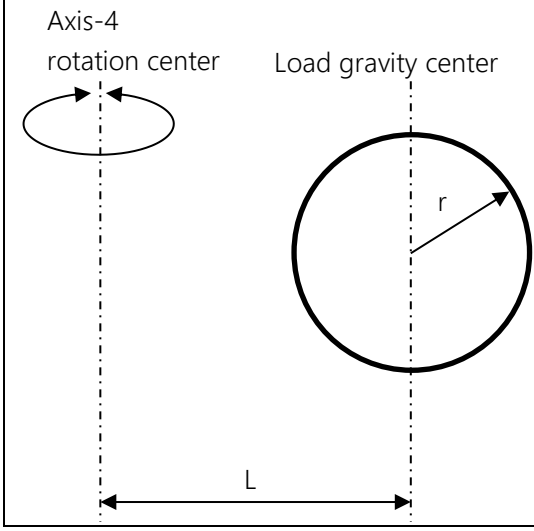
2) If the load shape is columnar



L: Distance from axis-4 center to load gravity center (m)
r: Load radius (m)
M: Load mass (kg)
J: Moment of inertia (kg·m^2)

$J=Mr^2/2+ML^2$

3) If the load shape is spherical



L: Distance from axis-4 center to load gravity center (m)
r: Load radius (m)
M: Load mass (kg)
J: Moment of inertia (kg·m^2)

$J=2Mr^2/5+ML^2$

Example of calculating moment of inertia

Fig. 4.8 and Fig. 4.9 show examples of calculating the moment of inertia.

The moment of inertia of the entire load can be obtained by total moment of inertia of individual parts.

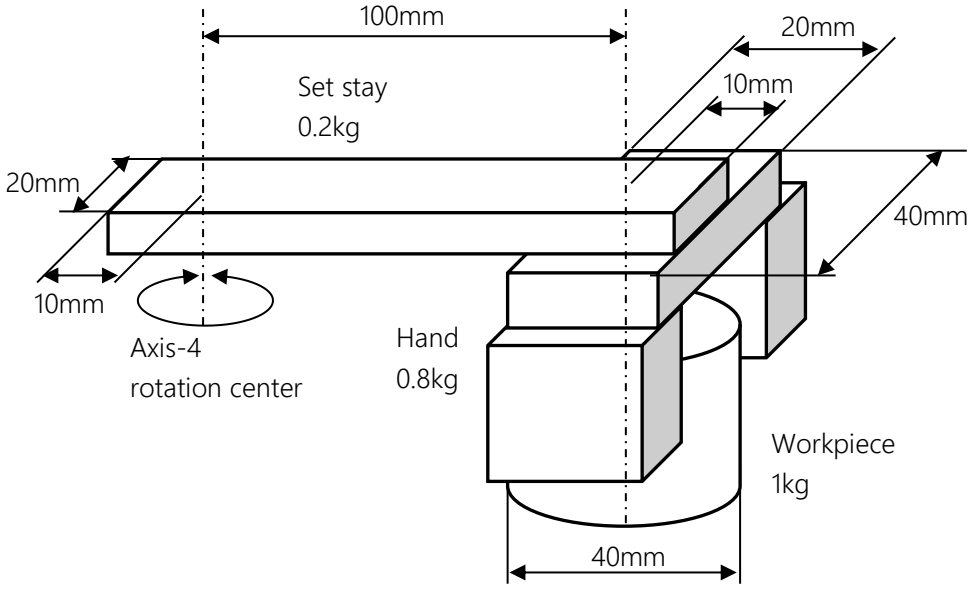
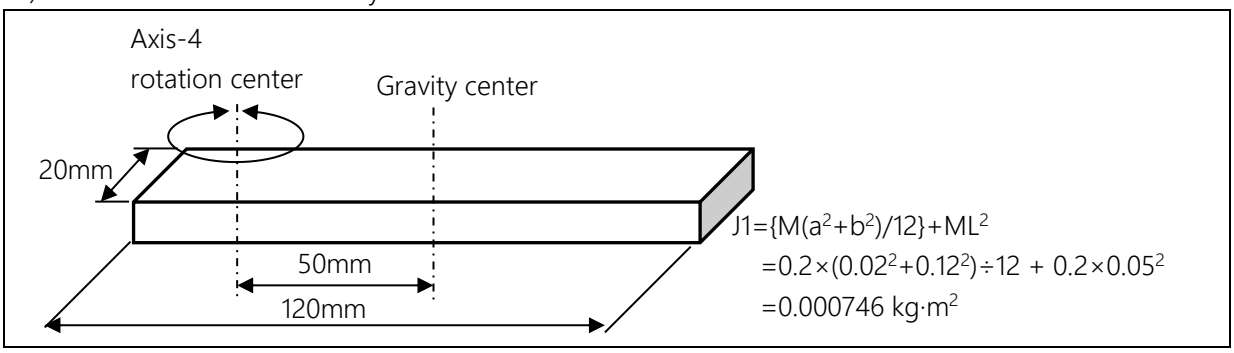
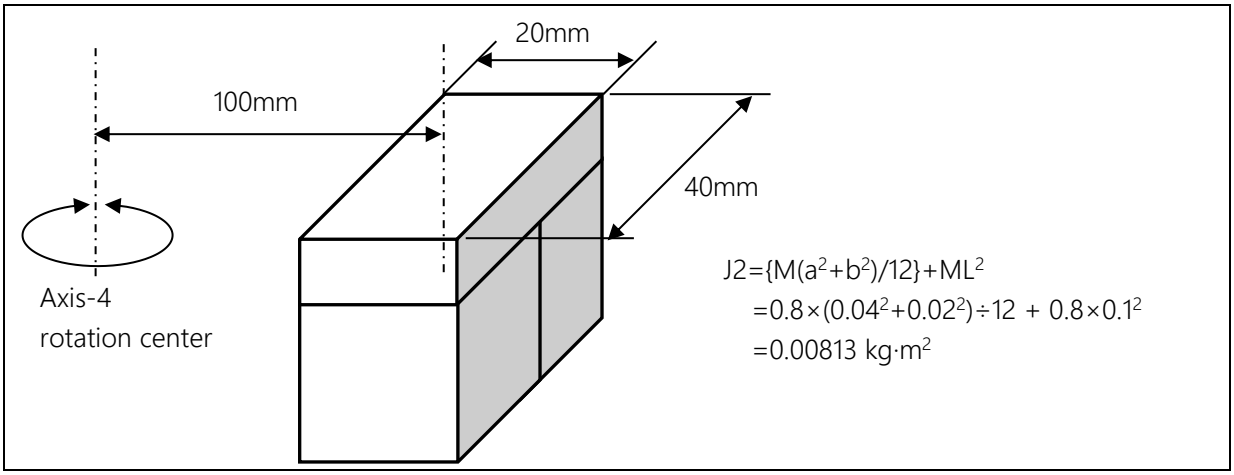


Fig. 4.8 Example of calculating the moment of inertia 1

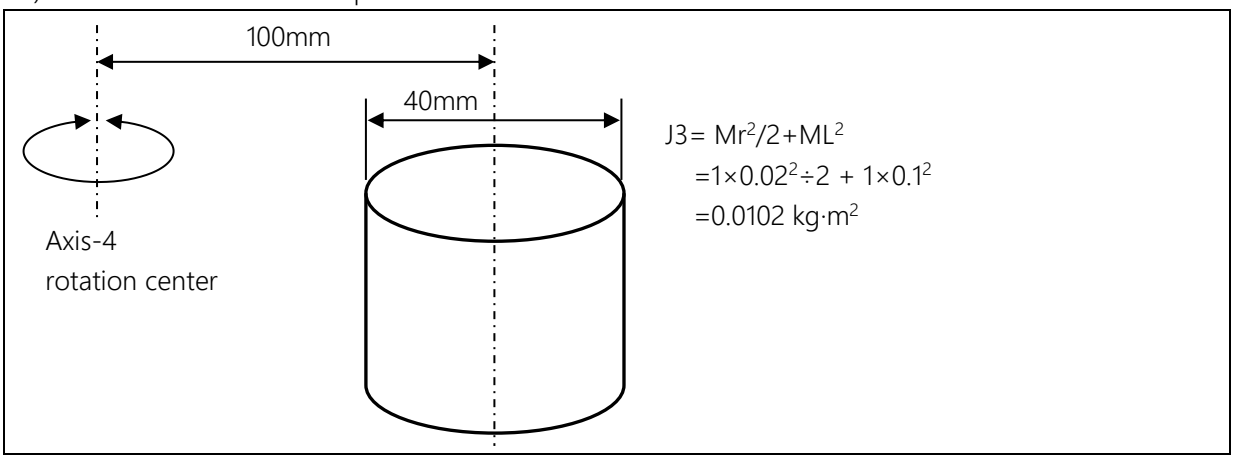
1) Moment of inertia of set stay



2) Moment of inertia of hand



3) Moment of inertia of workpiece



The entire moment of inertia is the sum of J1+J2+J3 to result in 0.019076 kg·m².

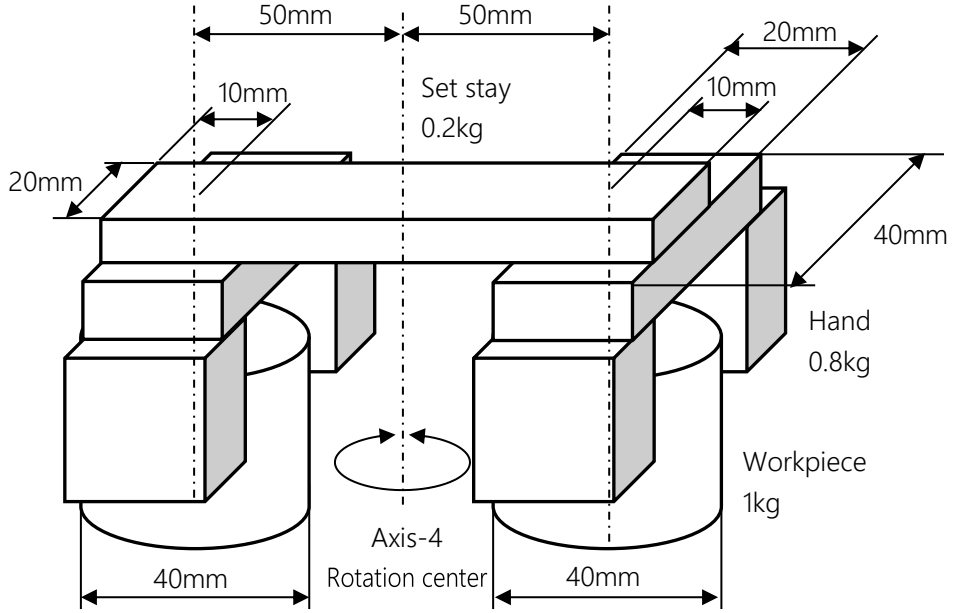
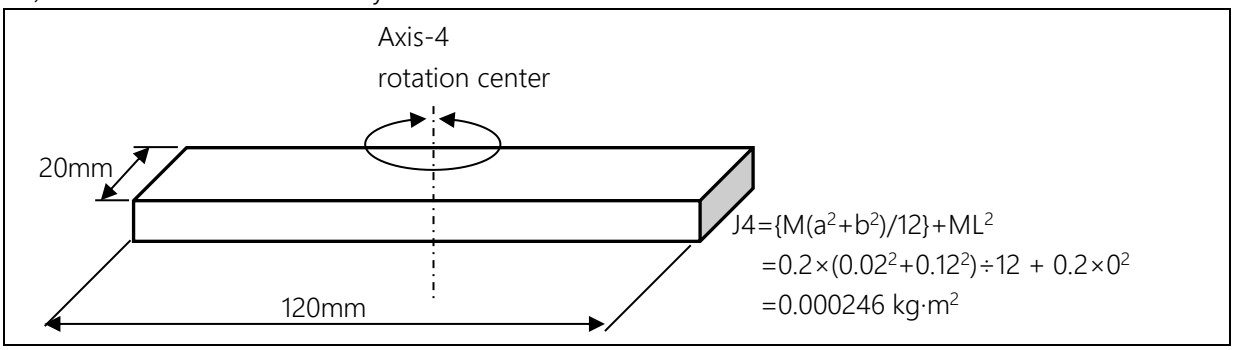
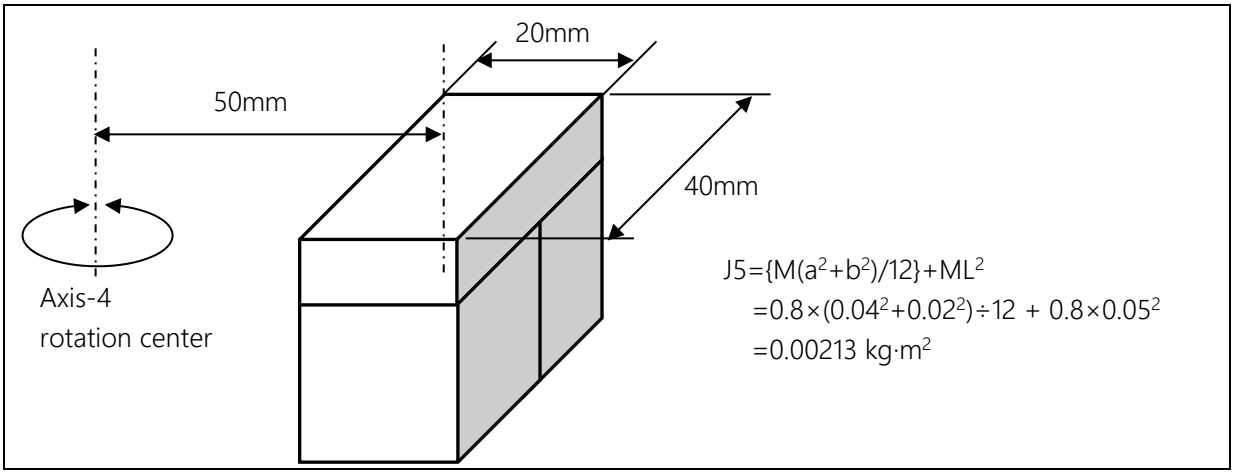


Fig. 4.9 Example of calculating the moment of inertia 2

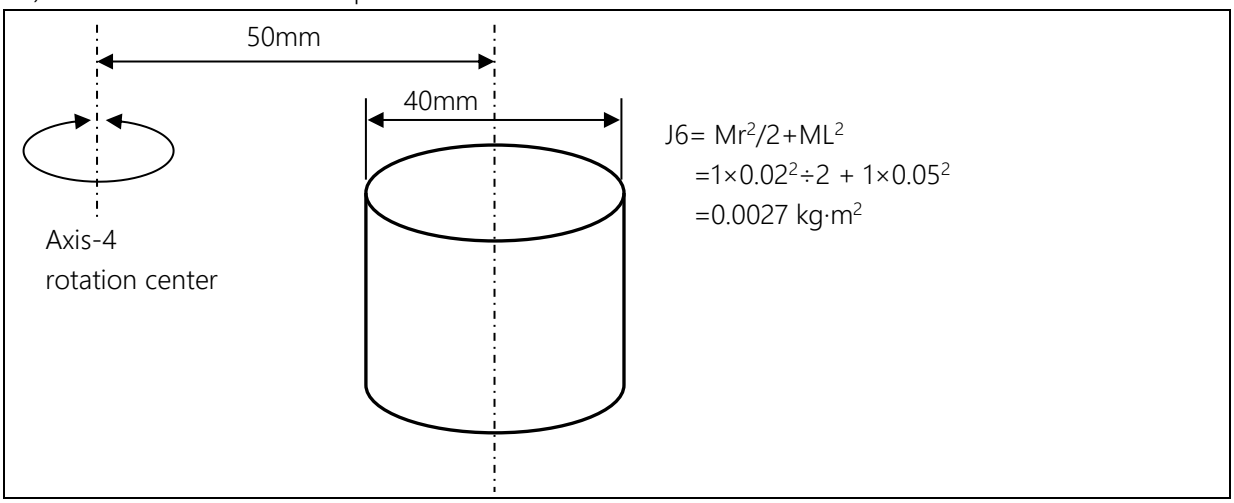
4) Moment of inertia of set stay



5) Moment of inertia of hand



6) Moment of inertia of workpiece



The entire moment of inertia is the sum of J4+J5×2+J6×2 to result in 0.009906 kg·m².

To obtain virtual gravity center offset L from the moment of inertia, see "Setting of PAYLOAD command"

In example of calculating the moment of inertia 2, the gravity center is at the axis-4 rotation center. When the virtual gravity center is obtained from the moment of inertia, the result is as follows.

$L=\sqrt{(J\times10^6 / M)}$

$=\sqrt{(0.009906\times10^6/3.8)}$

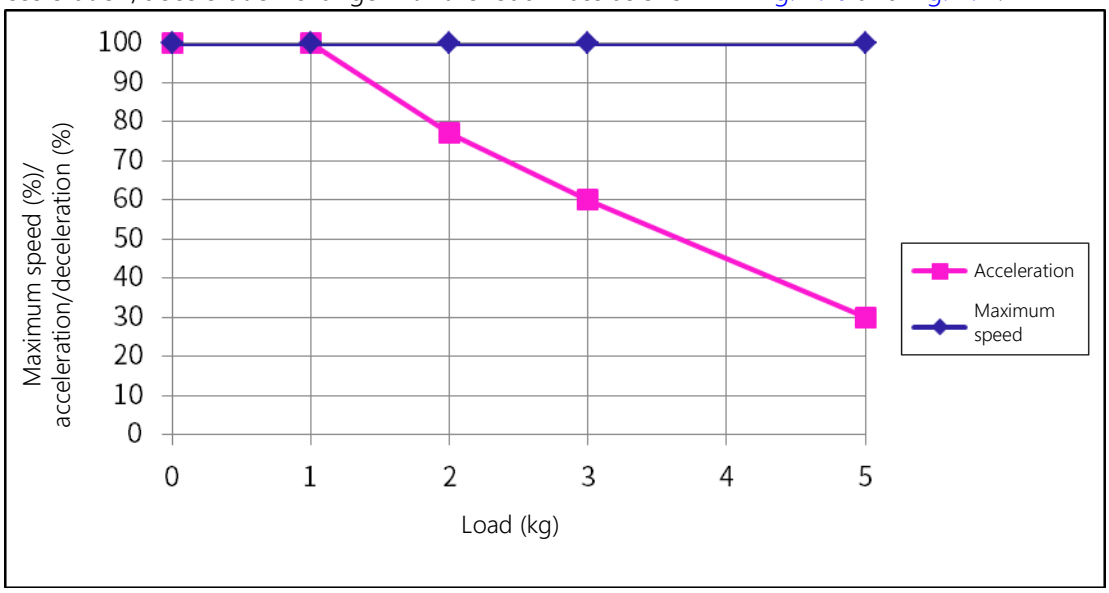
=51.057 (unit: mm)

The virtual gravity center offset is rounded up to become "51.1mm."

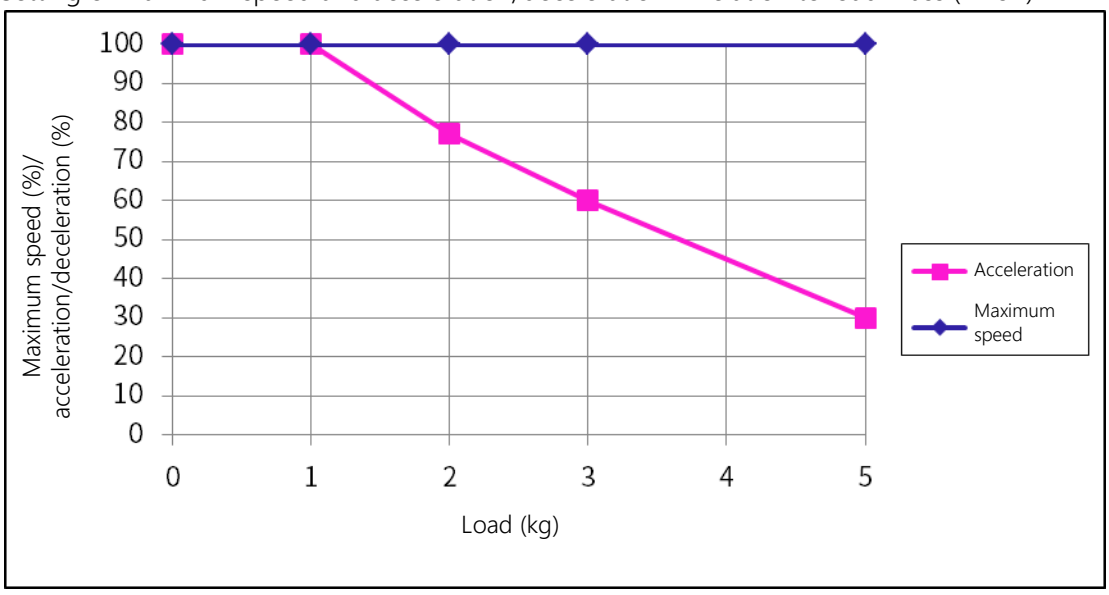
The PAYLOAD command to be set becomes PAYLOAD={3.8 , 51.1}.

4.4.3 Setting maximum speed and robot acceleration/deceleration for load conditions

When the PAYLOAD command is used, the maximum speed and acceleration/deceleration of the robot are automatically changed according to the load conditions. The maximum speed and acceleration/deceleration change with the load mass as shown in Fig. 4.10 and Fig. 4.11.

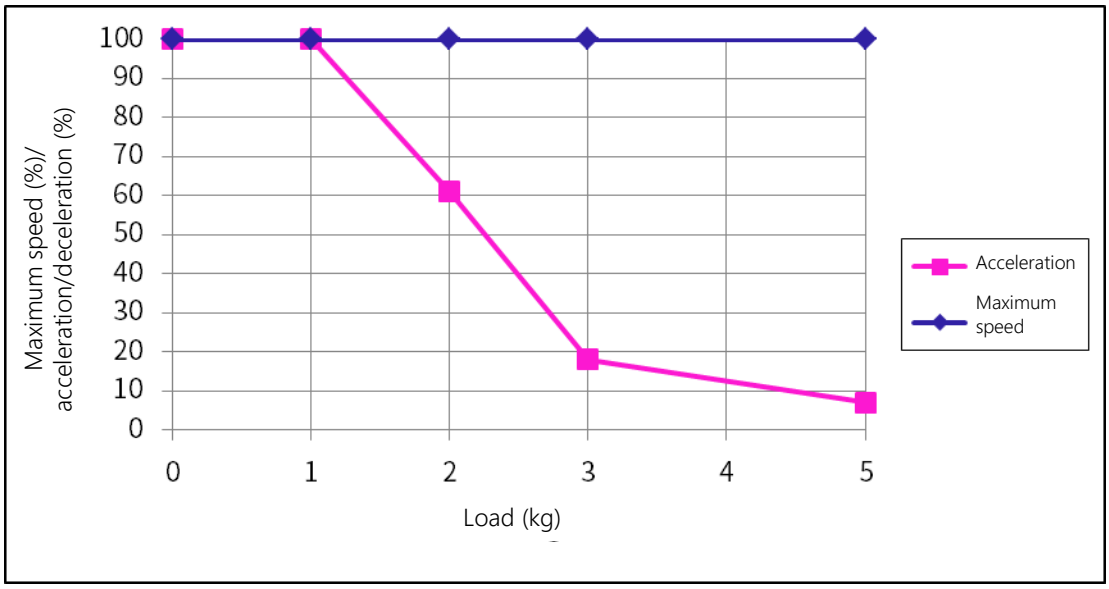


Setting of maximum speed and acceleration/deceleration in relation to load mass (Axis 1)

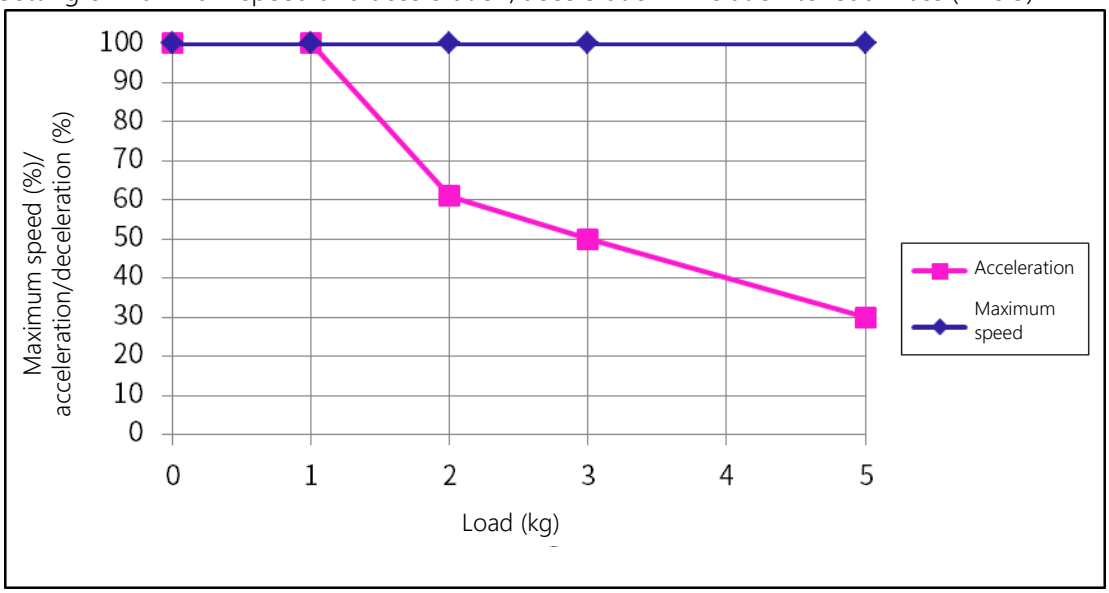


Setting of maximum speed and acceleration/deceleration in relation to load mass (Axis 2)

Fig. 4.10 Setting of maximum speed and acceleration/deceleration in relation to load mass (Axes 1 and 2)



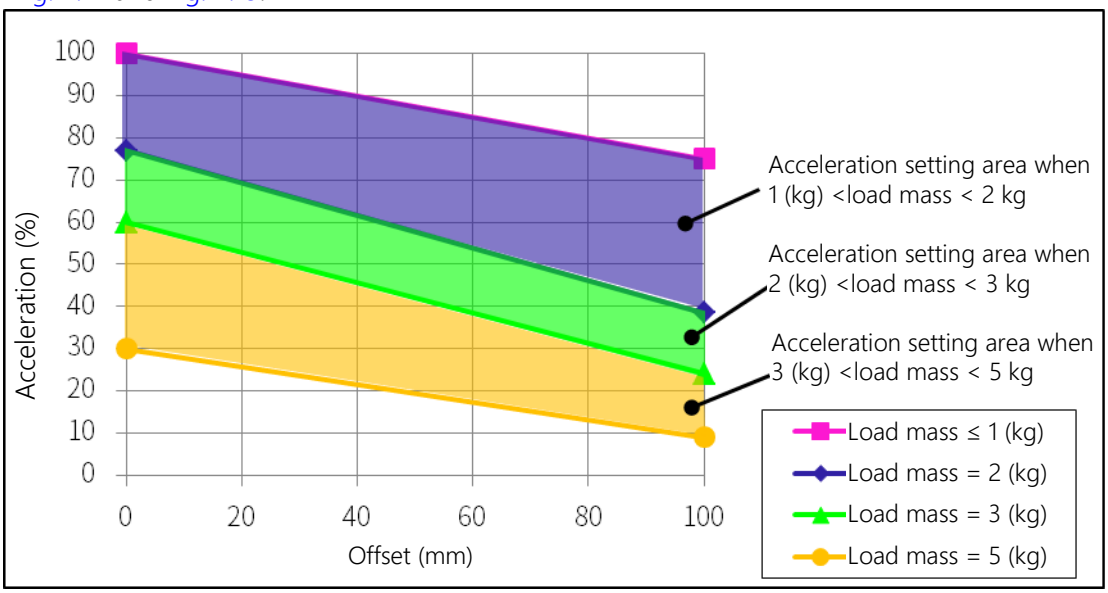
Setting of maximum speed and acceleration/deceleration in relation to load mass (Axis 3)



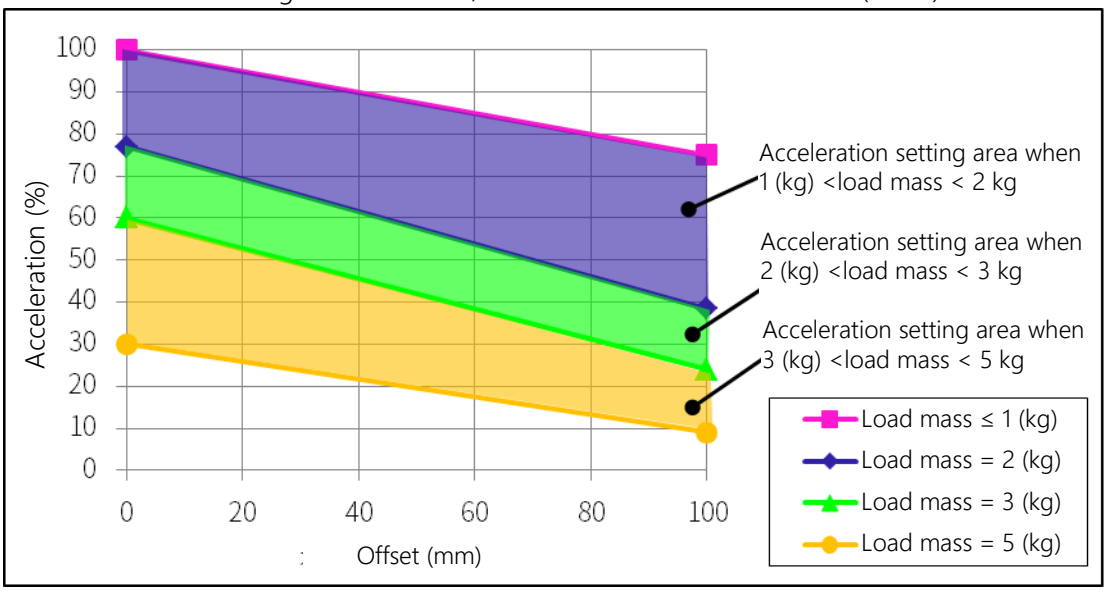
Setting of maximum speed and acceleration/deceleration in relation to load mass (Axis 4)

Fig. 4.11 Setting of maximum speed and acceleration/deceleration in relation to load mass (Axes 3 and 4)

Additionally, if there is an offset of load gravity center, the acceleration/deceleration change as shown in Fig. 4.12 and Fig. 4.13.

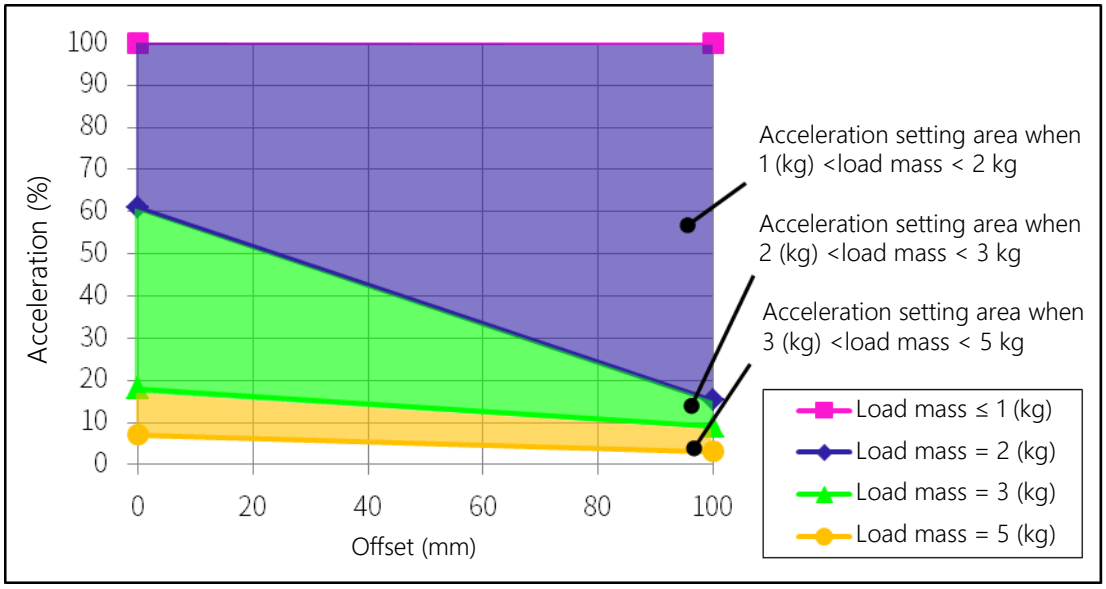


Setting of acceleration/deceleration in relation of offset (Axis 1)

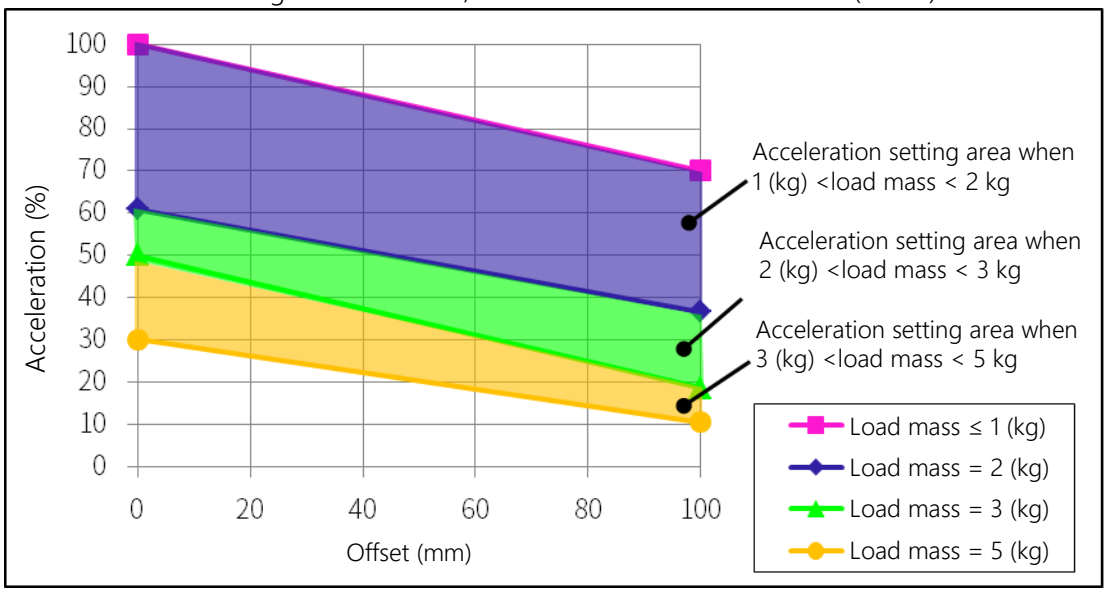


Setting of acceleration/deceleration in relation to offset (Axis 2)

Fig. 4.12 Setting of acceleration/deceleration in relation to gravity center offset (Axes 1 and 2)



Setting of acceleration/deceleration in relation to offset (Axis 3)



Setting of acceleration/deceleration in relation to offset (Axis 4)

Fig. 4.13 Setting of acceleration/deceleration in relation to gravity center offset (Axes 3 and 4)

5. User Wiring

The work should receive safety training defined by each country's laws and regulations.
Be aware that the failure and accident resulting from the work done by the customer will not be under our warranty.

5.1 Hand wiring

Hand wiring is controlled from the controller or from separately placed PLC (prepared by the customer).

5.1.1 Wiring controlled from the controller

Eight input signals for components such as sensors, eight control signals for components such as solenoid valves, 24 VDC/PGND are provided as hand wiring and connected to the controller. Fig. 5.6 to Fig. 5.9 are the wiring diagrams. The wiring is connected to the connector on the arm-2 rear.
Prepare the attached connector and connect the cable.
D-SUB connector (standard) type: <Shell> XM2S-2511 (manufacturer: OMRON)
<Connector> XM3A-2521 (manufacturer: OMRON)
Applicable cross sectional area of wire conductor AWG 22 to 28 (single wire and twisted wire)
The connector and wires are connected by soldering.
The signal line from the controller passes inside the robot and is wired to hand wiring connector "CN0."
Connect the manufactured cable connector to "CN0."

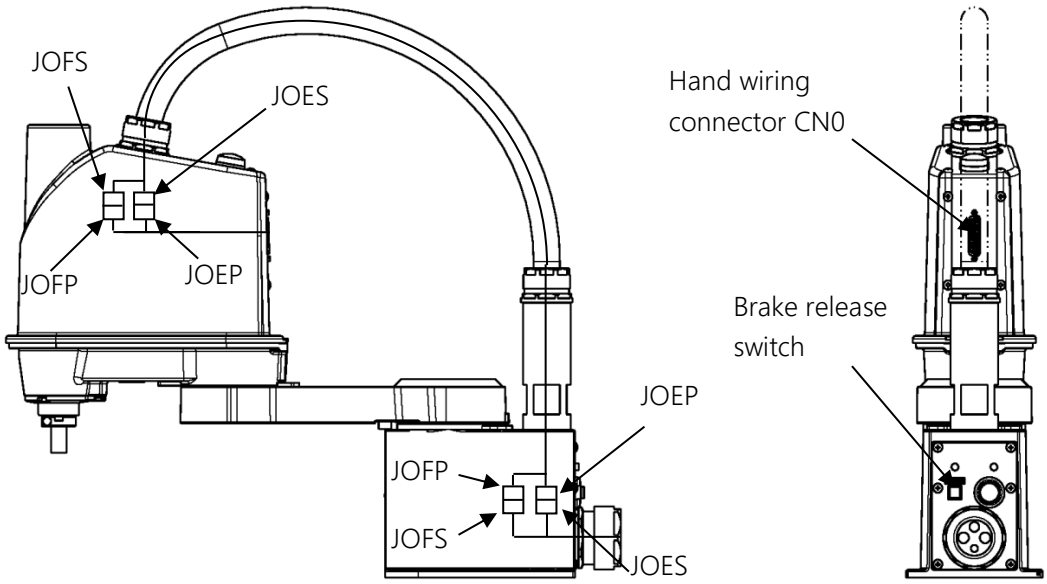
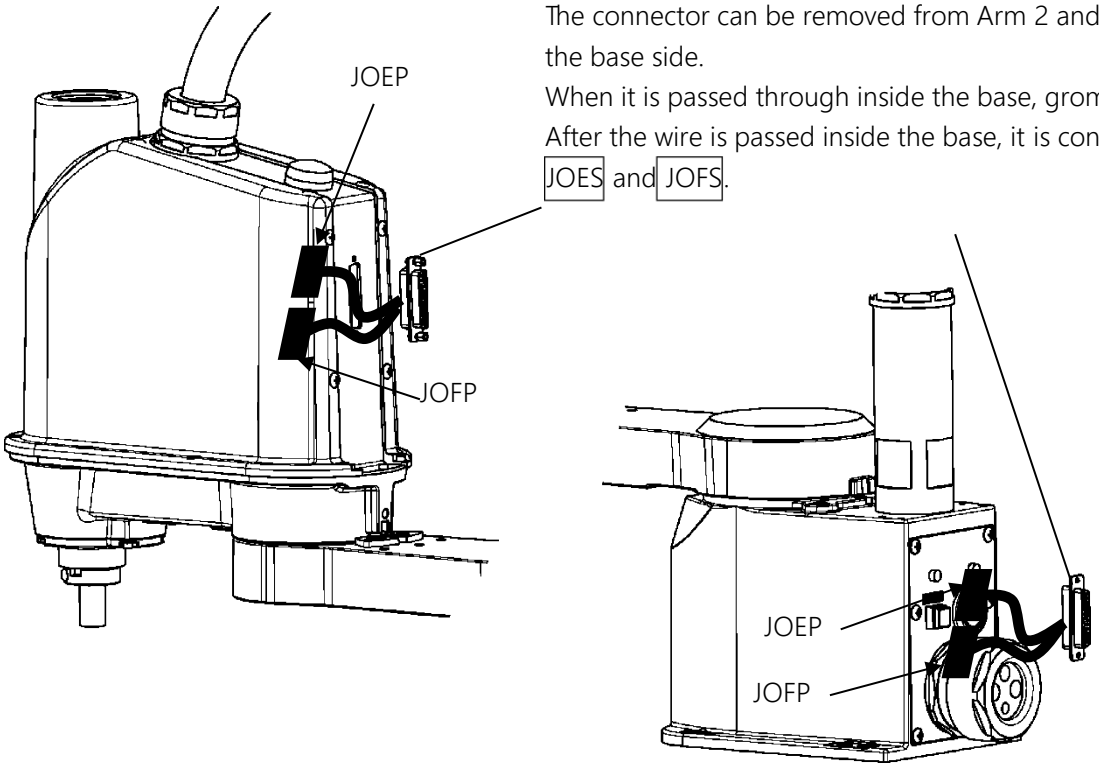


Fig. 5.1 Hand wiring

The CN0 connector is normally placed on the arm-2 rear shown in Fig. 5.1. However, it can be moved to the base. Fig. 5.2 shows how to move the connector.



The connector can be removed from Arm 2 and connected to the base side.
When it is passed through inside the base, grommet is used.
After the wire is passed inside the base, it is connected with JOES and JOFS.

Fig. 5.2 Moving CN0 connector

5.1.2 Wiring controlled from separately placed PLC

If wiring is controlled from separately placed PLC, the base rear cover is removed from the base unit. For how to remove the base rear cover, see "7.3.2 Base Cover."
After the base rear cover is removed, rear side connectors JOES and JOFS are disconnected, passed through spare grommet of the base rear cover, and connected to the cable from PLC.
From JOES and JOFS on, prepare the following plug connectors and connect the cable.

Connector type:	JOES	SMP-10V-BC (J.S.T. MFG. (JST))
	JOFS	SMP-11V-BC (J.S.T. MFG. (JST))
Contact type:		BHF-001T-0.8SS (J.S.T. MFG. (JST))
Applicable wire:		Cross sectional area of conduct AWG 22 to 28

Mating connector type

Connector type	JOEP	SMR-10V-B (J.S.T. MFG. (JST))
	JOFP	SMR-11V-B (J.S.T. MFG. (JST))
Contact type		BYM-001T-0.6 (J.S.T. MFG. (JST))

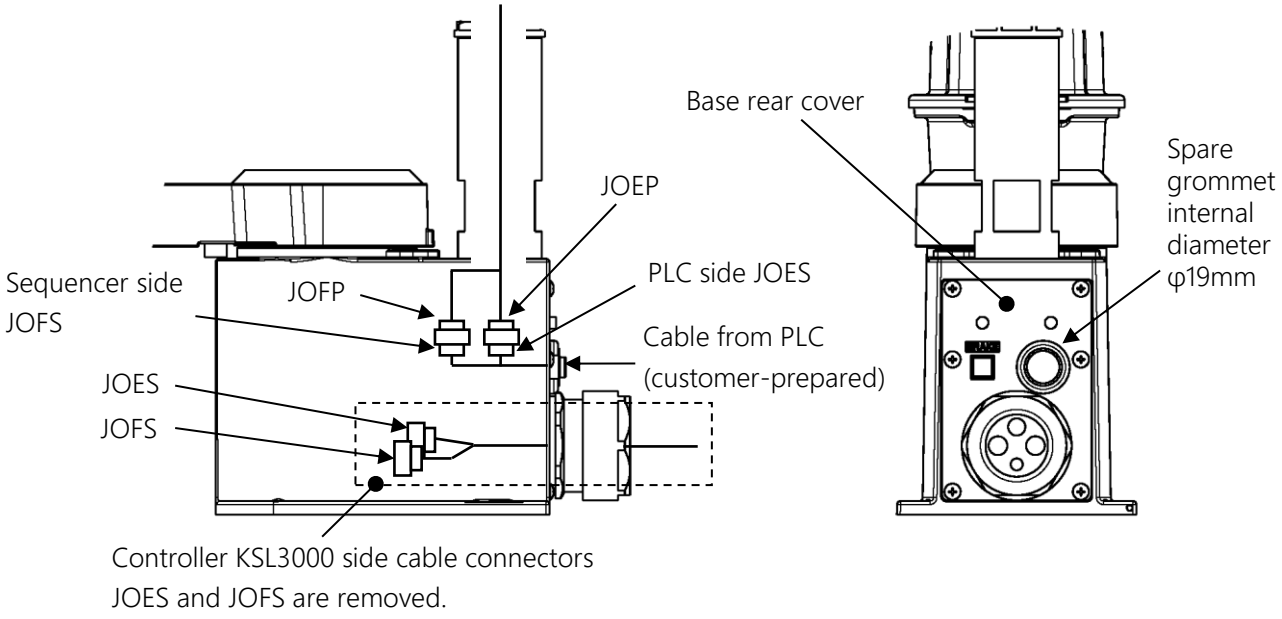


Fig. 5.3 Wiring to PLC

5.1.3 Specifications of hand connector CN0

Table 5.1 Input/output signal connector CN0 (KSL3000, Type-N)

Pin	Signal name		Signal No.	Input/output circuit and example of connections
1	D-IN1	Input signal 1	201	
2	D-IN2	Input signal 2	202	
3	D-IN3	Input signal 3	203	
4	D-IN4	Input signal 4	204	
5	D-IN5	Input signal 5	205	
6	D-IN6	Input signal 6	206	
7	D-IN7	Input signal 7	207	
8	D-IN8	Input signal 8	208	
9	24 VDC GND			
10	Shield (FG)			
11	D-OUT1	Output signal 1	201	
12	D-OUT2	Output signal 2	202	
13	D-OUT3	Output signal 3	203	
14	D-OUT4	Output signal 4	204	
15	D-OUT5	Output signal 5	205	
16	D-OUT6	Output signal 6	206	
17	D-OUT7	Output signal 7	207	
18	D-OUT8	Output signal 8	208	
19	24 VDC			

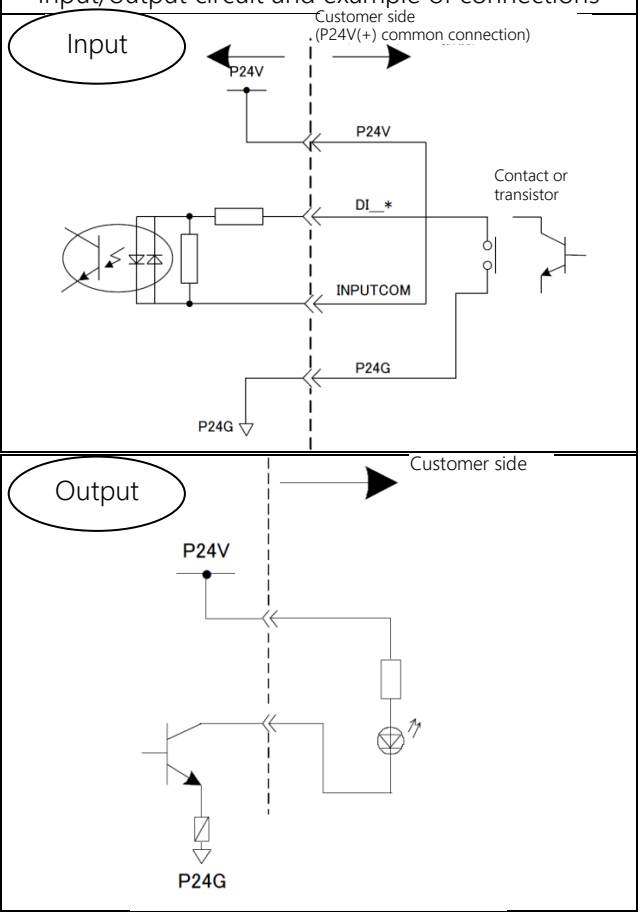
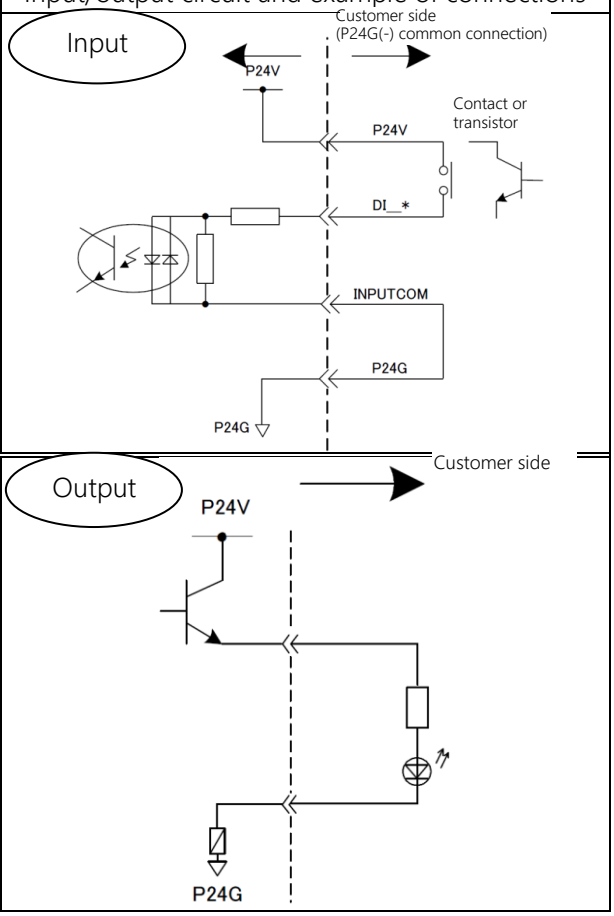


Table 5.2 Input/output signal connector CN0 (KSL3000, Type-P)

Pin	Signal name		Signal No.	Input/output circuit and example of connections
1	D-IN1	Input signal 1	201	
2	D-IN2	Input signal 2	202	
3	D-IN3	Input signal 3	203	
4	D-IN4	Input signal 4	204	
5	D-IN5	Input signal 5	205	
6	D-IN6	Input signal 6	206	
7	D-IN7	Input signal 7	207	
8	D-IN8	Input signal 8	208	
9	24 VDC			
10	Shield (FG)			
11	D-OUT1	Output signal 1	201	
12	D-OUT2	Output signal 2	202	
13	D-OUT3	Output signal 3	203	
14	D-OUT4	Output signal 4	204	
15	D-OUT5	Output signal 5	205	
16	D-OUT6	Output signal 6	206	
17	D-OUT7	Output signal 7	207	
18	D-OUT8	Output signal 8	208	
19	24 VDC GND			



Input signal

As input signals, no-voltage contacts or transistor open collector inputs are used.

No-voltage contact specifications:

Contact rating:	24 VDC, 10 mA or over (circuit current: approx. 7 mA)
Minimum contact current:	24 VDC, 1 mA
Contact impedance:	100 Ω or less

Transistor specifications:

Withhold voltage between collector and emitter:	30 V or over
Current between collector and emitter:	10 mA or over (circuit current: approx. 7 mA)
Leak current between collector and emitter:	100 μA or less

Output signal

By using the P24V of the controller, a relay, solenoid valve, etc. can be driven.

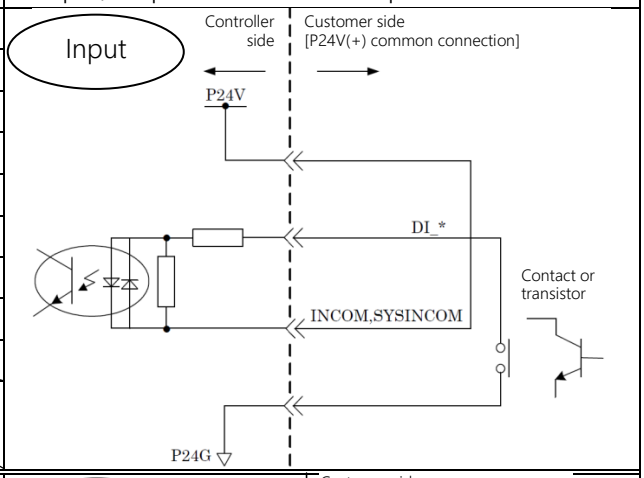
To use external power supply, connect GND of the external power supply with the GND (P24G) of the robot controller (GND common connection).

Transistor specifications: Rated voltage: 24 VDC (MAX 30 V)
Rated current: 100 mA

- Limit P24V supplied from the robot controller to within 3 A in total.
- To use external power supply, limit the total current value to within 3 A as well
- To connect a relay, solenoid valve, etc., use a surge killer or diode to absorb the surge voltage.

Table 5.3 Input/output signal connector CN0 (KSL3000E, Type-N)

Pin	Signal name		Signal No.	Input/output circuit and example of connections
1	D-IN1	Input signal 1	201	
2	D-IN2	Input signal 2	202	
3	D-IN3	Input signal 3	203	
4	D-IN4	Input signal 4	204	
5	D-IN5	Input signal 5	205	
6	D-IN6	Input signal 6	206	
7	D-IN7	Input signal 7	207	
8	D-IN8	Input signal 8	208	
9	24 VDC GND			
10	Shield (FG)			
11	D-OUT1	Output signal 1	201	
12	D-OUT2	Output signal 2	202	
13	D-OUT3	Output signal 3	203	
14	D-OUT4	Output signal 4	204	
15	D-OUT5	Output signal 5	205	
16	D-OUT6	Output signal 6	206	
17	D-OUT7	Output signal 7	207	
18	D-OUT8	Output signal 8	208	
19	24 VDC			



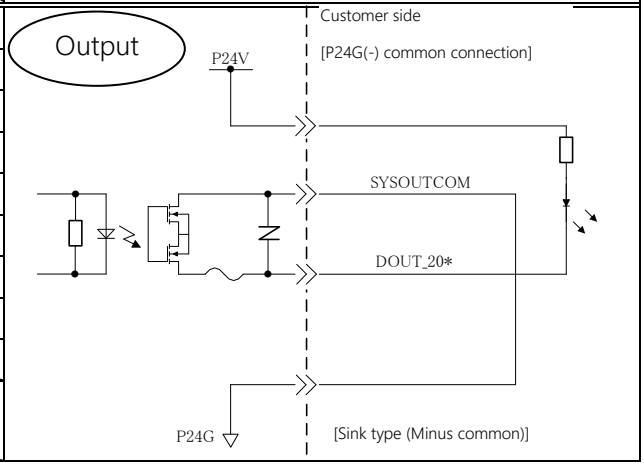
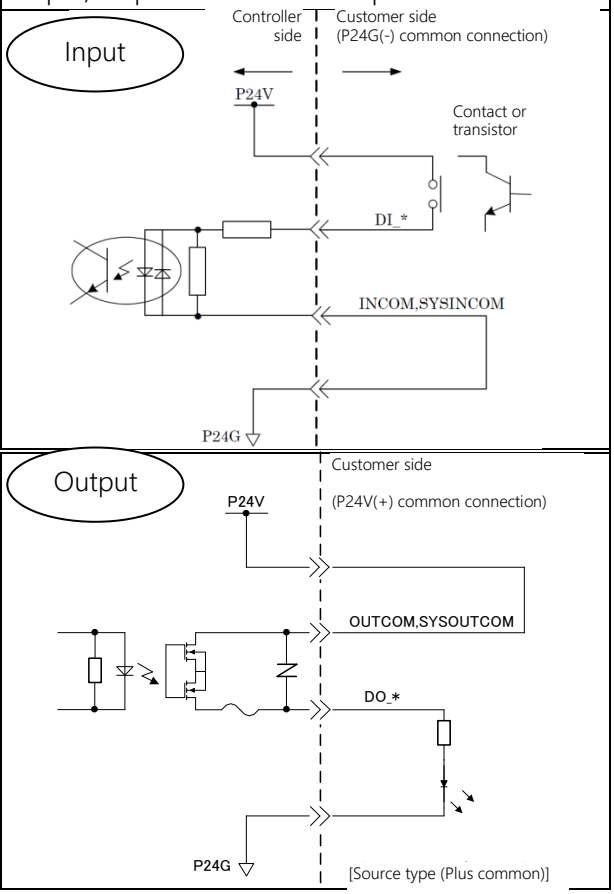


Table 5.4 Input/output signal connector CN0 (KSL3000E, Type-P)

Pin	Signal name		Signal No.	Input/output circuit and example of connections
1	D-IN1	Input signal 1	201	
2	D-IN2	Input signal 2	202	
3	D-IN3	Input signal 3	203	
4	D-IN4	Input signal 4	204	
5	D-IN5	Input signal 5	205	
6	D-IN6	Input signal 6	206	
7	D-IN7	Input signal 7	207	
8	D-IN8	Input signal 8	208	
9	24 VDC			
10	Shield (FG)			
11	D-OUT1	Output signal 1	201	
12	D-OUT2	Output signal 2	202	
13	D-OUT3	Output signal 3	203	
14	D-OUT4	Output signal 4	204	
15	D-OUT5	Output signal 5	205	
16	D-OUT6	Output signal 6	206	
17	D-OUT7	Output signal 7	207	
18	D-OUT8	Output signal 8	208	
19	24 VDC GND			



Input signal

As input signals, no-voltage contacts or transistor open collector inputs are used.

No-voltage contact specifications:

Contact rating:	24 VDC, 10 mA or over (circuit current: approx. 7 mA)
Minimum contact current:	24 VDC, 1 mA
Contact impedance:	100 Ω or less

Transistor specifications:

Withhold voltage between collector and emitter:	30 V or over
Current between collector and emitter:	10 mA or over (circuit current: approx. 7 mA)
Leak current between collector and emitter:	100 μA or less

Output signal

By using P24V of the controller, a relay, solenoid valve, etc. can be driven.

To use the external power supply, connect GND of the external power supply with GND (P24G) of the robot controller (GND common connection).

Photo MOS specifications:

Rated voltage:	24 VDC (MAX 30 V)
Rated current:	50mA (MAX)

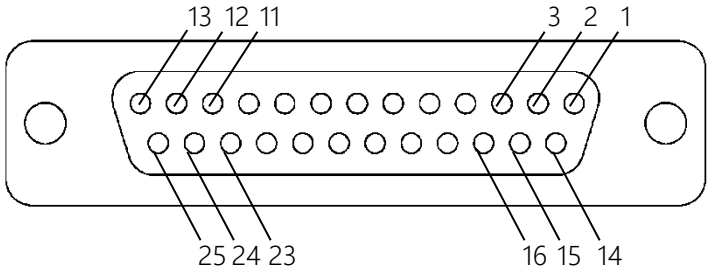


Fig. 5.4 Hand connector pin arrangement

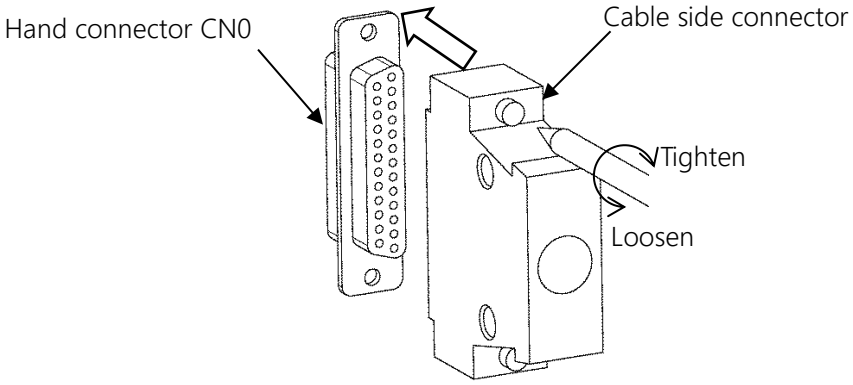


Fig. 5.5 Connecting/disconnecting hand input/output signal connector

⚠ DANGER

- Be sure to use the designated wire. Otherwise, fire or accident may be caused.
- When connecting the connector and wires, make sure not to mistake the terminal arrangement.
- After making the connection, use a tester, etc. to confirm the connection.

⚠ CAUTION

- Supplying a current exceeding the rated output current may damage the output element or burn the substrate. Be sure to limit the current to within the rated output current for use.
  Limit the total current of eight hand output signals to within 0.8 A.
- Connect the connectors securely. Otherwise, malfunction can be caused.

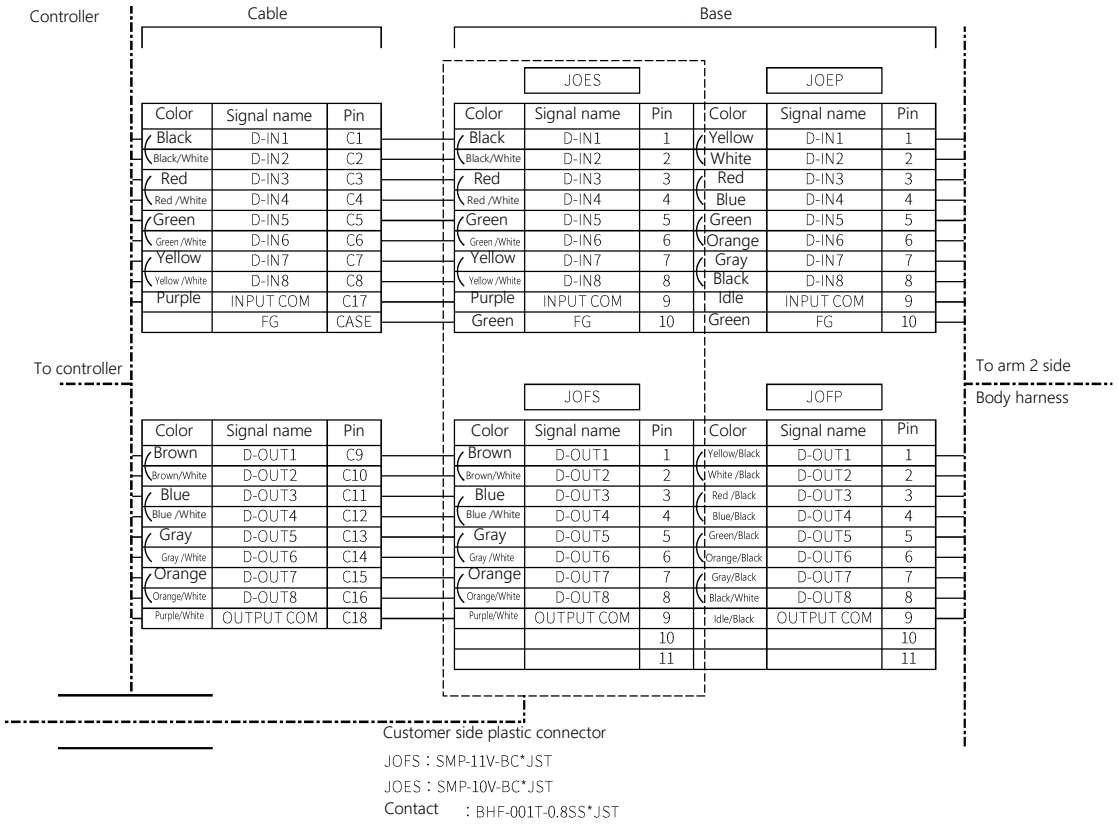


Fig. 5.6 Hand wiring diagram base side (common to Type-N, P KSL3000)

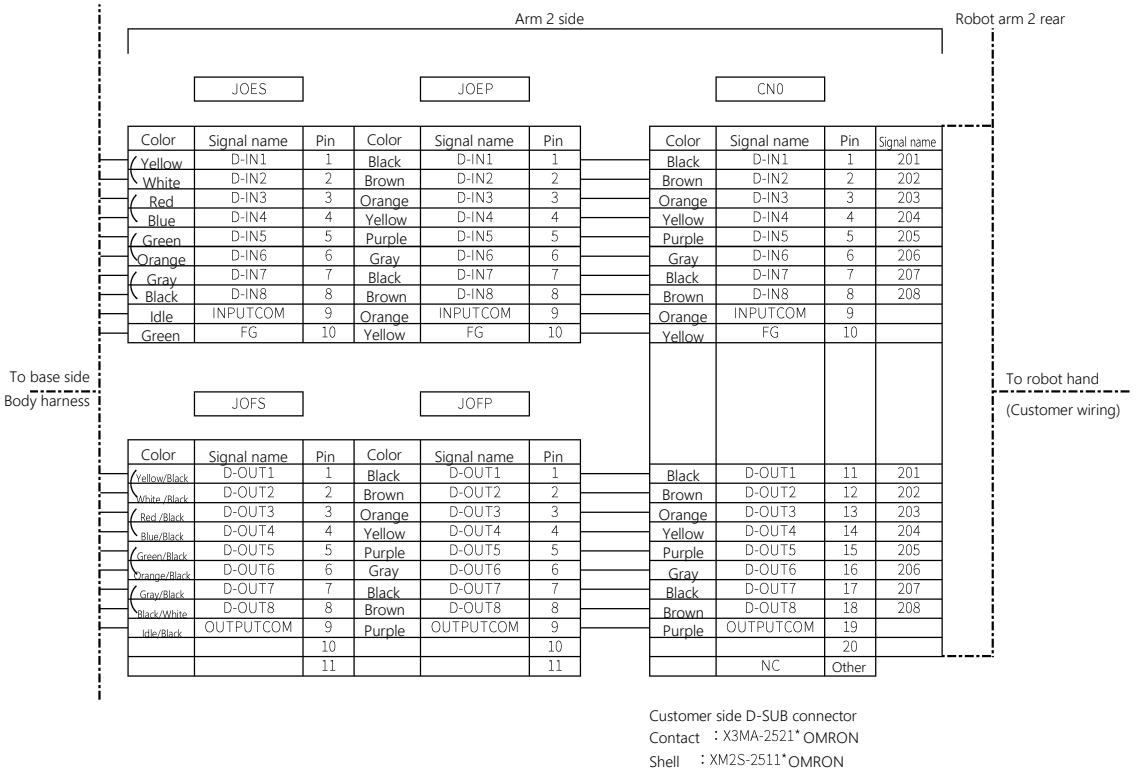


Fig. 5.7 Hand wiring diagram Arm 2 side (common to Type-N, P KSL3000)

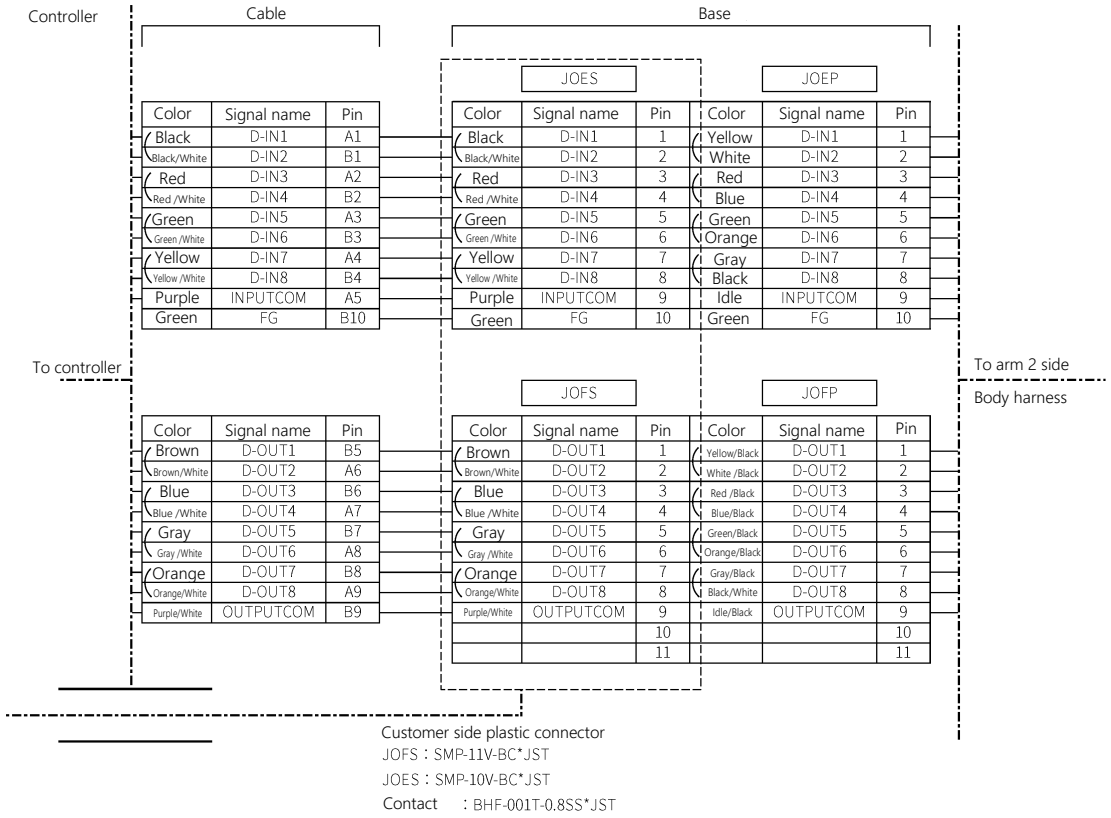


Fig. 5.8 Hand wiring diagram base side (common to Type-N, P KSL3000E)

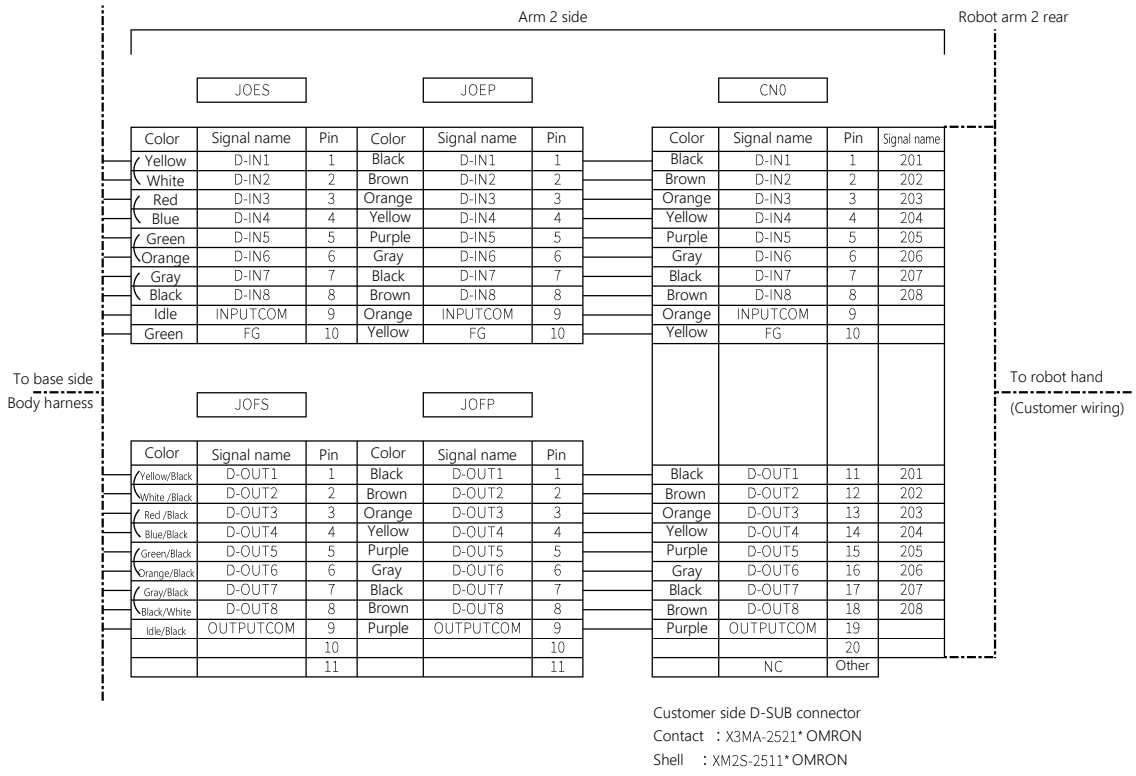


Fig. 5.9 Hand wiring diagram Arm 2 side (common to Type-N, P KSL3000E)

5.1.4 Connection example

Fig. 5.10 shows an example of hand wiring.

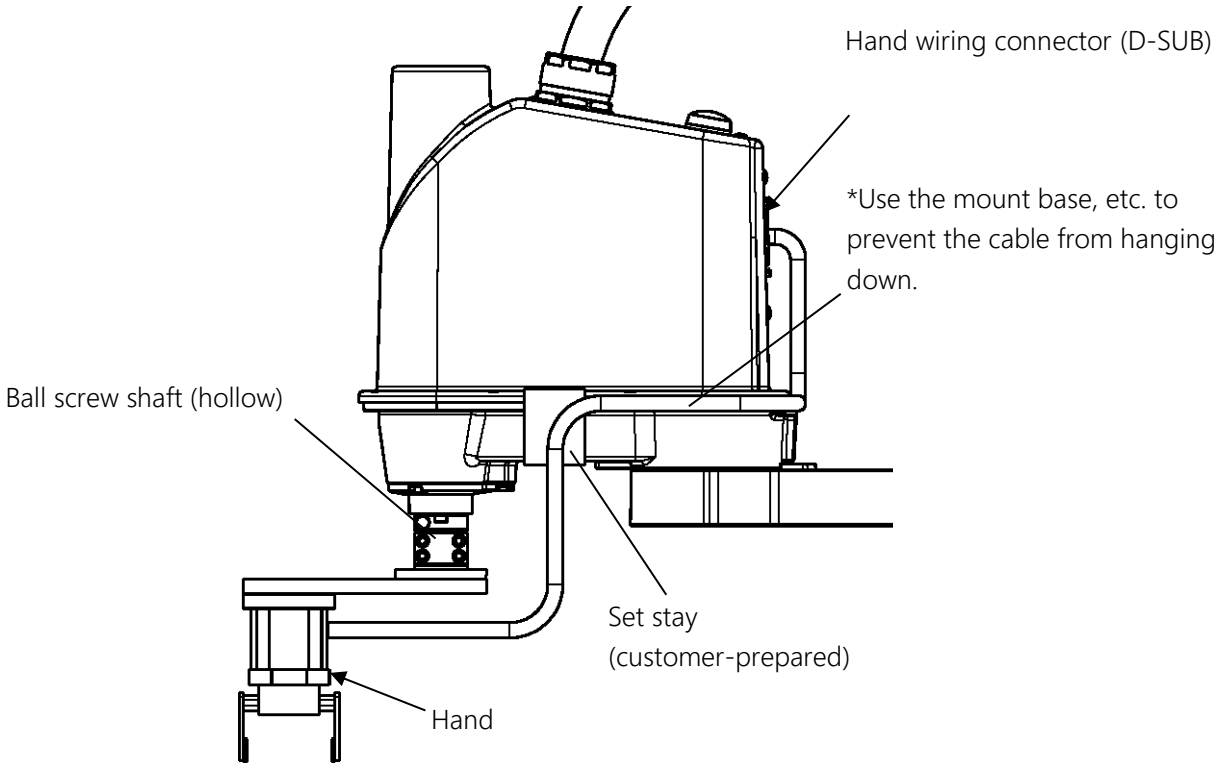


Fig. 5.10 Example of hand cable wiring from arm 2 rear

For the mounting dimensions of the set stay, see Fig. 4.2.

⚠ CAUTION

- Be sure to use a highly flexible robot cable, which should be secured below the arm with a cable clamp, etc. Unless a robot cable is used, the wire may be broken.
- When performing tool wiring and piping, take all necessary measures against breakage due to rub, etc.
- At robot operation, be careful not to exert a load on respective connectors.
- During operation, make sure that the set stay does not interfere with arm 1, etc.

5.2 Hand I/O cable (option) wiring

Fig. 5.11 and Fig. 5.12 show hand I/O cable (option) wiring, Table 5.5 lists the parts used, and Table 5.6 lists Shibaura drawing number of hand I/O cable (option) for reference.

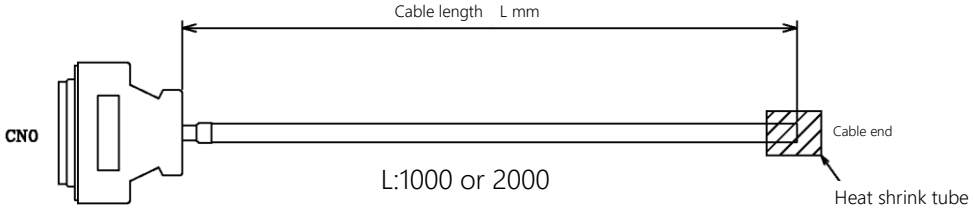


Fig. 5.11 External view drawing of hand I/O cable (option)

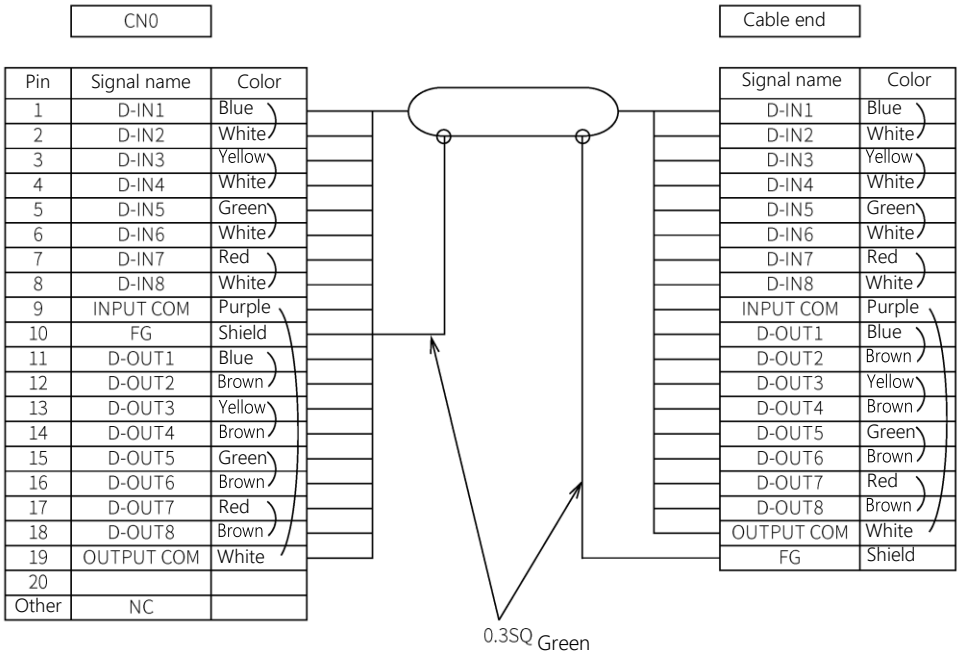


Fig. 5.12 Hand I/O cable (option) wiring diagram

Table 5.5 Hand I/O cable parts used

No.	Product name	Type	Manufacturer	Use qt.
1	Cable	RMFEV-SB 0.2SQ-10P	DYDEN Corp.	1
2	Plug with solder cut terminal	XM3A-2521	OMRON Corp.	1
3	D-Sub connector	XM2S-2511		1

Table 5.6 Hand I/O cable (option)

Product name	Type	Cable length	Shibaura Dwg. No.	Unit code
Hand I/O cable		1m	341N1901	Y610A3PE0
		2m	341N1902	Y610A3PF0

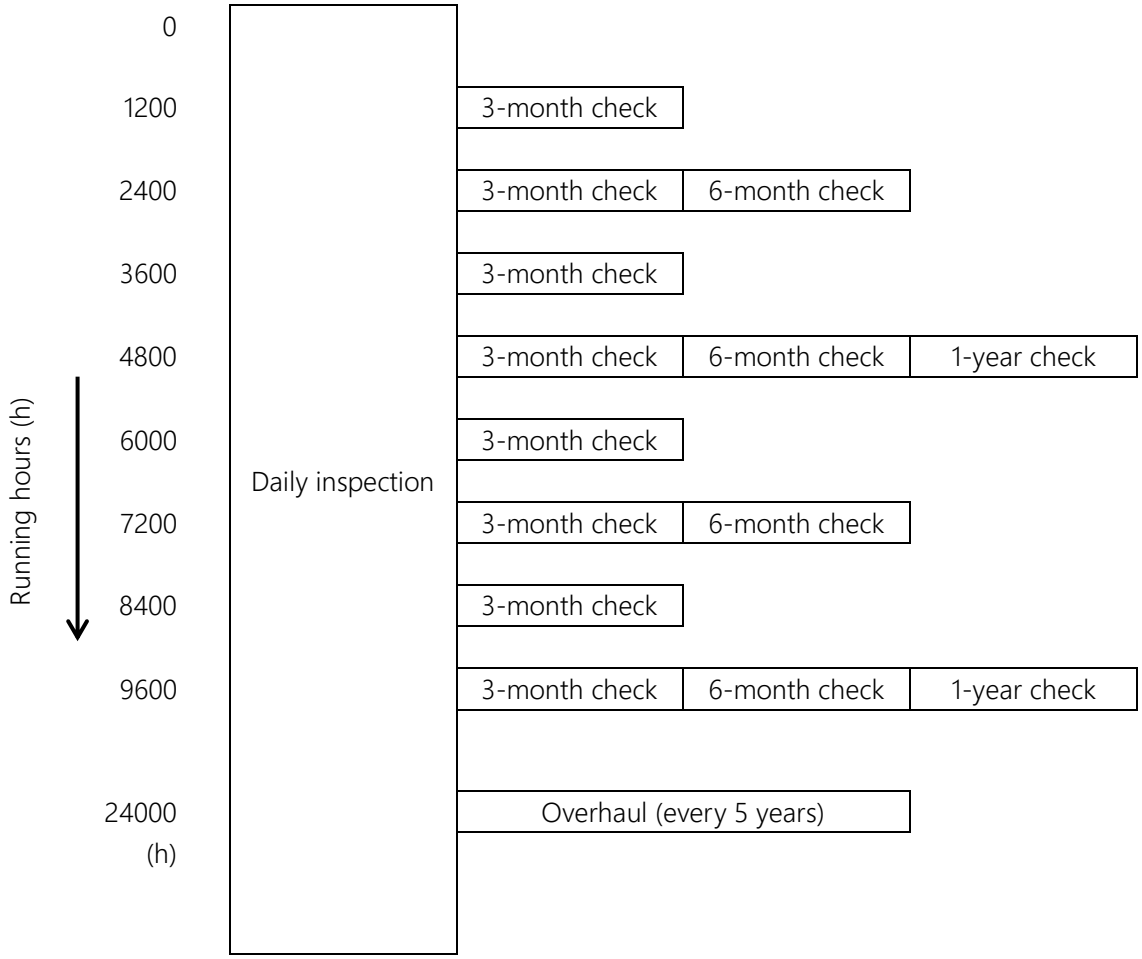
Maintenance Manual

This manual describes how to maintain respective units of the KHE series robot.

6. Maintenance

6.1 Maintenance Schedule

Maintenance comes in two types: daily inspection, and regular inspection and maintenance.
For the regular inspection and maintenance, inspection items are added every 1,200 running hours.



Regular Inspection interval (reference)
When the system is operated for 16 hours per day: 1,200 hours ÷ 16 hours ÷ 25 days = 3 months
When the system is operated for 24 hours per day: 1,200 hours ÷ 24 hours ÷ 25 days = 2 months

When the system is operated for 16 hours per day, regular inspection should be conducted every three months. However, if the running hours per day are increased, regular inspection must be done at shorter intervals.

Fig. 6.1 Maintenance schedule

6.2 Items for Maintenance and Inspection

Maintenance comes in two types: daily inspection, and regular maintenance and inspection that are performed every time a predetermined period elapses.
For the executing procedures, see the relevant paragraphs listed in the table below.

6.2.1 Inspection at Power OFF

Table 6.1 Inspection at Power OFF

D: Daily inspection Q: Quarterly inspection
S: Semi-annual inspection A: Annual inspection

Description	Inspection point	D	Q	S	A	Refer to
Make sure that all bolts are completely tightened and secured. If there are any loosened or unsecured bolts, re-tighten them.	Tool set bolts	○	○	○	○	7.1.1
	Robot installation bolts	○	○	○	○	
	Motor set bolts				○	
Check the cable clamp for tightening.	Upper part of arm 2 and base				○	7.1.4
Make sure that no cut or scratch is found. Clean the contaminant, if any.	Entire robot	○	○	○	○	
	Inside of arm 2			○	○	
State of corrosion inhibitor and application	Ball spline nut and ball screw shaft end	○	○	○	○	7.6.3
Make sure that each timing belt is not worn off or cracked. Check each timing belt for tension.	Inside of arm 2			○	○	7.5.1
Make sure that the cables and air tubing are not worn out.	Cables and air tubing of each unit	○	○	○	○	7.1.3
Check each axis operation. Move each axis by hand for check.	Entire robot			○	○	7.1.5

6.2.2 Inspection at Power ON

Table 6.2 Inspection at Power ON

D: Daily inspection Q: Quarterly inspection
S: Semi-annual inspection A: Annual inspection

Description	Inspection point	D	Q	S	A	Refer to
Check grease state and grease.	Ball screw shaft	○	○	○	○	7.6.3
Push each arm by hand in the servo ON condition to make sure that the arm is secured.	Each joint				○	
Make sure that no abnormal vibration or noise is caused.	Entire robot	○	○	○	○	
Make sure that the teaching points are in place.	Robot tip		○	○	○	
Replace the batteries for position detection with new ones.	Battery box				○	8.3

6.2.3 Overhaul

Table 6.3 Overhaul

Description	Maintenance parts	Every 5 years	Refer to
Check the consumable parts and replace as necessary.	Motors, reduction gears, belts, ball screw, body harness, LED lamp	○	7.3 to 7.8

6.3 Cautions on Maintenance and Inspection

Be sure to perform maintenance and inspection according to each country's laws and regulations.
The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations.
When performing inspection or maintenance of the robot mechanical unit, strictly observe the following precautions to protect yourself and coworkers.

⚠ DANGER

- Be sure to remove the power plug of the controller from the power supply before approaching the robot for maintenance and inspection.
- When manually moving the robot with the power supply connected, ensure safety and effect emergency stop beforehand.
- Then, when performing working while pressing the axis-3 motor brake release switch, be sure to perform work by two persons. One person performs work and other person should observe the work in a safe location. During the operation of work, the observer should be ready to cut off the power supply of the controller immediately if a fault occurs. Cutting off the power supply of the controller causes the motor brake to operate even when the axis-3 motor brake switch is being pressed.
- If the axis-3 motor brake release switch is pressed with the robot carrying heavy load, the axis 3 may drop suddenly, and the user must take this into account.

6.4 Maintenance Tools

We recommend to use the following tools for maintaining the robot and controller.

- Screwdriver (Phillips screwdriver, flathead screwdriver)
- Hexagonal wrench key, nominal size: 1.5 mm to 8 mm
- Torque wrench, nominal size: 3 mm to 5 mm
- Torque driver • Spanner, nominal size: 5.5 mm
- Box wrench, nominal size: 5.5 mm • Nipper • Longnose pliers • Pliers
- Torque wrench extension bar • Plastic hammer • Scale

Recommended provisions other than the tools:

- Alcohol (for cleaning) • Waste cloth • Vise (fixing tool) • Spatula (for applying grease)
- Screw locking adhesive Recommended: Loctite (241 medium strength) (221 low strength)
- Belt tension meter • Corrosion inhibitor, Kluber A20 or WD-40
- TSAssist <KSL-TSA> program creation/instruction support software (optional)

6.5 Clamping Hexagon Socket Head Cap Screws and Locking Screws

This robot uses hexagon socket head cap screws at places requiring mechanical strength. At the time of factory-assembly, screw locking adhesives are applied and each screw is tightened with the following clamping torque.

When these screws or locking screws are tightened again according to the inspection and maintenance as stipulated in this manual, apply Loctite (medium-strength) and use a torque wrench or torque driver to assure the appropriate clamping torque.

Table 6.4 Clamping torque

Hexagon socket head cap screws	—	—	M3	M4	M5
Locking screw	M3	M4	M5	M6	M8
Clamping torque	1.5 N·m	1.8 N·m	2.0 N·m	4.7 N·m	9.0 N·m

Hexagon socket head cap screws	M6	M8	M10	M12
Locking screw	M10	M12	M16	M20
Clamping torque	15 N·m	37 N·m	75 N·m	128 N·m

To mount the reduction gear, for the screws arranged on a circle, tighten them in the diagonal order, as shown below.

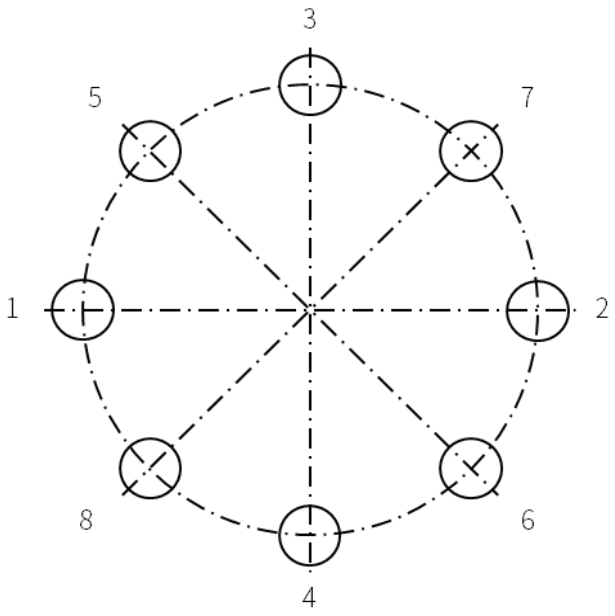


Fig. 6.2 Clamping bolts on a circle

DO NOT tighten one screw at a time. Tighten each screw in multiple steps, using a hexagonal wrench key, and secure with appropriate clamping torque by means of a torque wrench.

6.6 Maintenance Contract and Repair

6.6.1 Maintenance Contract

CKD Service Department also accepts replacement work at an extra cost.
We recommend that the user contact CKD Service Department and conclude an after-sale service contract with us.

6.6.2 Repair

If a fault has occurred or if repair is necessary, turn off the controller power and contact the CKD Service Department. At this time, advise us of the details of the fault and the following information stated on the robot and controller.
(For contact information of CKD Service Department, see Service Network.)

- Model name of the robot
- Manufacture number of the robot
- Manufacture number of the controller
- Date of manufacture of the robot
- Running hours

For the manufacture number and the date of manufacture, see the following label on the robot body base.

6.6.3 Modification

This robot and controller MUST NOT be modified or disassembled without a prior consent from CKD.

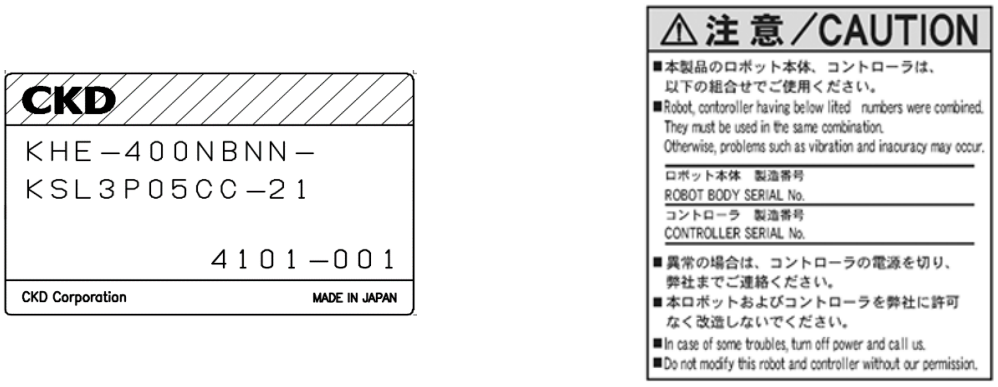


Fig. 6.3 Label

⚠ CAUTION

- The user must NEVER replace or modify parts other than those described in the instruction manual. Otherwise, the performance may deteriorate or faults or accidents will be caused.

7. Maintenance of the Robot Body

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.

Be aware that failure and accident resulting from the work done by the customer will not be under our warranty.

Recommended protector:

Type and name	Protection part and use	Recommended example
Helmet	Protection part: Head Use: Protect from a falling object. Protect from collision with the arm.	
Safety glasses	Protection part: Eyes Use: Protect from a flying object. Protect from collision with the arm.	
Protective gloves	Protection part: Hands and fingers Use: Protect hands and fingers when caught in the machine. Prevent a carried object from dropping.	
Protective shoes	Protection part: Feet and toes Use: Protect from a falling object.	

7.1 Details of Inspection

7.1.1 Check of Each Bolt (or Screw) for Clamping

1) Tool Set Bolts

Use the hexagonal wrench key to make sure that the four tool flange split clamp bolts (M4) of the tool flange (option) split clamped to the tool shaft are tightened completely. If they are loosened, tighten them completely.

Use the hexagonal wrench key to make sure that the four tool clamp bolts securing the tool to the tool flange are tightened completely. If they are loosened, tighten them completely. (Screw locking adhesive is unnecessary.)

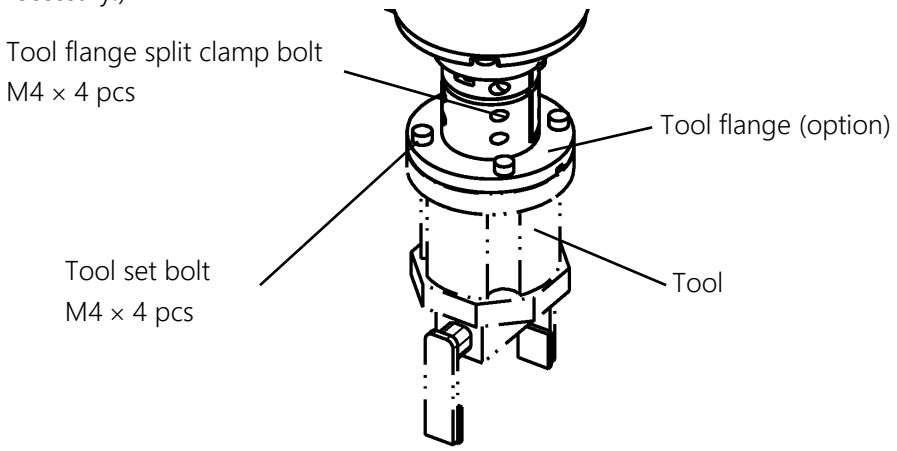


Fig. 7.1 Tool set bolts

2) Robot installation bolts

Use the hexagonal wrench key to make sure that the installation bolts of the robot body base are tightened completely. If they are loosened, tighten them completely. (Screw locking adhesive is unnecessary.)

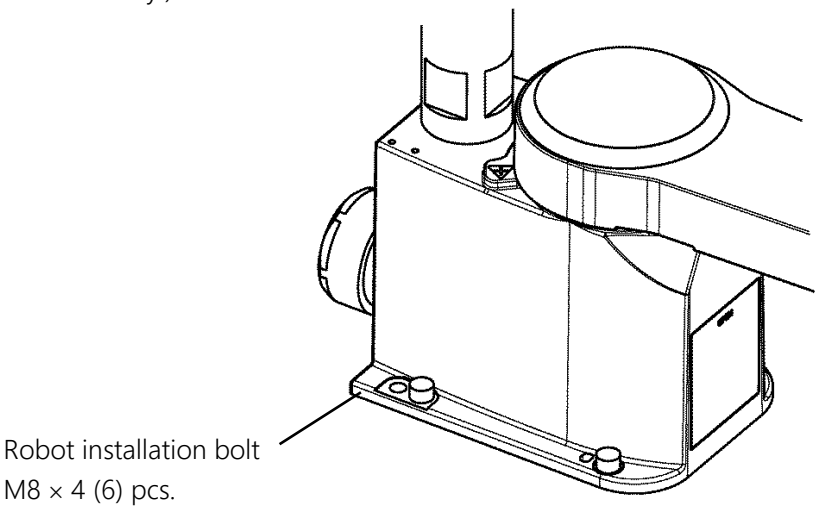


Fig. 7.2 Robot installation bolts

7.1.2 Check of Motor Set Bolts

Use the hexagonal wrench key to make sure that axis drive motor clamp bolts are tightened completely. Also, check the motor and motor plate clamp bolts. For the following bolt use positions, see "7.4 Replacement of Motors."

Table 7.1 Motor and motor plate clamp bolts

Use position	Type	No. of bolts	Reference destination
Axis-1 motor clamp bolt	M5×16	4	7.4.4 Fitting the Axis-1 Motor
Axis-2 motor clamp bolt	M4×14	4	7.4.6 Fitting the Axis-2 Motor
Axis-3 motor clamp bolt	M3×10	4	7.4.8 Fitting the Axis-3 Motor
Axis-3 motor plate clamp bolt	M4×8	4	7.4.8 Fitting the Axis-3 Motor
Axis-4 motor clamp bolt	M4×12	4	7.4.10 Fitting the Axis-4 Motor
Axis-4 reduction gear clamp bolt	M5×16	4	7.7.8 Fitting the Axis-4 Reduction Gear
Axis-4 motor plate clamp bolt	M4×8	4	7.5.4 Replacing the Axis-4 Timing Belt

* For the recommended clamping torque, see 6.5 Clamping Hexagon Socket Head Cap Screws and Locking Screws."
* It is unnecessary to apply screw locking adhesive to the hexagon socket head cap screws for the axis-3 and axis-4 motor plate clamp bolts.

7.1.3 Check of the Wearing Out of Cables and Air tube

Remove the arm-2 cover and base rear cover to make sure that the cable is not worn out, bent or cracked. Particular care should be taken in checking locations near the ends of the cable. For how to remove the cover, see "7.3 Dismounting and Mounting Each Cover." Fig. 7.3 shows an example of routing the air tube. Also, check for the wearing out or entanglement of the air tube and the connection of ductwork. Check that the air tube is not entangled and that the connection of ductwork is correct. Then, solve problems if there are any.

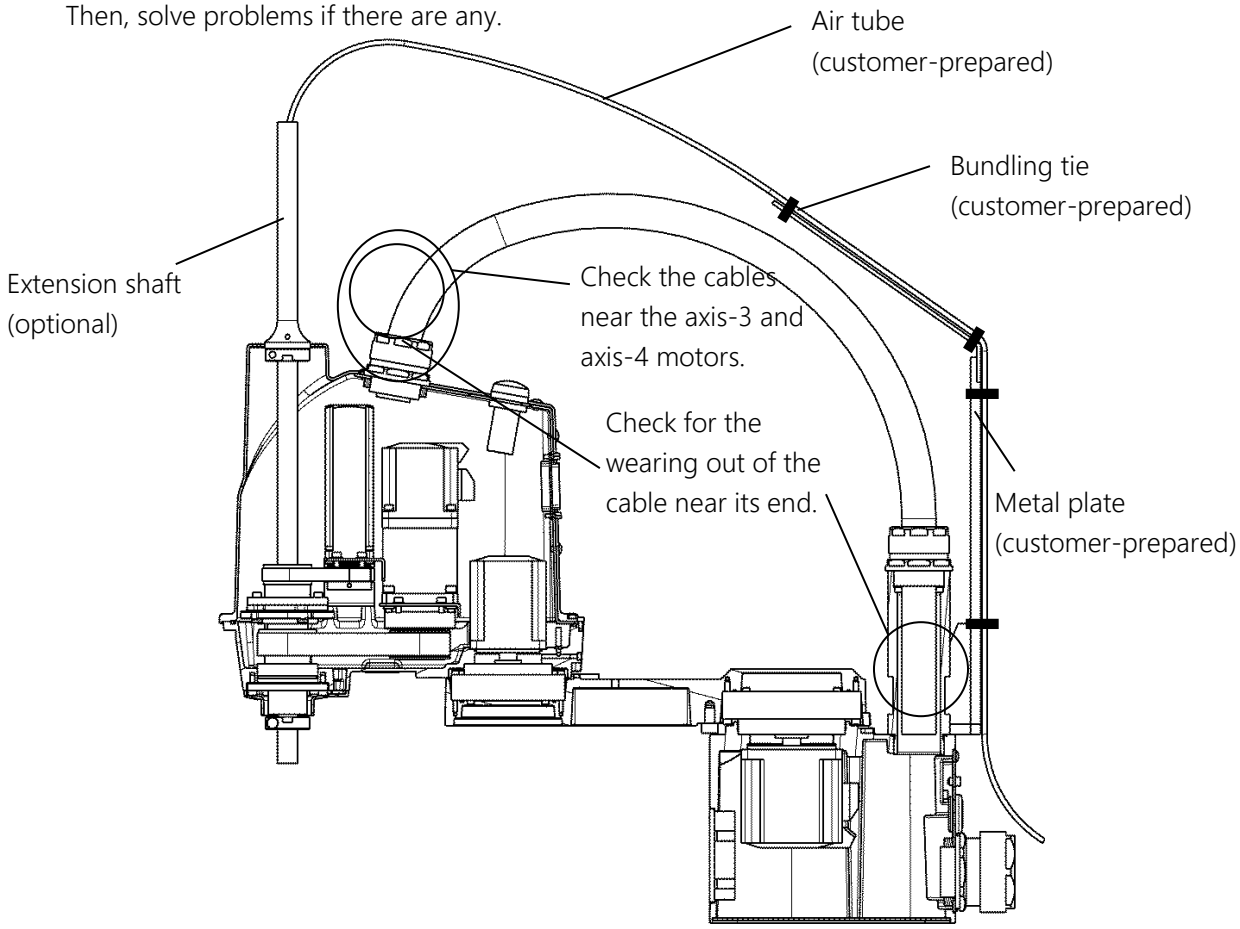


Fig. 7.3 Inspection points of cable

⚠ CAUTION

- The air tube is a consumable item. It must be checked periodically, and replaced if broken.
- Fig. 7.3 shows an example of ductwork. Note that breakage of air tube, etc. is not always under our warranty.

7.1.4 Check of Cable Clamps for Clamping

Use the wrench to make sure that the clamps securing the cable are tightened completely. There are clamps at two positions: Arm-2 side and base side. If the clamps are loosened, apply Loctite (low-strength) to them and tighten them. Check the clamp on the base side for clamping first. By checking the base side clamp first, a twist, etc. on the base side cable can be adjusted slightly from the arm 2 side. Also, tighten the clamps in a position shown in Fig. 7.4. If the clamp is tightened with the arm bent, the cable cannot be connected accurately.

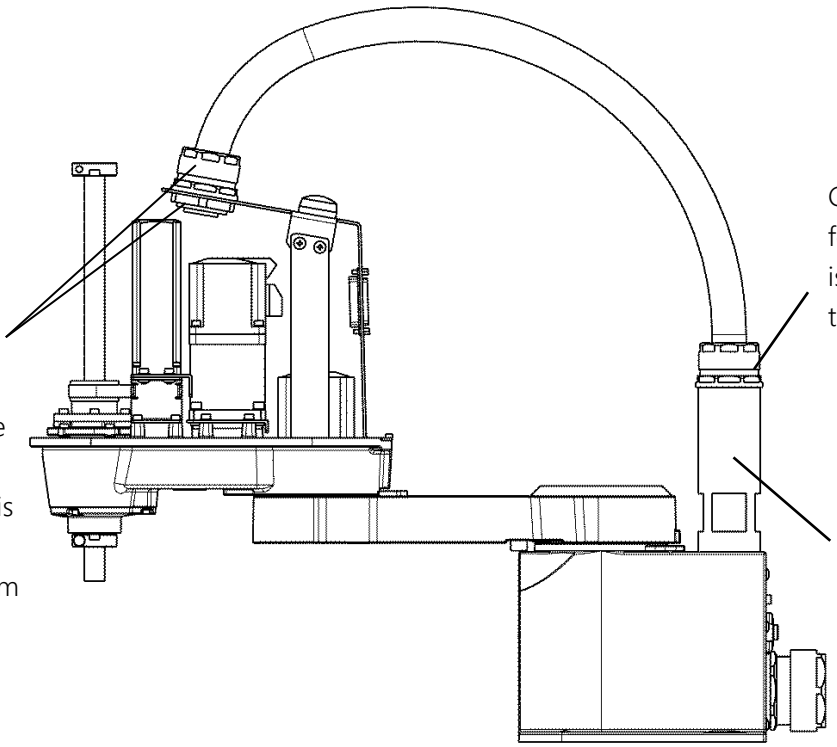


Fig. 7.4 Inspection spot of cable clamp

7.1.5 Check of Operation of Each Axis

After connecting the power plug of the controller to the power supply, keep the emergency stop switch pressed. Make sure that each axis is smoothly moved by hand. Axis 3 enters a non-braking state when the brake release switch is pressed. Note that the tool shaft drops due to the weight of the hand and the tool.

⚠ CAUTION

- When axis 1 and axis 2 are moved near the working envelope limit and a hand is off from them, axis 1 and axis 2 may move due to reaction of the cable.

7.2 Configuration of Mechanical Components

Fig. 7.5 shows the configuration of the mechanical components.

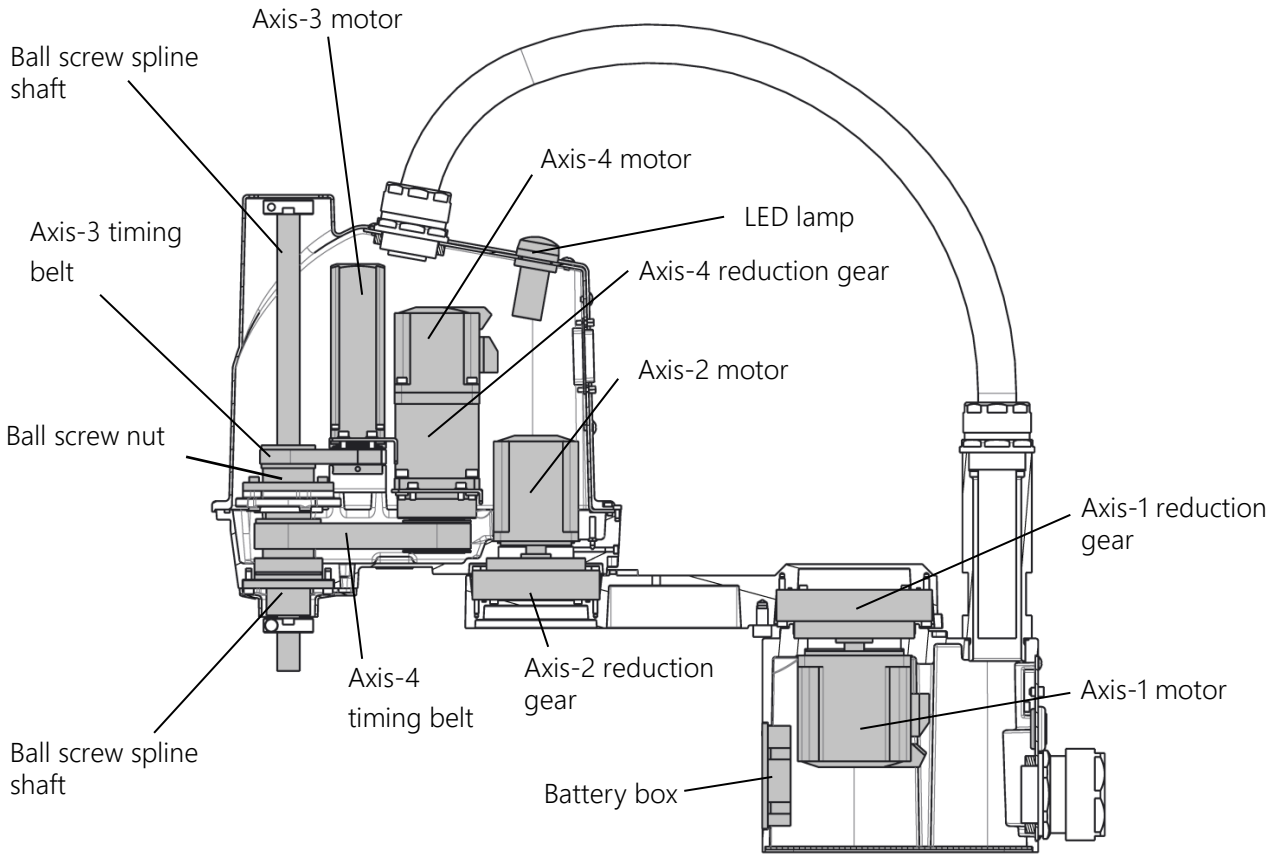


Fig. 7.5 Configuration of mechanical components

7.3 Dismounting and Mounting Each Cover

This paragraph describes the dismounting and mounting of the covers, which are common to the maintenance and replacement of each unit.

⚠ DANGER

- When opening the cover, take careful precautions not to allow entry of moisture or contaminant into the robot. If the power is turned on while moisture or contaminant is left, you may get an electric shock or the robot may malfunction, which is very dangerous.

⚠ CAUTION

- When mounting the arm-2 cover and base cover, be careful to prevent cables from being caught. If the cables are bent and pushed by force, they will be broken. The cables are secured to the metal plates with cable straps; therefore, check the cable arrangement when the covers are removed, and return to reasonable wiring state.

7.3.1 Arm-2 Cover

The arm-2 cover is secured to arm 2 and harness guide with eight hexagon socket head bolts (M3×6×6 and M3×8×2) and eight cross truss screws. (During mounting, application of screw locking adhesive is not required.)

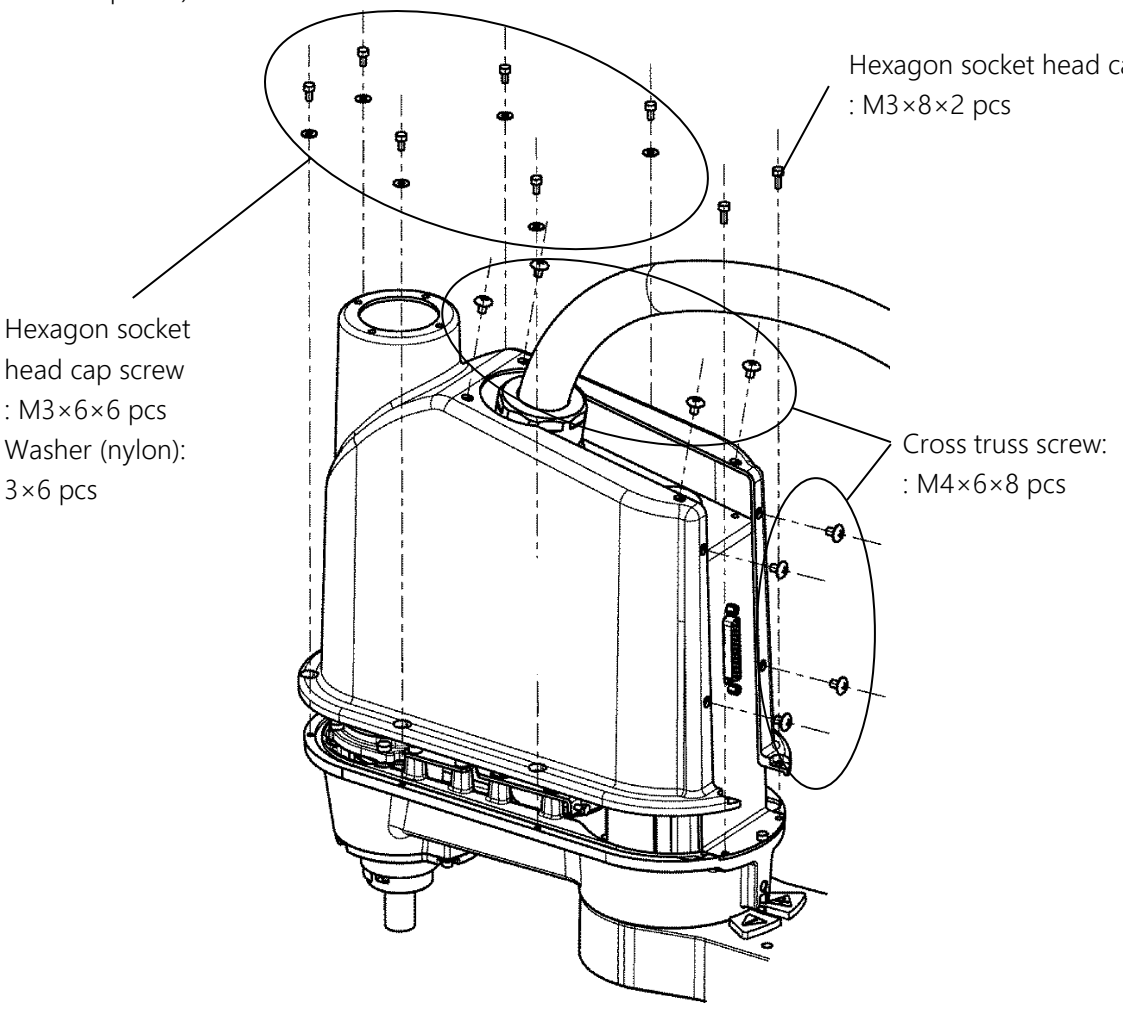


Fig. 7.6 Arm-2 covers

After mounting the cover, move the ball screw spline shaft up and down manually while pressing the brake release switch, and make sure that the hole for ball screw of the arm-2 cover does not interfere with the stopper.

7.3.2 Base Cover

The base cover is provided in two types: base rear cover and base bottom cover. (When the covers are mounted, application of Loctite is not required.)

The base rear cover is secured to the base with six cross truss screws (M4×8). When the fixing screws are removed, the rear cover is separated from the base. However, the cover is connected to connectors inside; therefore, do not pull it forcibly.

The base bottom cover is secured to the base with six hexagon socket countersunk head screws (M4×8).

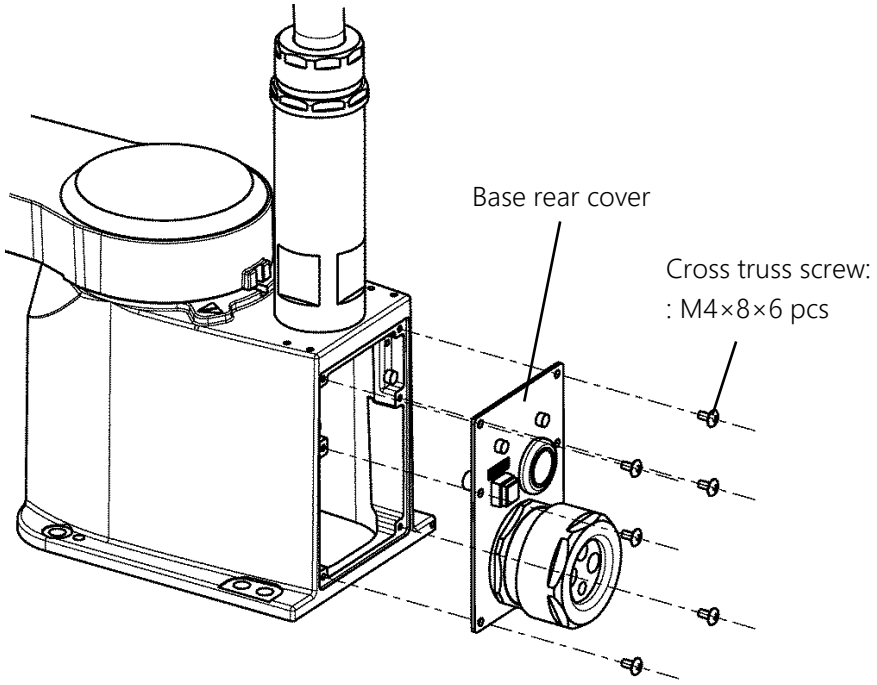


Fig. 7.7 Base rear cover

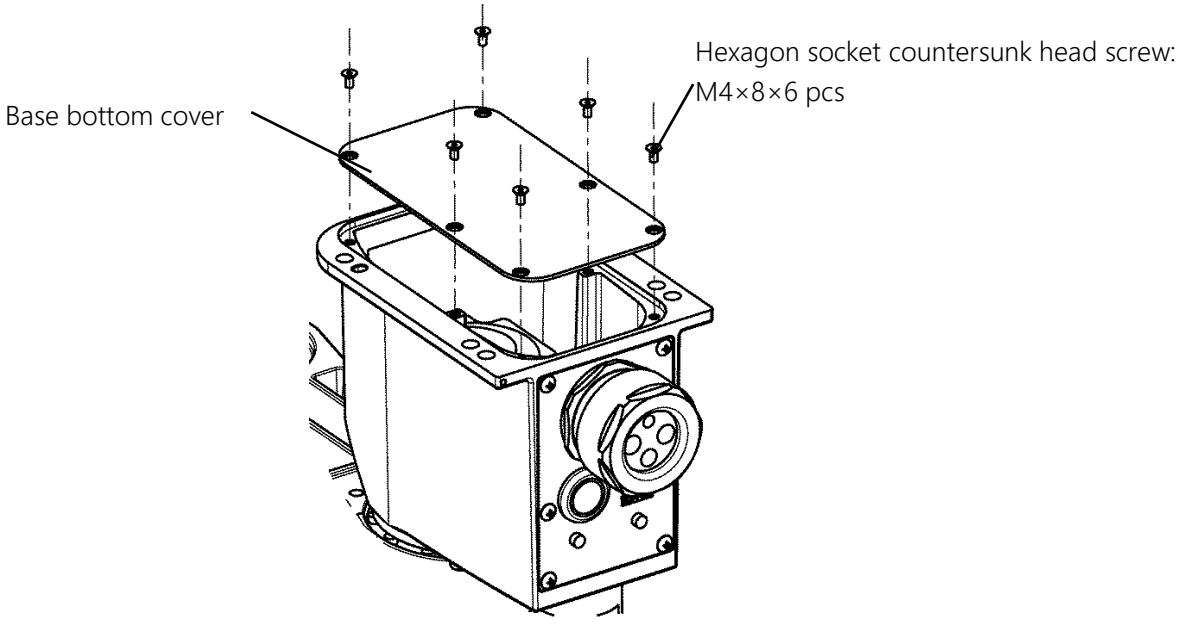


Fig. 7.8 Base bottom cover

7.4 Replacement of Motors

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.
Be aware that failure and accident resulting from the work done by the customer will not be under our warranty.

⚠ DANGER

- The power plug of the controller must be removed before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- When replacing a motor, take care not to cause heavy impact on the motor shaft. Impact may damage the motor or the encoder.
- The user must never disassemble the motor or the encoder. Disassembling them may cause differences in position, making it impossible to use the system.
- Replacing a motor causes deviation from mechanical zero position, making normal control impossible. Therefore, it is necessary to restore the zero position after replacing a motor.
  For how to restore the zero position, see "8 Robot Zero Point and Position Detector Error".

7.4.1 Types of Motors

The motors used by this robot are listed in the table below. When ordering a replacement motor, check the robot model name (KHE-400) and manufacture number on the label (see Fig. 6.3 Label), and then check applicable axis, Shibaura drawing number, and unit code according to Table 7.2. For the location of the manufacture number label, see "Safety Manual."

Table 7.2 Types of motors

Part name	Applicable axis	Shibaura Dwg. No.	Unit code
AC servo motor	Axis 1	S948801	Y610D04M0
	Axis 2	S948802	Y610D04N0
	Axis 3	S948803	Y610D04P0
	Axis 4	S948804	Y610D04Q0

7.4.2 Locations of Motors

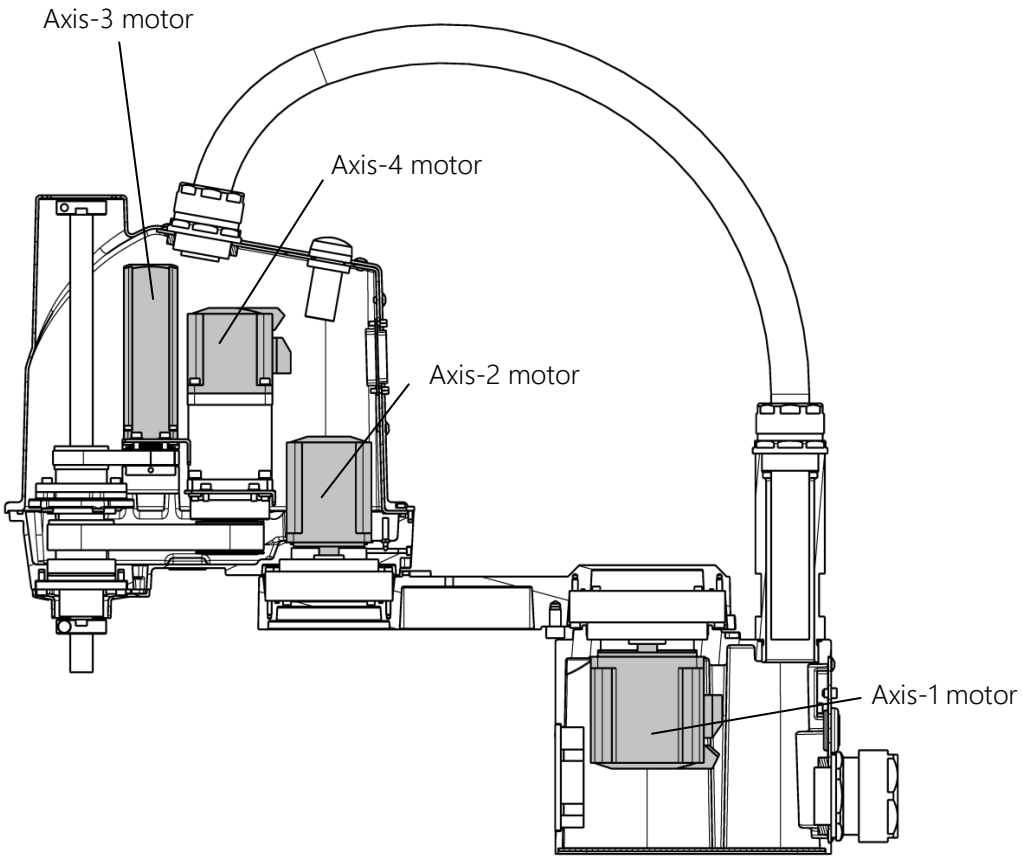


Fig. 7.9 Motor locations

7.4.3 Removing the Axis-1 Motor

1) Remove the base rear cover and base bottom cover. (See "7.3.2 Base Cover.")
   The rear cover is connected to the connectors inside; therefore, do not pull it forcibly.
2) Remove the hexagon socket head cap screws (M5×6×4 pieces) and washers, pull the axis-1 motor assembly out axially. When pulling out the assembly, grease may drip off from the fitting surface of the motor. Prepare waste cloth. At this time, remove the O ring (CO0545A) mounted on the base groove side face. When taking out the motor assembly, do not pull it forcibly as the motor connector is connected to it.
3) Disconnect the cable connectors of the axis-1 motor, J1AS and J1AP (power drive cables) and J1BS and J1BP (encoder cables).

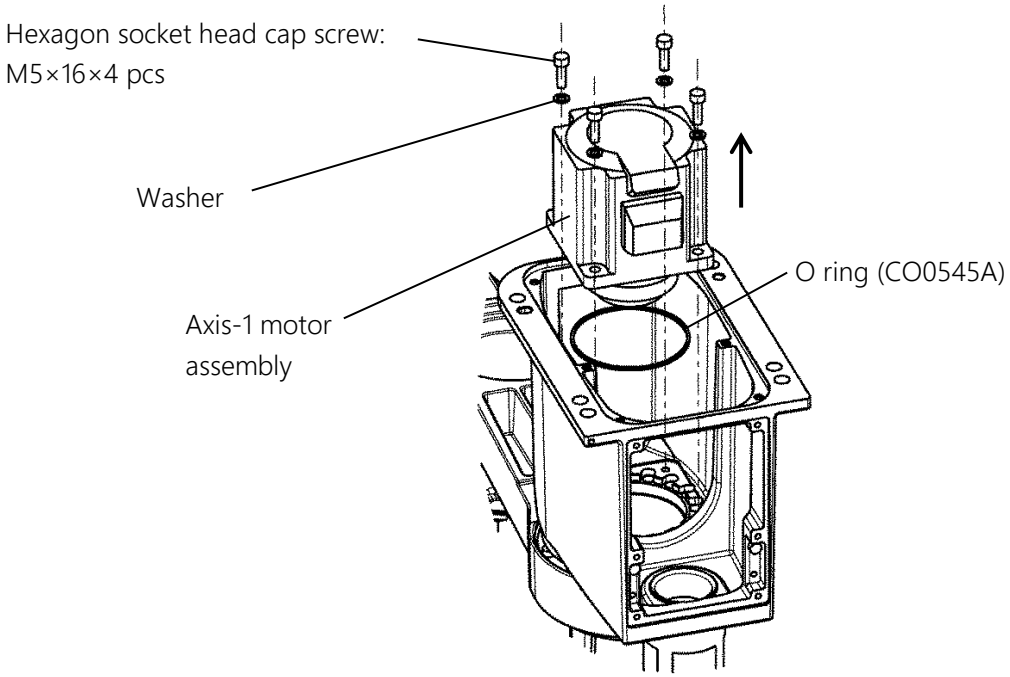


Fig. 7.10 Removing axis-1 motor assembly

4) Secure the protrusion part of elliptical cam with a plier, etc., and then remove the hexagon socket head cap screw (M4×10×1 piece) at the end of the shaft. When securing the elliptical cam, place a cushioning material such as waste cloth, etc. between it and the plier to prevent it from being damaged. After removing the hexagon socket head cap screw, pull out the press plate and elliptical cam.

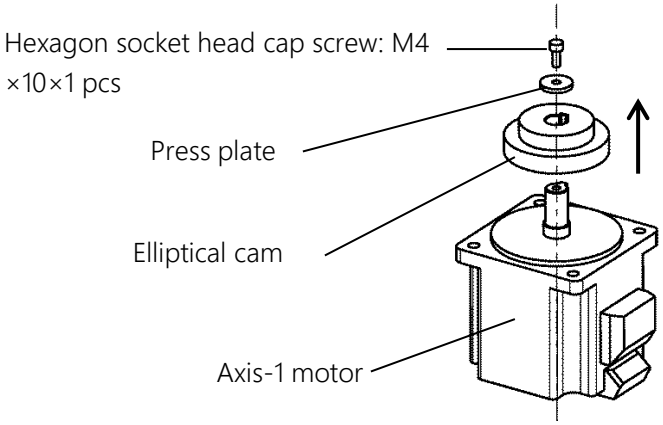


Fig. 7.11 Removing the axis-1 elliptical cam

7.4.4 Fitting the Axis-1 Motor

1) Fit the elliptical cam and secure it with the hexagon socket head cap screw (M4×10×1 piece) at the end of the shaft and the press plate. Secure the protrusion part of elliptical cam with a plier, etc., and tighten the hexagon socket head cap screw (M4×10×1 piece) at the end of the shaft. When securing the elliptical cam, place a cushioning material such as waste cloth, etc. between it and the plier to prevent it from being damaged.

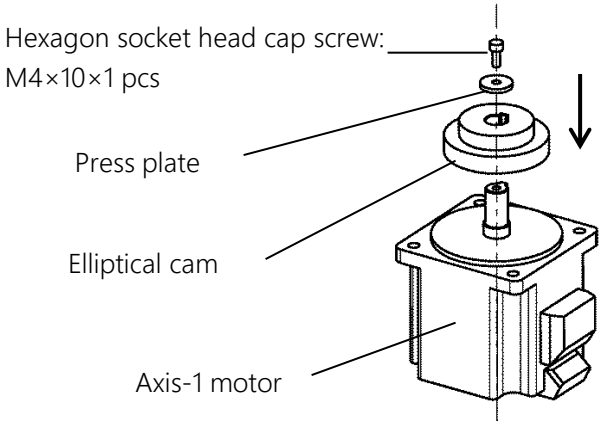


Fig. 7.12 Fitting axis-1 elliptical cam

2) Apply grease to the O ring (CO0545A) and fit it so that it comes into contact with the base groove side face. At this time, be careful to prevent the O ring from dropping.

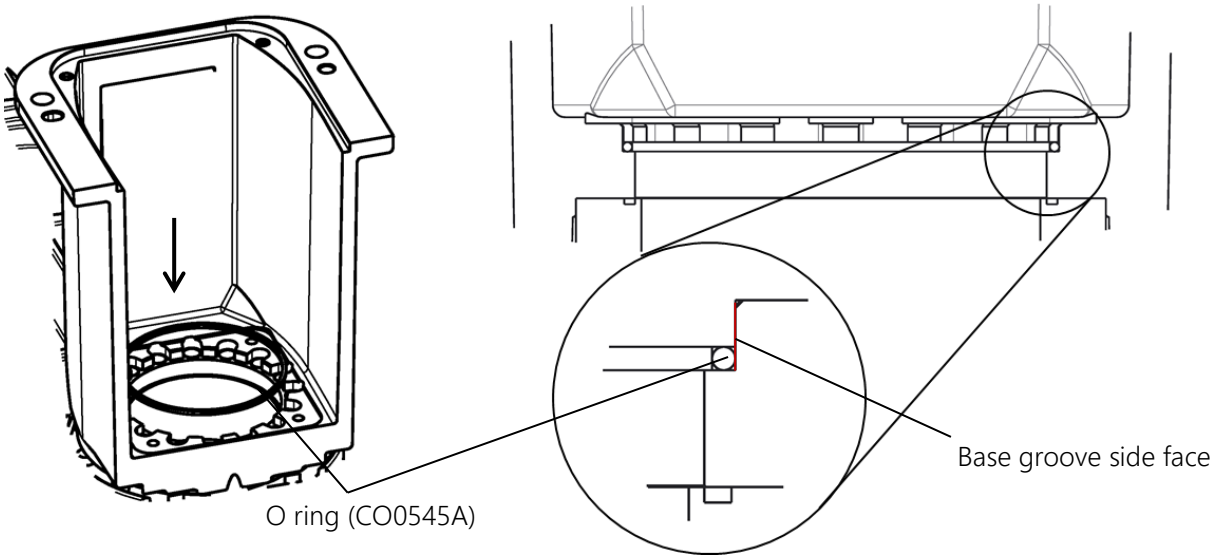


Fig. 7.13 Fitting O ring on axis-1 base side

3) Apply grease to the axis-1 motor. (See 4) in "7.7.4 Fitting the Axis-1 Reduction Gear.")
4) Connect the cable connectors of the axis-1 motor, J1AS and J1AP (power drive cables) and J1BS and J1BP (encoder cables).
5) Be careful about the fitting phase of the motor, the orientation of the reduction gear and elliptical cam when the motor is inserted and the misaligned O ring to insert the axis-1 motor assembly into the base.
6) Secure the axis-1 motor assembly with the hexagon socket head cap screws (M5×16×4 pieces) and washers.

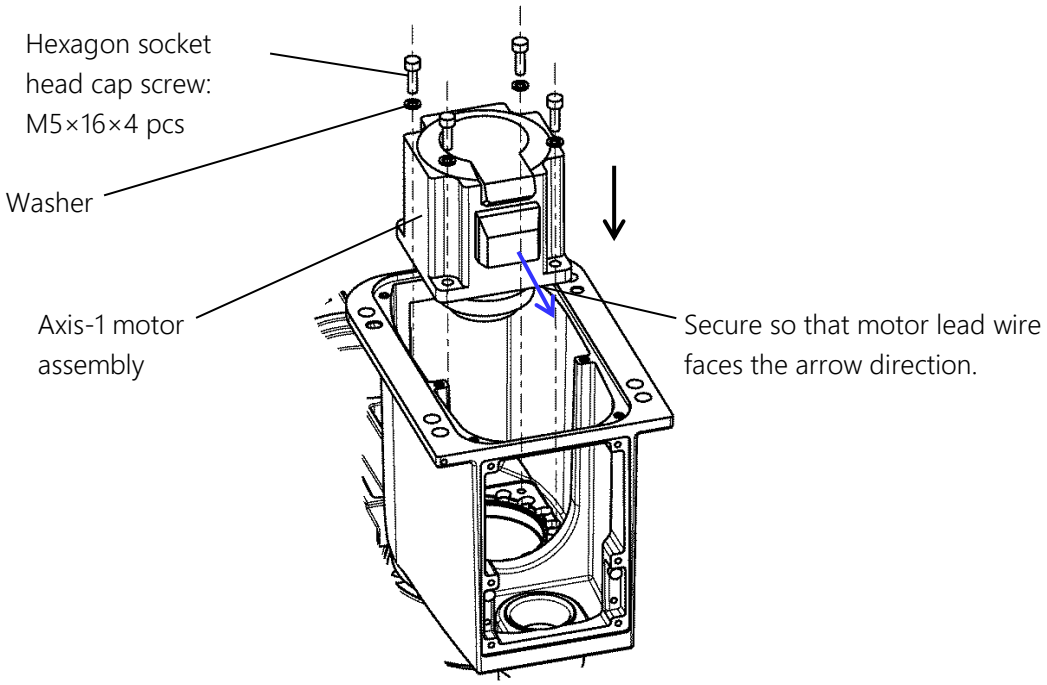


Fig. 7.14 Fitting axis-1 motor assembly

7) Move the arm 1 by hand to make sure that there is no abnormal sound.
8) Fit the base rear cover and base bottom cover. (See "7.3.2 Base Cover.")
9) Turn on the power and set the zero position of the axis 1 to complete the replacement of the axis-1 motor. (Check the coordinates of axes 2, 3, and 4 and set the zero position as required. See "8 Robot Zero Point and Position Detector Error")
10) Perform test operation on the axis 1 to check whether there is any problem with operation of each part.

⚠ CAUTION

- Be careful to prevent the O ring from being forgotten to be fitted.
  Unless the O ring is fitted, grease leaks from the fitting surface of the motor.

7.4.5 Removing the Axis-2 Motor

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a nipper or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect J2AS and J2AP (axis-2 power drive cables) and J2BS and J2BP (axis-2 encoder cables).
4) Remove the harness guide secured with the hexagon socket head cap screw (M3×6×1 piece) and the support plate secured with the hexagon socket head cap screws (M3×6×2 pieces).

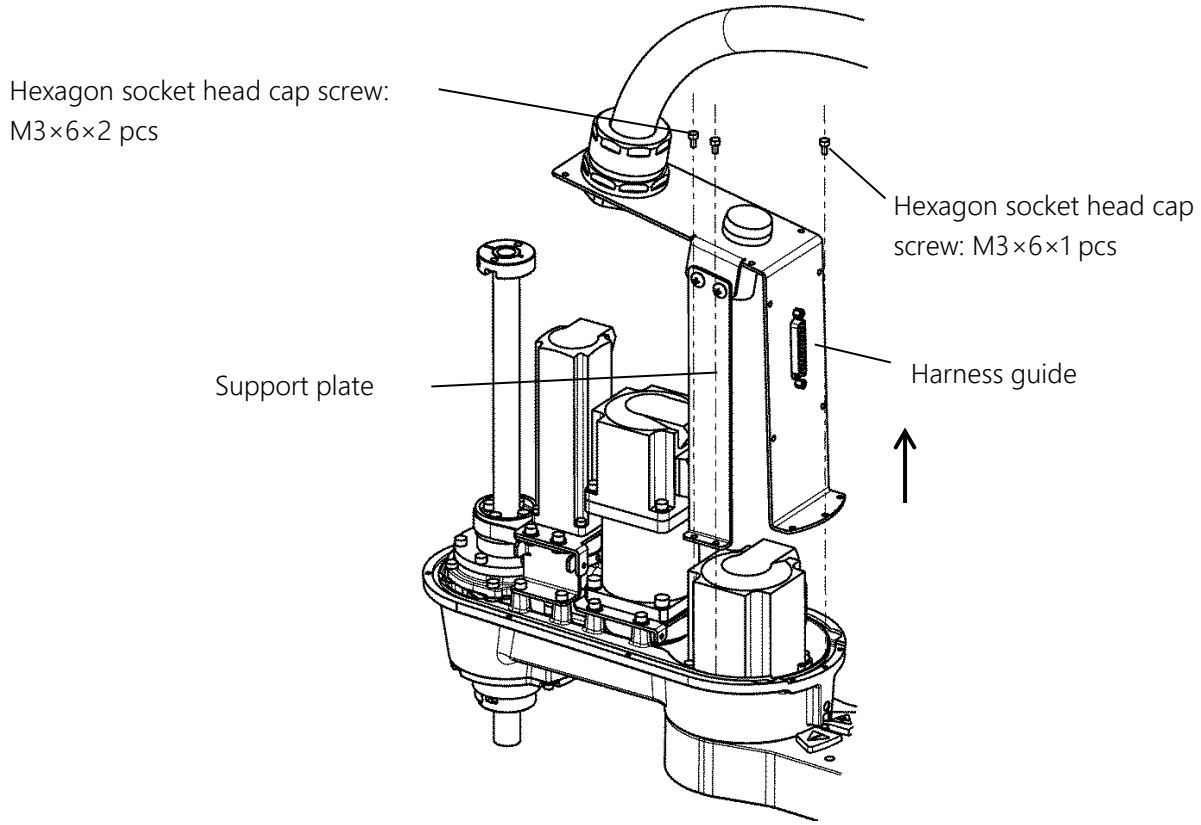
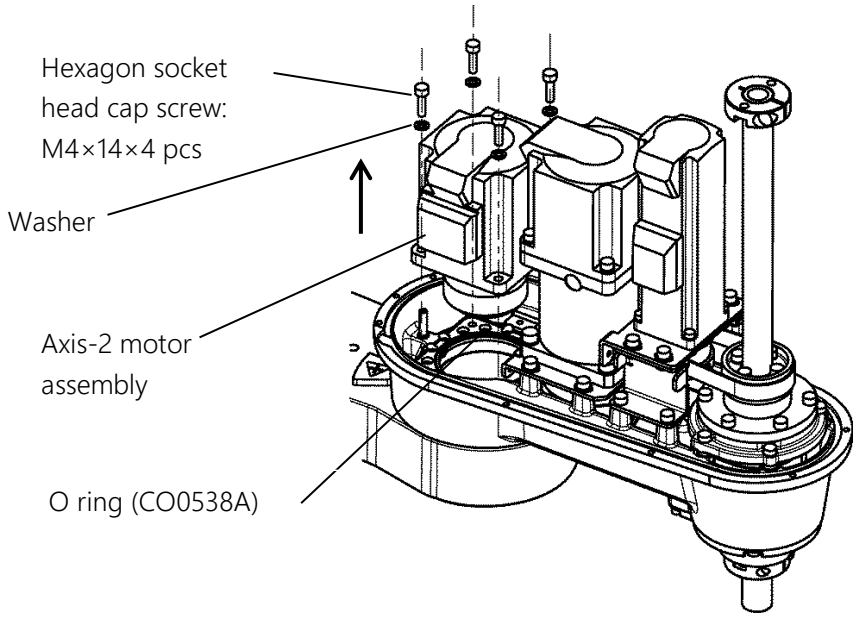


Fig. 7.15 Removing harness guide and support plate

5) Remove the hexagon socket head cap screws (M4×14×4 pieces) and washers securing the axis-2 motor. Pull out the axis-2 motor assembly. At this time, remove the O ring (CO0538A) as well.



6) Remove the elliptical cam from the axis-2 motor assembly. (Same as the instruction in 4) in "7.4.3 Removing the Axis-1 Motor.")

7.4.6 Fitting the Axis-2 Motor

1) Apply grease to the O ring (CO0538A) and fit it in the spigot joint of the axis-2 motor.

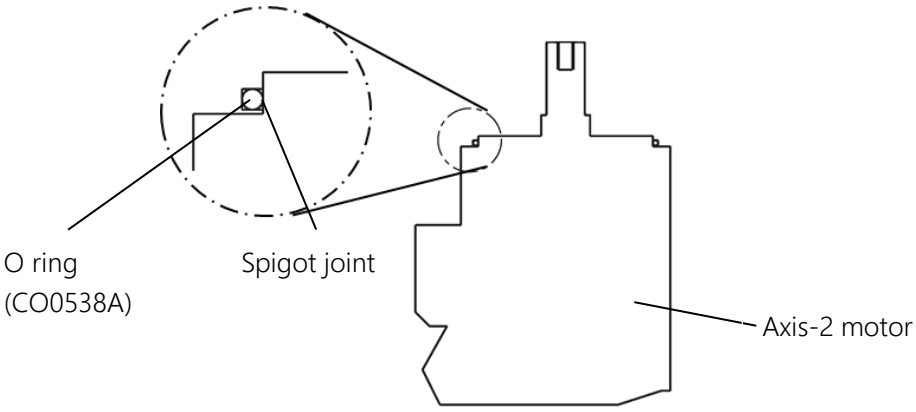


Fig. 7.16 Fitting O ring

2) Fit the elliptical cam to the axis-2 motor. (Same as the instruction in 1) in "7.4.4 Fitting the Axis-1 Motor.")
3) Apply grease to the axis-2 motor. (See 4) in "7.7.6 Fitting the Axis-2 Reduction Gear.")
4) Be careful about the fitting phase of the motor, the orientation of the reduction gear and elliptical cam when the motor is inserted (match the reduction gear body and the long portion of ellipse of the elliptical cam) and the misaligned O ring to insert the axis-2 motor assembly into arm 2.
5) Secure the axis-2 motor with the hexagon socket head cap screws (M4×14×4 pieces) and washers.

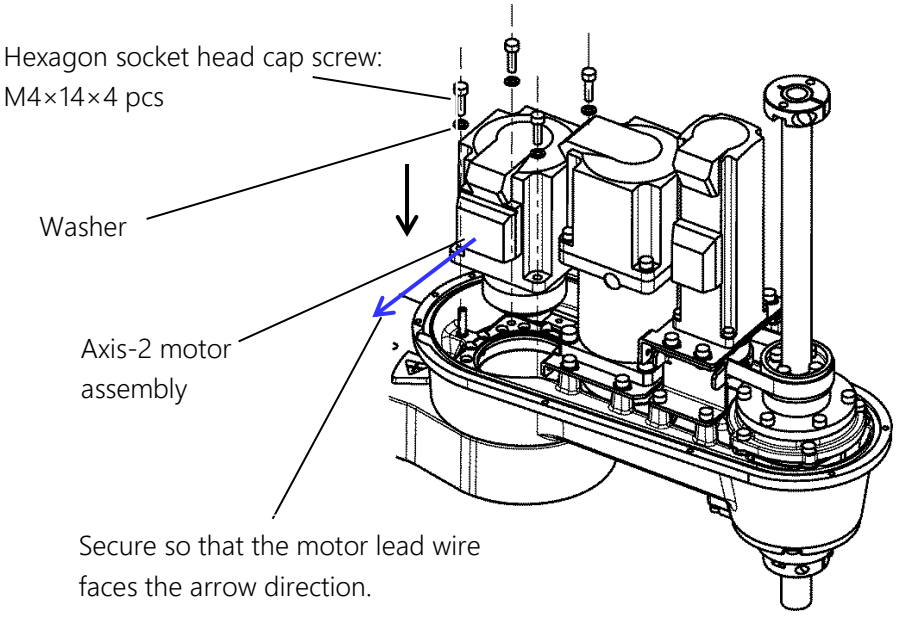


Fig. 7.17 Fitting the axis-2 motor assembly

⚠ CAUTION

- Be careful to prevent the O ring from being forgotten to be fitted.
  Unless the O ring is fitted, grease leaks from the fitting surface of the motor.

6) Secure the harness guide and support plate with the hexagon socket head cap screws (M3×6×3 pieces, of which one screw on the harness guide does not require application of screw locking adhesive).

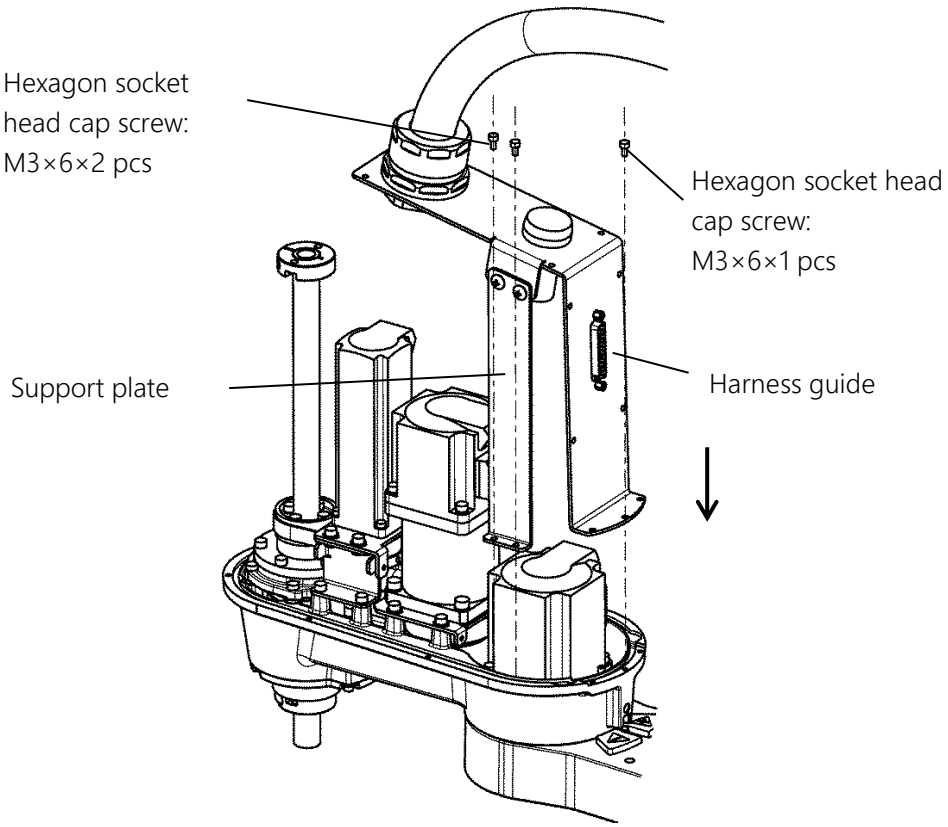


Fig. 7.18 Fitting harness guide and support plate

7) Move the arm 2 by hand to make sure that there is no abnormal sound.
8) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.4.5 Removing the Axis-2 Motor.")
9) Fit the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
10) Turn on the power and set the zero position of the axis 1 to complete the replacement of the axis-2 motor. (Check the coordinates of axes 1, 3, and 4 and set the zero position as required. See "8 Robot Zero Point and Position Detector Error")
11) Perform test operation on the axis 2 to check whether there is any problem with operation of each part.

7.4.7 Removing the Axis-3 Motor

⚠ CAUTION

- The axis-3 motor is provided with a brake. During the replacement of the axis-3 motor, this brake does not work; therefore, the ball screw spline must be lowered to the lower limit before replacement work. The weight of the shaft or the workpiece could the shaft to drop and catch your hand or fingers.

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a nipper or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect the cable connectors of the axis 3, J3AS and J3AP (axis-3 power drive cables), J3BS and J3BP (axis-3 encoder cables), and J3DS and J3DP (axis-3 brake cables).
4) Use a tension meter to measure the tension of the axis-3 timing belt. Enter the following values as the values input to the tension meter. Be sure to record the results of measuring the tension using the tension meter.

Table 7.3 Values Input to Tension Meter

Unit Mass (g/m)	Belt Width (mm)	Span (mm)
2.9	18	105

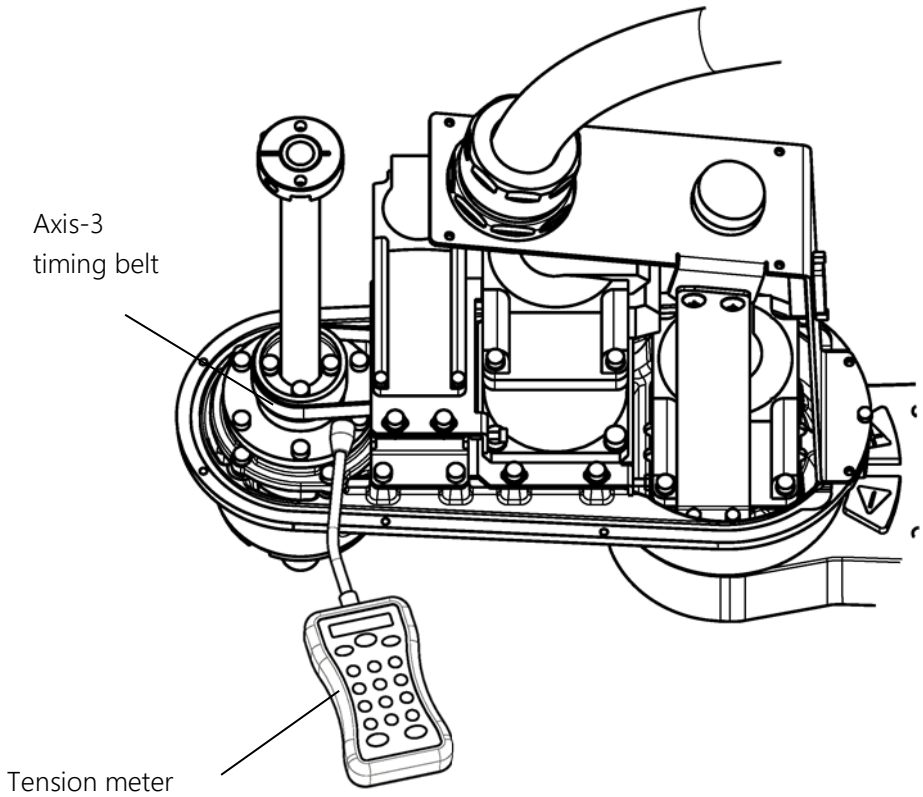


Fig. 7.19 Measuring the Tension of the Axis-3 Timing Belt

5) Remove the hexagon socket head cap screws (M4×8×4 pieces) and washers securing the axis-3 motor plate to release the tension of the axis-3 timing belt. Then, remove the axis-3 motor assembly so that it

does not hit the metal plate or ball screw spline.

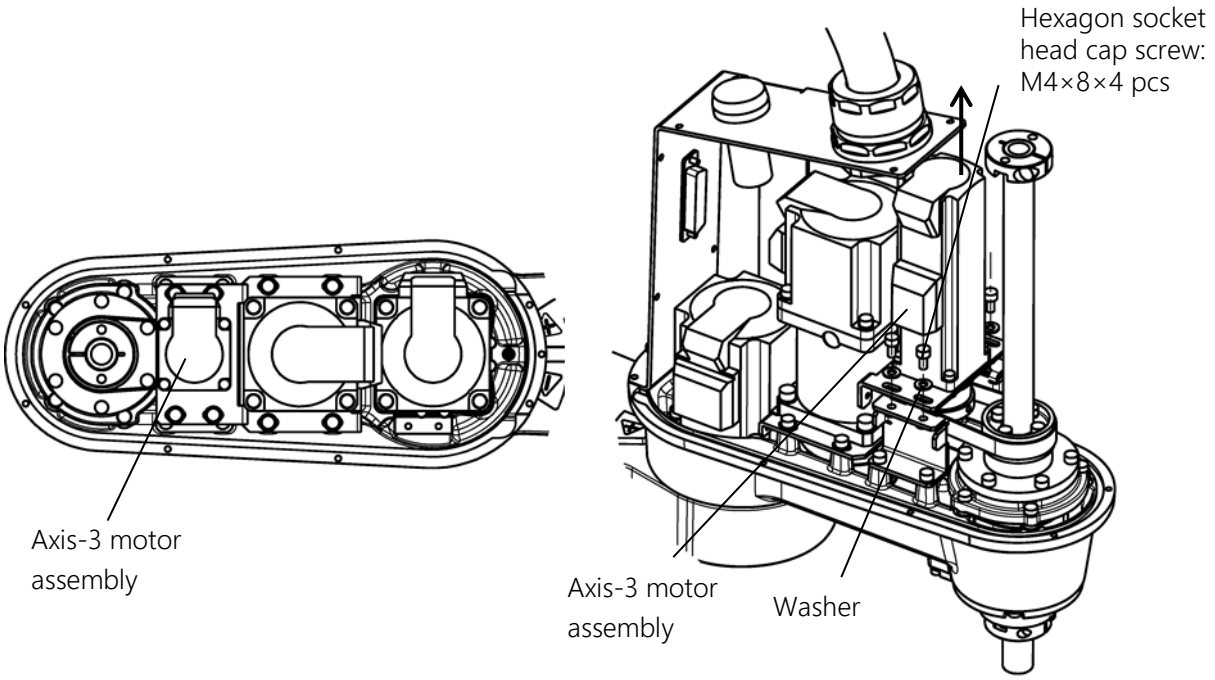


Fig. 7.20 Removing the axis-3 motor assembly

6) Remove the setscrews (M4×5×2 pieces). Then, pull out the pulley.
7) Remove the hexagon socket head cap screws (M3×10×4 pieces) and washers securing the axis-3 motor to separate the axis-3 motor plate from the axis-3 motor.

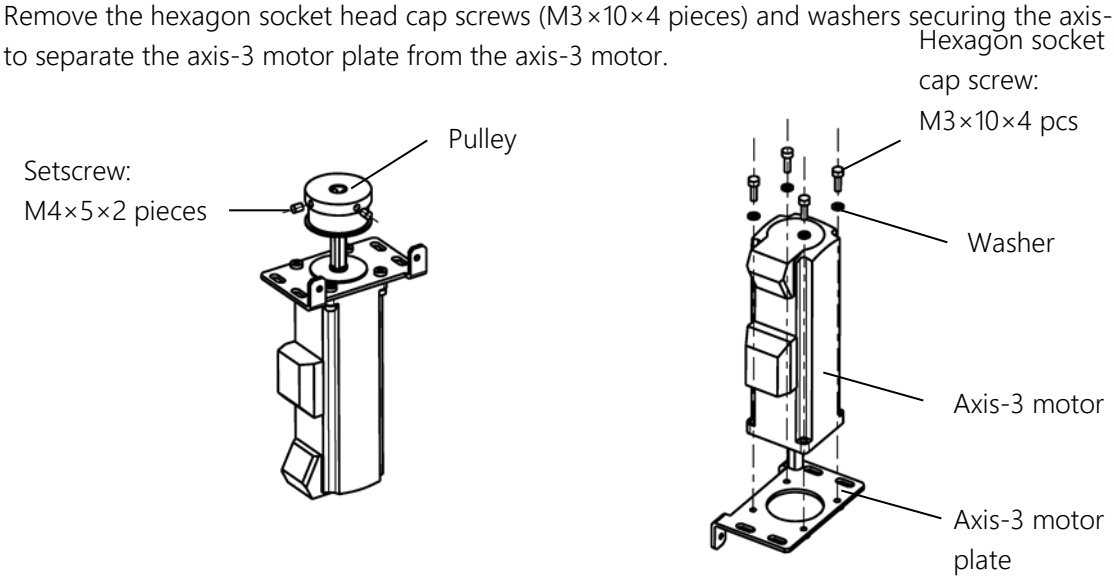


Fig. 7.21 Removing the axis-3 pulley and plate

7.4.8 Fitting the Axis-3 Motor

1) Secure the axis-3 motor to the axis-3 motor plate with the hexagon socket head cap screws (M3×10×4 pieces) and waters. At this time, be careful about the fitting phase of the axis-3 motor and axis-3 motor plate.
2) Fit the axis-3 motor pulley and secure it with setscrews (M4×5×2 pieces). When securing the pulley, match the phase of the pulley setscrew hole and D cut of the shaft as shown in sectional view A – A for fitting.

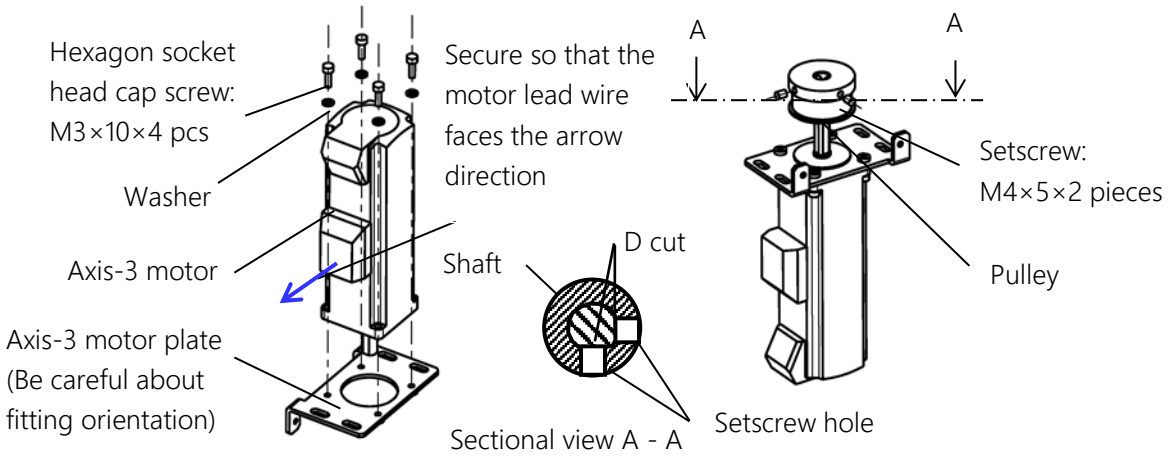


Fig. 7.22 Fitting the axis-3 pulley and plate

3) Put the axis-3 timing belt on the axis-3 motor pulley, and temporarily fix the axis-3 motor plate to the axis-3 bracket (metal plate) with the hexagon socket head cap screws (M4×8×4 pieces) and washers. At this time, be careful about the fitting phase of the motor.

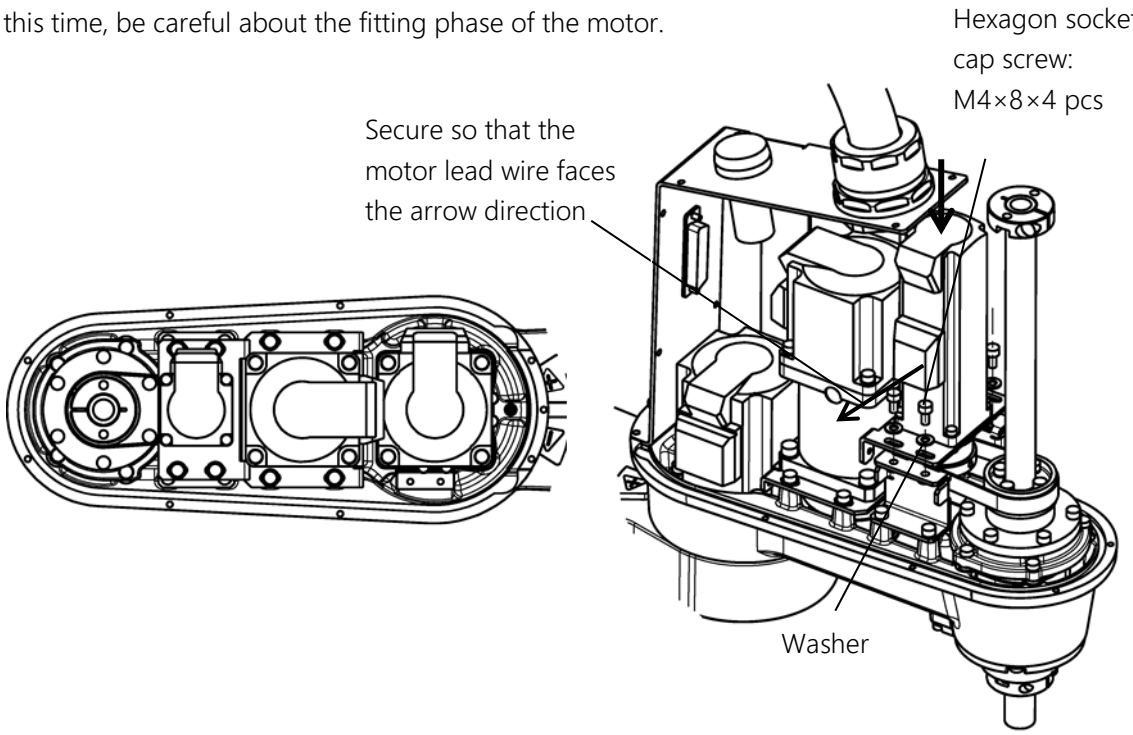


Fig. 7.23 Fitting the axis-3 motor assembly

4) Move up and down the ball screw spline unit to adjust it. Use the screws for tension adjustment of the axis 3 (M3×12×2 pieces (accessory), not requiring application of screw locking adhesive) to apply tension. While using the screws for the tension adjustment of the axis 3 to pull the axis-3 motor plate, use a tension meter to measure the tension. Tighten the hexagon socket head cap screws at a position where the tension has become a little smaller than the value A*(N) measured in step 4) of "7.4.7 Removing the Axis-3 Motor" (This is because retightening the hexagon socket head cap screws increases the tension.) Make adjustment so that the tension becomes A*×0.95 to A*×1.05(N) when the hexagon socket head cap screws are retightened. After the hexagon socket head cap screws are retightened, remove the screws for the tension adjustment (M3×12×2 pieces). The value to be used in the tension meter is as follows.

Table 7.4 Tension of the axis-3 timing belt

Tension (N)	Unit Mass (g/m)	Belt Width (mm)	Span (mm)
A*×0.95 to A*×1.05	2.2	10	50

A is the value measured in step 4) of "7.4.7 Removing the Axis-3 Motor."

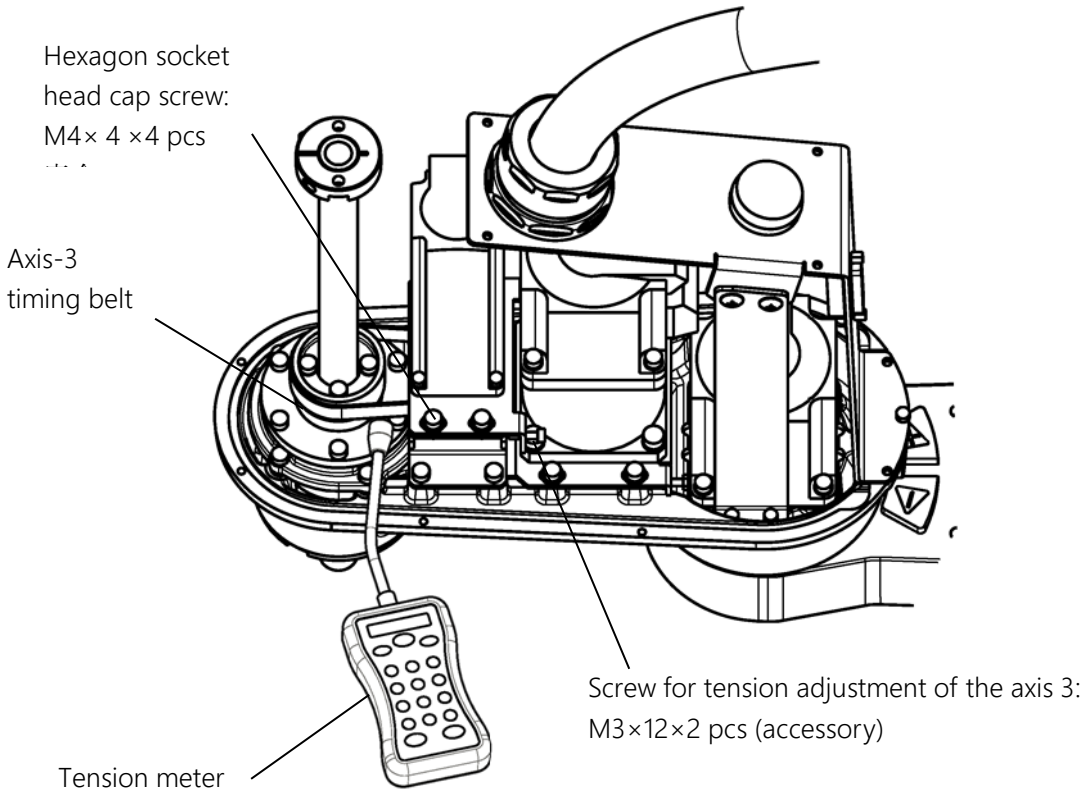


Fig. 7.24 Adjusting the tension of the axis 3

5) Connect the connectors and return the cable to its original state. (See the pictures taken in 3) of "7.4.7 Removing the Axis-3 Motor.")
6) Fit the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
7) Turn on the power and set the zero position of the axes 3 and 4 to complete the replacement of the axis-3 motor. The replacement of the axis-3 motor also always requires the zero position of the axis-4 motor to be set. (See "8 Robot Zero Point and Position Detector Error.")
8) Move up and down the ball screw manually while pressing the brake release switch in the servo OFF condition to make sure that the ball screw moves smoothly.
9) Perform test operation on the axes 3 and 4 to check whether there is any problem with operation of each part.

7.4.9 Removing the Axis-4 Motor

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect the cable connectors of the axis-4 motor, J4AS and J4AP (axis-4 power drive cables) and J4BS and J4BP (axis-4 encoder cables).
4) Remove the harness guide secured with the hexagon socket head cap screw (M3×6×1 piece) and the support plate secured with the hexagon socket head cap screws (M3×6×2 pieces). (See 4) of "7.4.5 Removing the Axis-2 Motor.")
5) Remove the cap on the side of the axis-4 reduction gear and loosen the bolt (M3) of the coupling that fastens the axis-4 motor shaft and the input shaft of the axis-4 reduction gear. If the phase of the hexagon hole of the bolt is not matched, rotate the ball screw spline shaft by hand to match the phase.
6) Remove the hexagon socket head cap screws (M4×12×4 pieces) and washers securing the axis-4 motor, and pull out the axis-4 motor upward.

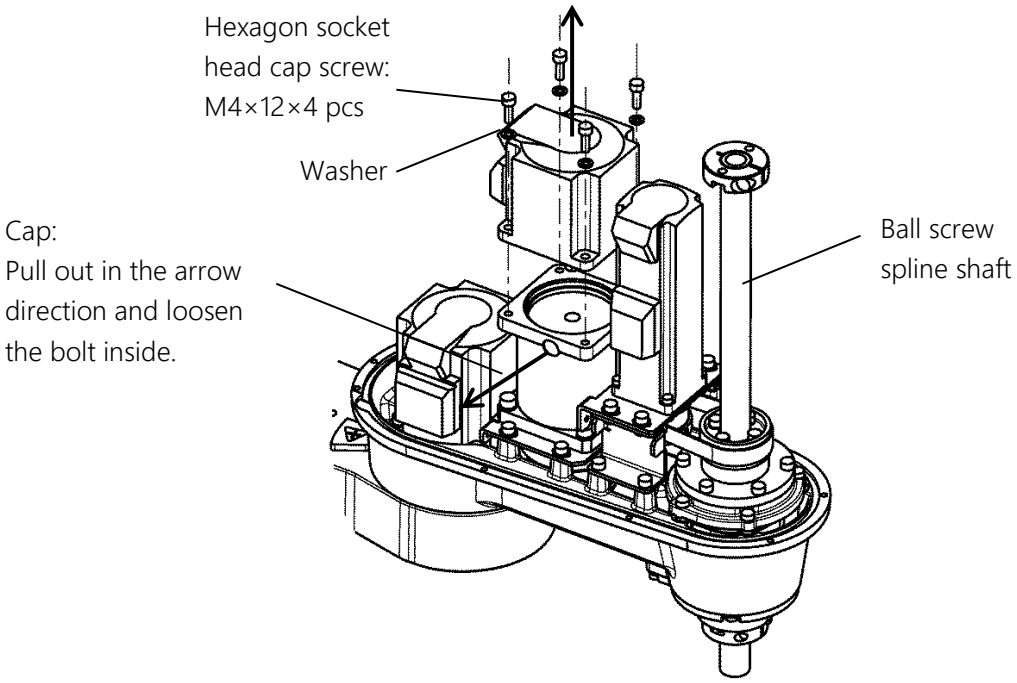


Fig. 7.25 Removing the axis-4 motor

7.4.10 Fitting the Axis-4 Motor

1) Fit a new motor to the axis-4 reduction gear with the hexagon socket head cap screws (M4×12×4 pieces) and washers. When fitting the motor, be careful about the phase. (Recommended clamping torque: 2.5N・m)
2) Clamp the coupling of the axis-4 reduction gear with the accessory bolt (M3) and fit the cap. (Recommended clamping torque: 1.9N・m)

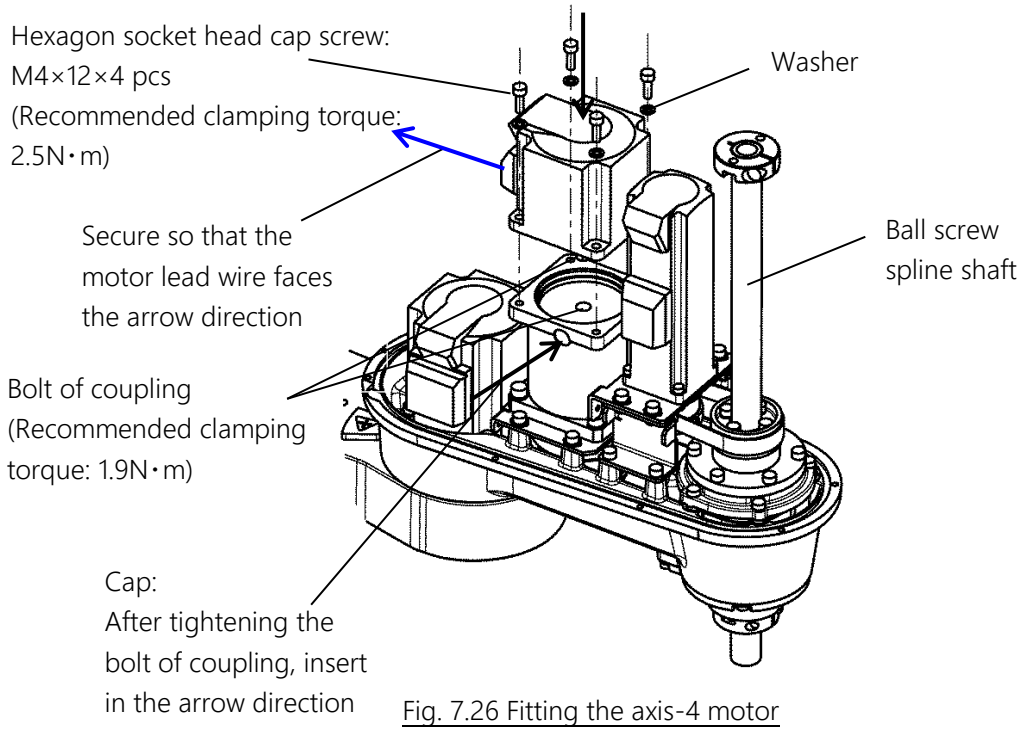


Fig. 7.26 Fitting the axis-4 motor

3) Secure the harness guide and support plate with the hexagon socket head cap screws (M3×6×3 pieces, of which one screw does not require application of Loctite). (See 6) of "7.4.6 Fitting the Axis-2 Motor.")
4) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.4.9 Removing the Axis-4 Motor.")
5) Mount the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
6) Turn on the power and set the zero position of axes 3 and 4 to complete the replacement of the axis-4 motor. The replacement of the axis-4 motor also requires the zero position of the axis 3 to be set. (See "8 Robot Zero Point and Position Detector Error")
7) Perform test operation on axes 3 and 4 to check whether there is any problem with operation of each part.

7.5 Adjustment and Replacement of Timing Belts

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.

Be aware that CKD's warranty does not cover failures and accidents resulting from the replacement of the parts by the customer.

⚠ DANGER

- Be sure to remove the power plug of the controller before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- The axis-3 motor is provided with a brake. During the replacement of the axis-3 timing belt, this brake does not work; therefore, the shaft must be lowered to the lower limit before replacement work. The weight of the shaft or the workpiece could cause the shaft to drop and catch your hand or fingers.
- The removal of a timing belt causes deviation from a mechanical zero position, making normal control impossible. Therefore, it is necessary to restore the zero position after replacing a timing belt. For how to restore the zero position, see "8 Robot Zero Point and Position Detector Error".

7.5.1 Types of Timing Belts

The timing belts used by this robot are as listed in Table 7.5.

When ordering a replacement belt, specify the robot model name, manufacture number, applicable axis, and Shibaura drawing number.

For the location of the manufacture number label, see the INSTRUCTION MANUAL "SAFETY MANUAL".

Table 7.5 Types of timing belts

Part name	Applicable Axis	Width	Shibaura Dwg. No>
Timing belt	Axis 3	10 mm	S958024
	Axis 4	18 mm	S958025

7.5.2 Locations of Timing Belts

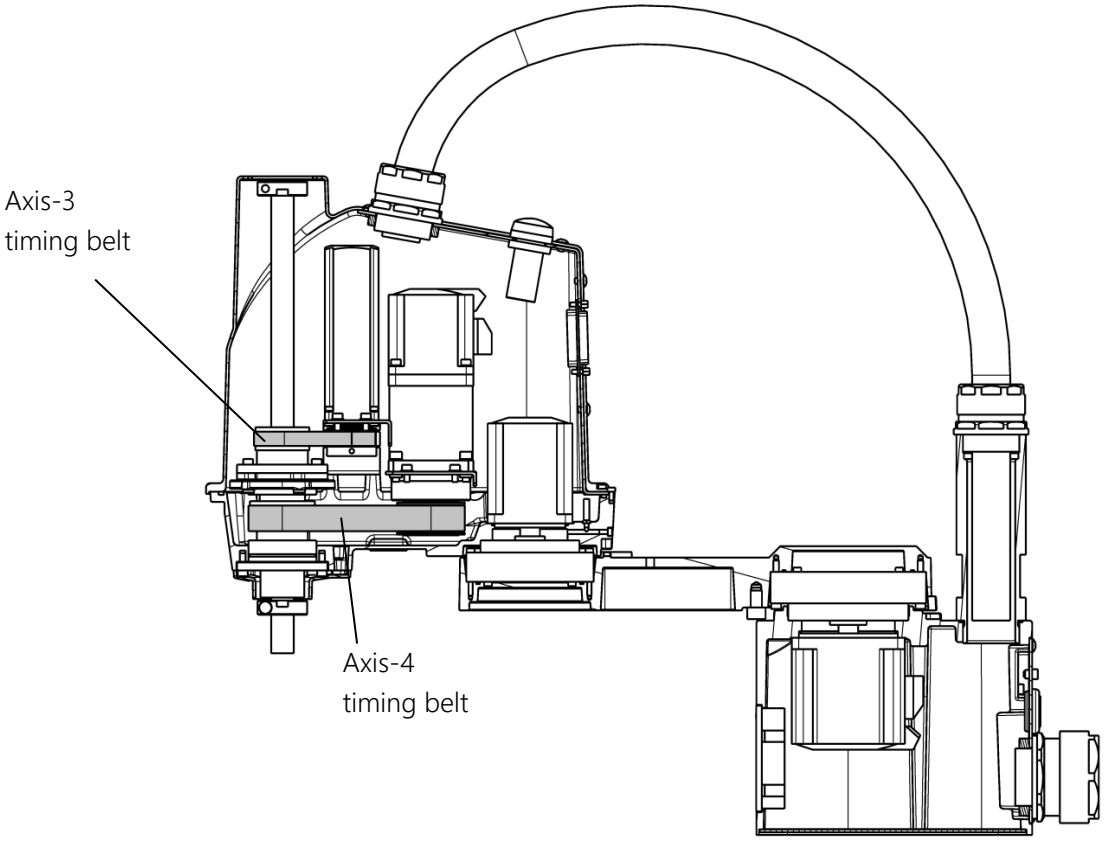


Fig. 7.27 Locations of Timing Belts

7.5.3 Replacing the Axis-3 Timing Belt

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Remove the axis-3 motor assembly. For removal, see "3) and 5) in "7.4.7 Removing the Axis-3 Motor."

⚠ CAUTION

- The axis-3 motor is provided with a brake. During the replacement of the axis-3 motor, this brake does not work; therefore, the ball screw spline must be lowered to the lower limit before replacement work. The weight of the shaft or the workpiece could cause the shaft to drop and catch your hand or fingers.

4) Remove the axis-3 timing belt.

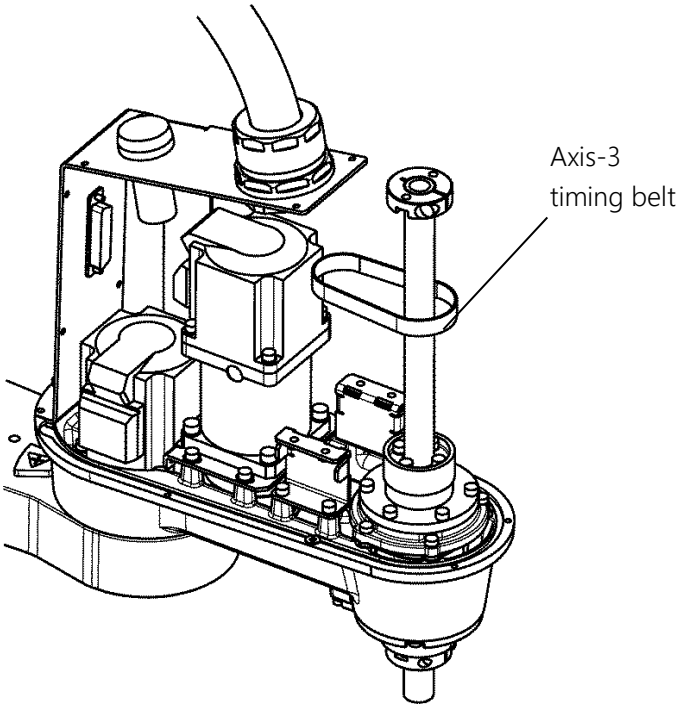


Fig. 7.28 Replacing the axis-3 timing belt

5) Fit a new timing belt.
6) Put the axis-3 timing belt removed in 3) on the axis-3 motor pulley, and temporarily fix the axis-3 motor plate to the axis-3 bracket (metal plate) with the hexagon socket head cap screws (M4×8×4 pieces, not requiring application of screw locking adhesive) and washers. At this time, be careful about the fitting phase of the motor. Move up and down the ball screw spline unit to adjust it. Use the screws for the tension adjustment of the axis 3 (M3×12×2 pieces (accessory), not requiring application of screw locking adhesive) to apply tension. Use a tension meter to measure the tension while pulling the axis-3 motor plate with the screws for the tension adjustment of the axis 3. Tighten the hexagon socket head cap screws at a position where the tension has become a little smaller than 41.5N. (This is because retightening the hexagon socket head cap screws increases the tension.) Make adjustment so that the tension becomes 41.5 to 59.8N when the hexagon socket head cap screws are retightened. After the hexagon socket head cap screws are retightened, remove the screws for the tension adjustment (M3 ×12 ×2 pieces). The value to be used in the tension meter is aslisted in Table 7.6.

Table 7.6 Tension of the axis-3 timing belt

Tension (N)	Unit mass (g/m)	Belt width (mm)	Span (mm)
41.5 to 59.8	2.2	10	50

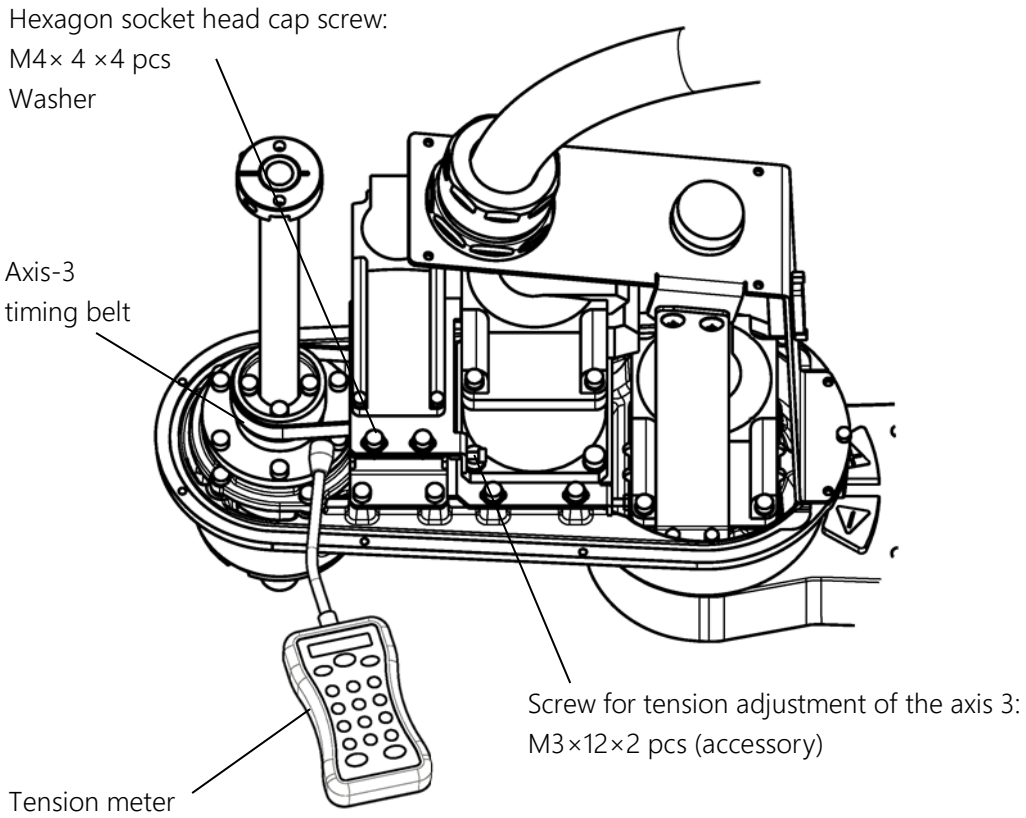


Fig. 7.29 Adjusting the tension of the axis 3

7) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.5.3 Replacing the Axis-3 Timing Belt.")
8) Mount the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
9) Turn on the power and set the zero position of the axes 3 and 4 to complete the replacement of the axis-3 timing belt. (See "8 Robot Zero Point and Position Detector Error")
10) Move up and down the ball screw manually while pressing the brake release switch in the servo OFF condition to make that the ball screw moves smoothly.
11) Perform test operation on the axes 3 and 4 to check whether there is any problem with operation of each part.

7.5.4 Replacing the Axis-4 Timing Belt

⚠ CAUTION

- When the axis-4 timing belt is replaced, the axis 3 must also be disassembled structurally. Therefore, the precautions for the replacement of the axis-3 timing belt and motor must also be observed.
- Take care not to pull out the ball screw spline shaft from the ball screw nut removed together with the ball screw spline shaft. Otherwise, balls will accidentally come out of the ball screw nut, and this will ruin the timing belt.

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect the cable connectors of the axis 3, J3AS and J3AP (axis-3 power drive cables), J3BS and J3BP (axis-3 encoder cables), J3DS and J3DP (axis-3 brake cables) and the cable connectors of the axis-4 motor, J4AS and J4AP (axis-4 power drive cables) and J4BS and J4BP (axis-4 encoder cables).
4) Remove the harness guide secured with the hexagon socket head cap screw (M3×6×1 piece) and the support plate secured with the hexagon socket head cap screws (M3×6×2 pieces). (See 4) in "7.4.5 Removing the Axis-2 Motor.")
5) Remove the axis-3 motor assembly and the axis-3 timing belt. For removal, see 3) and 4) in "7.5.3 Replacing the Axis-3 Timing Belt."
6) Remove the hexagon socket head cap screws (M4×8×4 pieces) securing the axis-3 brackets (metal plate, 2 pieces), and then remove the axis-3 brackets (metal plate, 2 pieces).

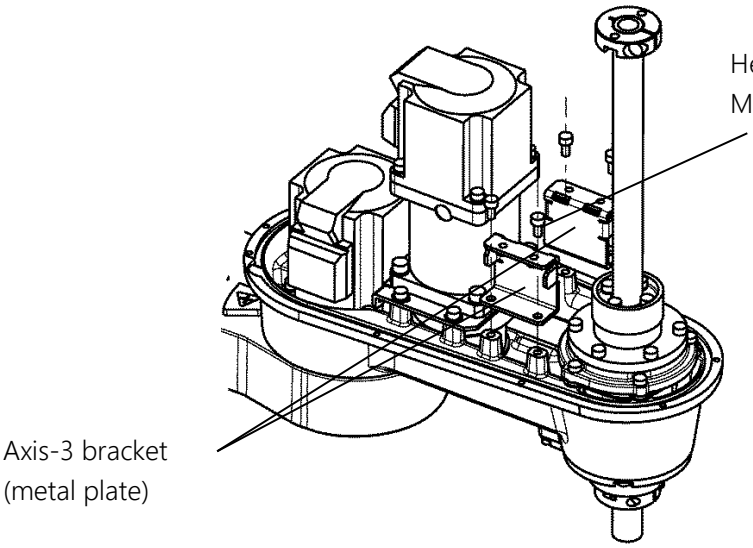


Fig. 7.30 Removing the axis-3 bracket (metal plate)

7) Remove the stopper, ball screw spline shaft, ball screw nut, and axis-3 bracket (cast). For removal, see "7.6.4 Removing the Ball Screw Spline Unit."
8) Remove the hexagon socket head cap screws (M4×8×4 pieces) and washers and remove the axis-4 motor assembly and axis-4 timing belt.

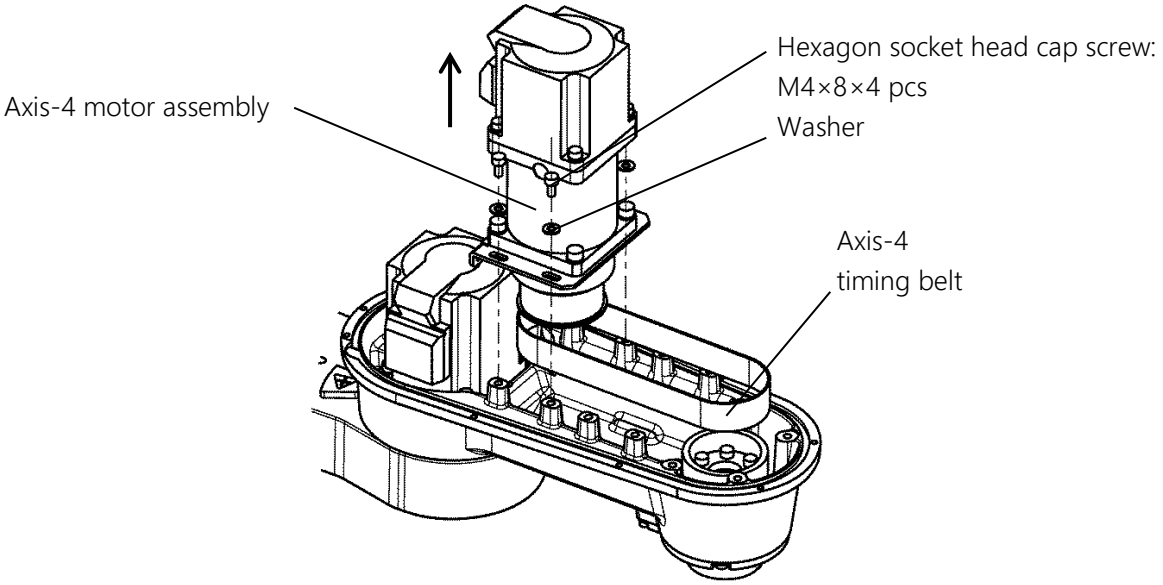


Fig. 7.31 Removing the axis-4 belt and motor assembly

9) Put a new axis-4 timing belt on the pulley, and temporarily fix the axis-4 motor assembly to the arm 2 with the hexagon socket head cap screws (M4×8×4 pieces) and washers.

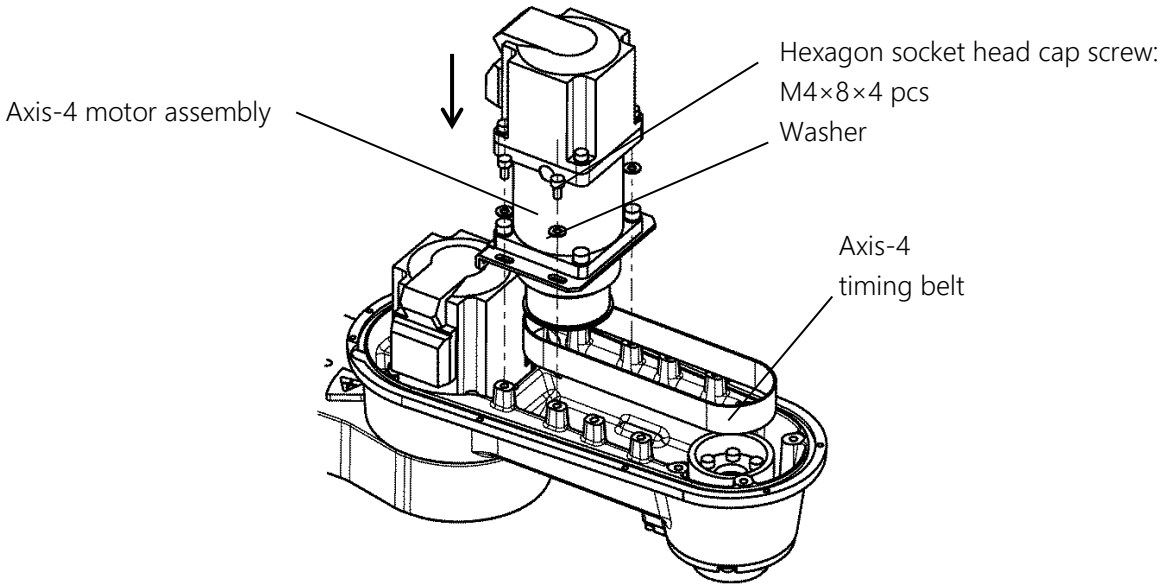


Fig. 7.32 Fitting the axis-4 motor assembly

10) Use a tension meter to measure the tension while pulling the axis-4 motor plate with the screws for the tension adjustment of the axis 4 (hexagon socket head cap screws M3×12×2 pieces (accessory), not requiring application of screw locking adhesive). Tighten the hexagon socket head cap screws at a position where the tension has become a little smaller than 170N. (This is because retightening the hexagon socket head cap screws increases the tension.) Make adjustment so that the tension becomes 170 to 227N when the hexagon socket head cap screws are retightened. After the hexagon socket head cap screws are retightened, remove the screws for the tension adjustment of the axis 4 (hexagon socket head cap screws M3×12×2 pieces).

Table 7.7 Tension of the axis-4 timing belt

Tension (N)	Unit Mass (g/m)	Belt Width (mm)	Span (mm)
170 to 227	2.9	18	105

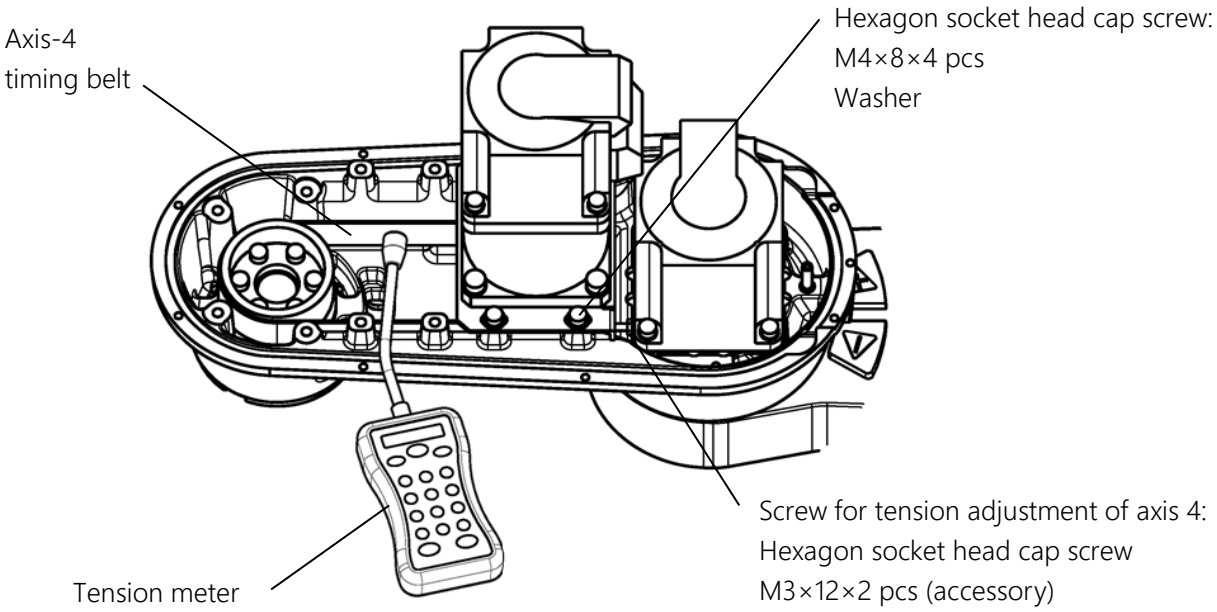


Fig. 7.33 Adjusting the tension of axis 4

11) Temporarily fix the axis-3 bracket (cast) to the arm 2 with the hexagon socket head cap screws (M4×16×4 pieces).

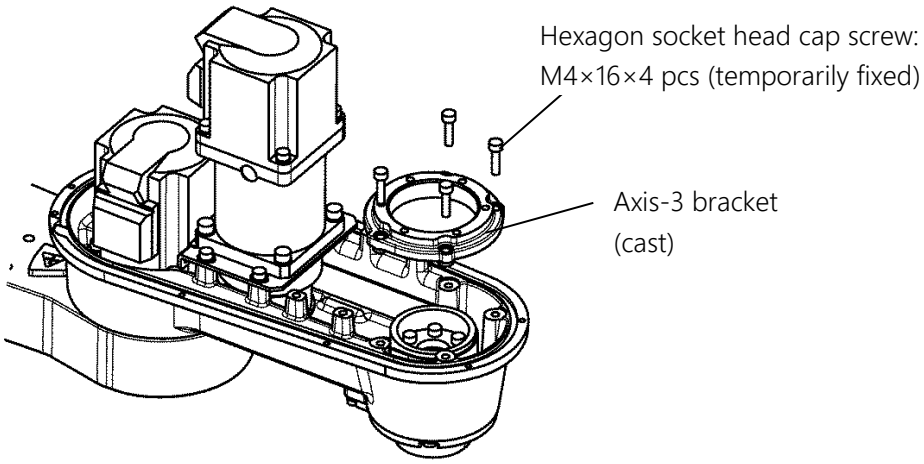


Fig. 7.34 Fitting the axis-3 bracket (cast)

12) Secure the ball screw nut, ball screw spline shaft, and stopper removed in 7) to the arm 2. For how to fit

the ball screw spline unit and stopper, see "7.6.5 Fitting the Ball Screw Spline Unit."

13) Fit the axis-3 motor assembly and timing belt. For how to fit them, see "7.5.3 Replacing the Axis-3 Timing Belt."
14) Secure the harness guide and support plate with the hexagon socket head cap screws (M3×6×3 pieces, of which one piece on the harness guide does not require application of Loctite). (See 6) in "7.4.6 Fitting the Axis-2 Motor.")
15) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.5.4 Replacing the Axis-4 Timing Belt.")
16) Mount the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
17) Turn on the power and set the zero position of the axes 3 and 4 to complete the axis-4 timing belt. (See "8 Robot Zero Point and Position Detector Error")
18) Move up and down the ball screw manually while pressing the brake release switch in the servo OFF condition to make sure that the ball screw moves smoothly.
19) Perform test operation on the axes 3 and 4 to check whether there is any problem with operation of each part.

7.6 Greasing up and Replacement of the Ball Screw Spline Unit

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.

Be aware that CKD's warranty does not cover failures and accidents resulting from the replacement of the parts by the customer.

⚠ DANGER

- The power plug of the controller must be removed before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- The removal of a timing belt causes deviation from a mechanical zero position, making normal control impossible.
  Therefore, it is necessary to restore the zero position after replacing the ball screw spline unit.
  For how to restore the zero position, see "8 Robot Zero Point and Position Detector Error".

7.6.1 Type of the Ball Screw Spline Unit

The ball screw spline units used by this robot are listed in the Table 7.8. When ordering a replacement product, specify the robot model name, manufacture number, Shibaura drawing number and unit code. For the location of the manufacture number label, see the INSTRUCTION MANUAL "SAFETY MANUAL".

Table 7.8 Ball screw spline unit

Part name	Stroke	Shibaura Dwg. No.	Unit code
Ball screw spline unit	160 mm	H852810	Y610A3NE0

7.6.2 Location of the Ball Screw Spline Unit

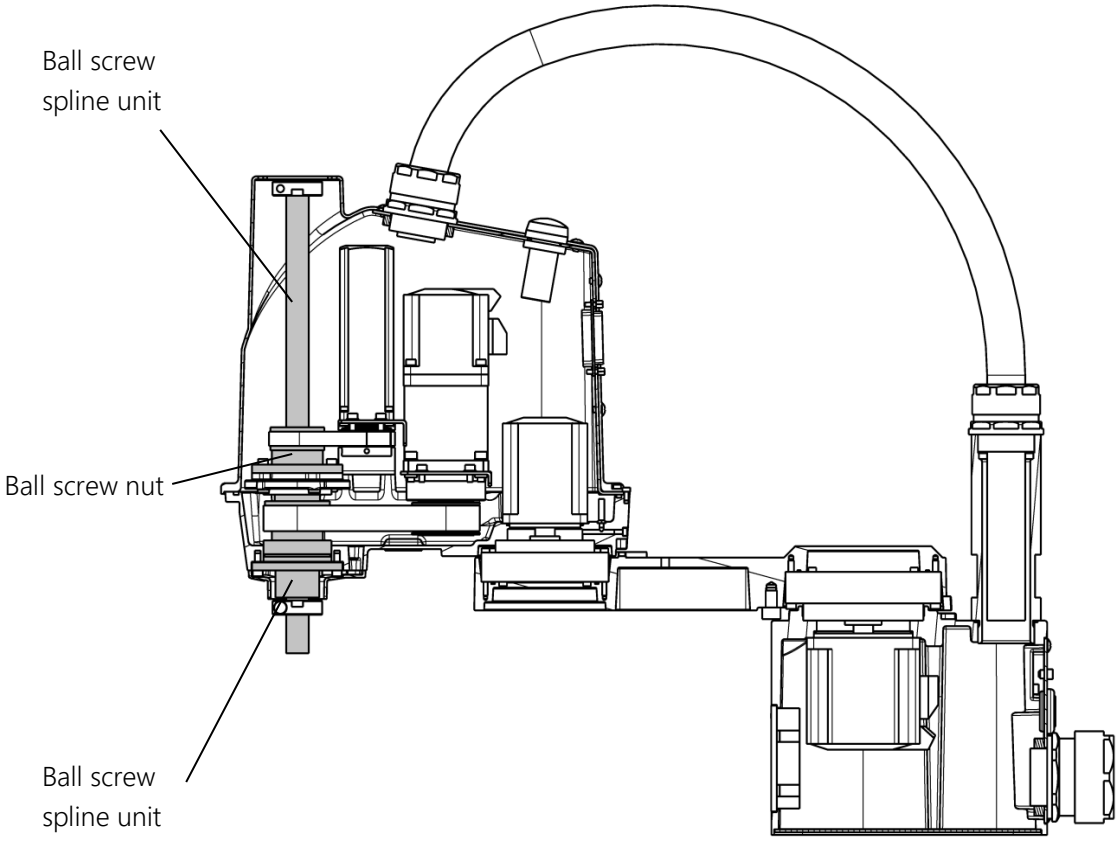


Fig. 7.35 Location of the ball screw spline unit

7.6.3 Greasing Up the Ball Screw Spline Unit and Applying Corrosion Inhibitor

⚠ CAUTION

- When moving up and down the ball screw by hand, take care to prevent your hands and fingers from being caught.
- Since grease may drops onto peripheral equipment, it should be covered.
- A shortage of grease may cause flaws in the sliding part, etc., resulting in a reduction in performance; therefore, take care to prevent a shortage of grease.
- Specified types of grease must be used.
- Corrosion inhibitor must be applied only when it is used up. Failure to apply it results in corrosion of the ball screw spline unit.
- Never touch the ball screw spline unit with bare hands. Touching it with bare hands could accelerate corrosion. Be sure to wear gloves.

The greasing up of the ball screw spline unit should be basically done every three months, but grease must be applied when it is used up.
Also, during a daily inspection, the grease of the ball screw spline unit must be checked.
The state of corrosion inhibitor should be checked during a daily inspection, and if corrosion inhibitor is used up, it must be applied.

Table 7.9 Recommended corrosion inhibitors

Recommended corrosion inhibitor	Maker
Kluber A20	NOK
WD-40	ST Trading

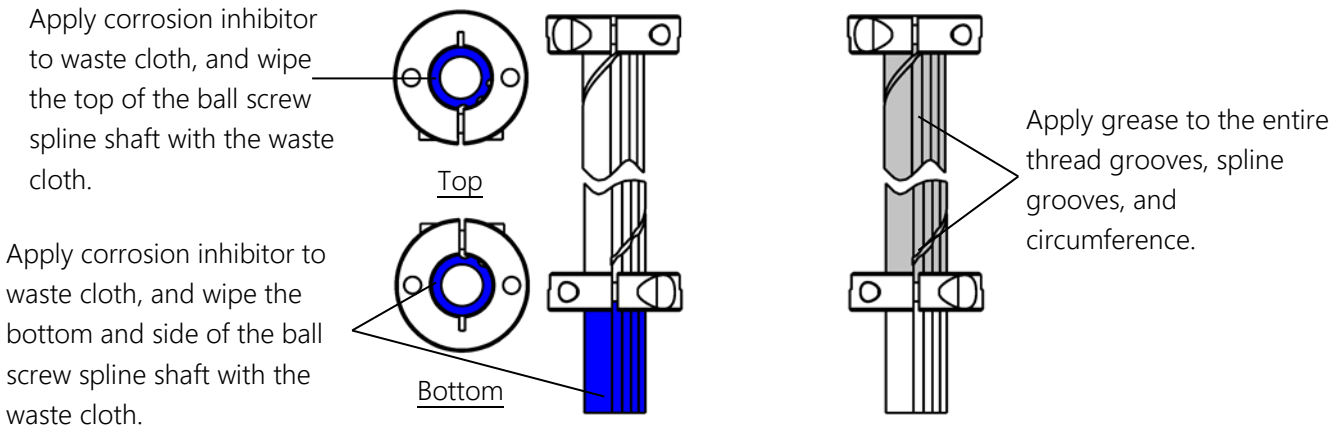


Fig. 7.36 Parts of the ball screw spline unit to which corrosion inhibitor or grease is applied

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Connect the power plug of the controller, and turn off the servos.
3) Move the arm by hand to a position where it can be moved along its full stroke length on the axis 3.
4) Press down the ball screw spline shaft to the lower limit while pressing the axis-3 brake release switch.
5) Apply grease, with a brush, etc., to the visible part of the shaft. Apply it so that shaft grooves are filled. For the part to apply grease to, see Fig. 7.36.

Table 7.10 Recommended grease

Recommended grease	Maker
AFF grease	THK

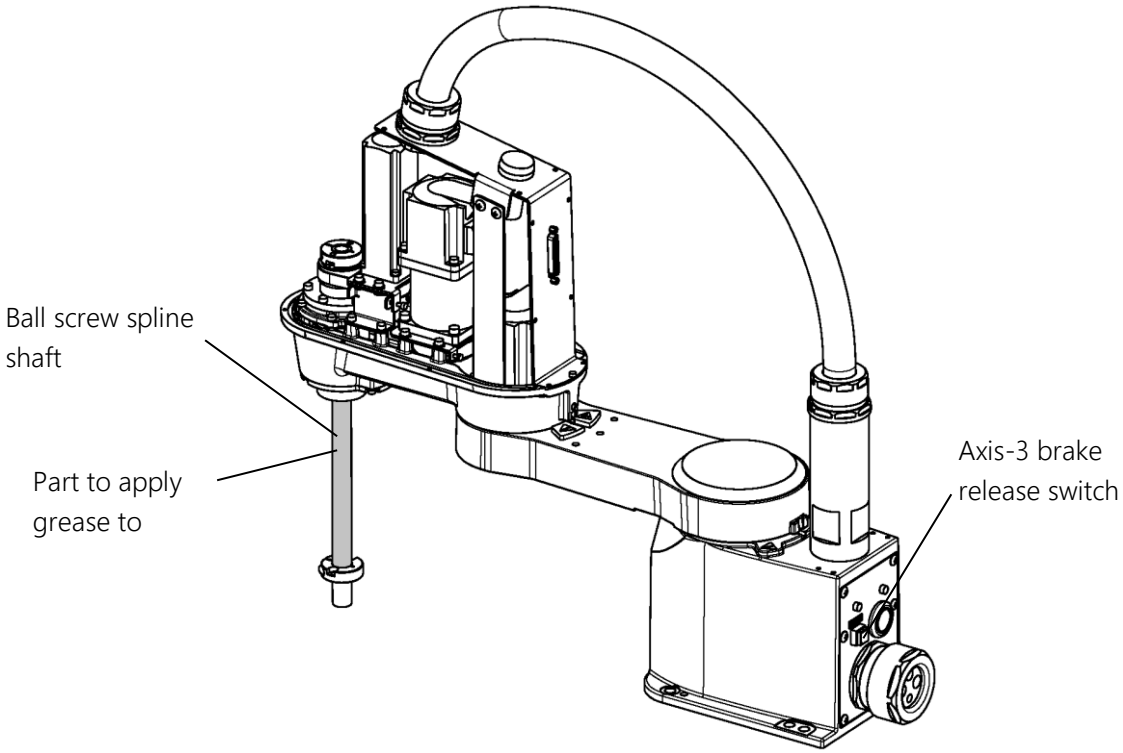


Fig. 7.37 Greasing up the lower side of the ball screw spline unit

6) Press up the shaft to the upper limit while pressing the axis-3 brake release switch.
7) Use a brush or the like to apply grease to the visible part of the shaft on the top of the ball screw nut. Apply it so that shaft grooves are filled. For the part to apply grease to, see Fig. 7.36.

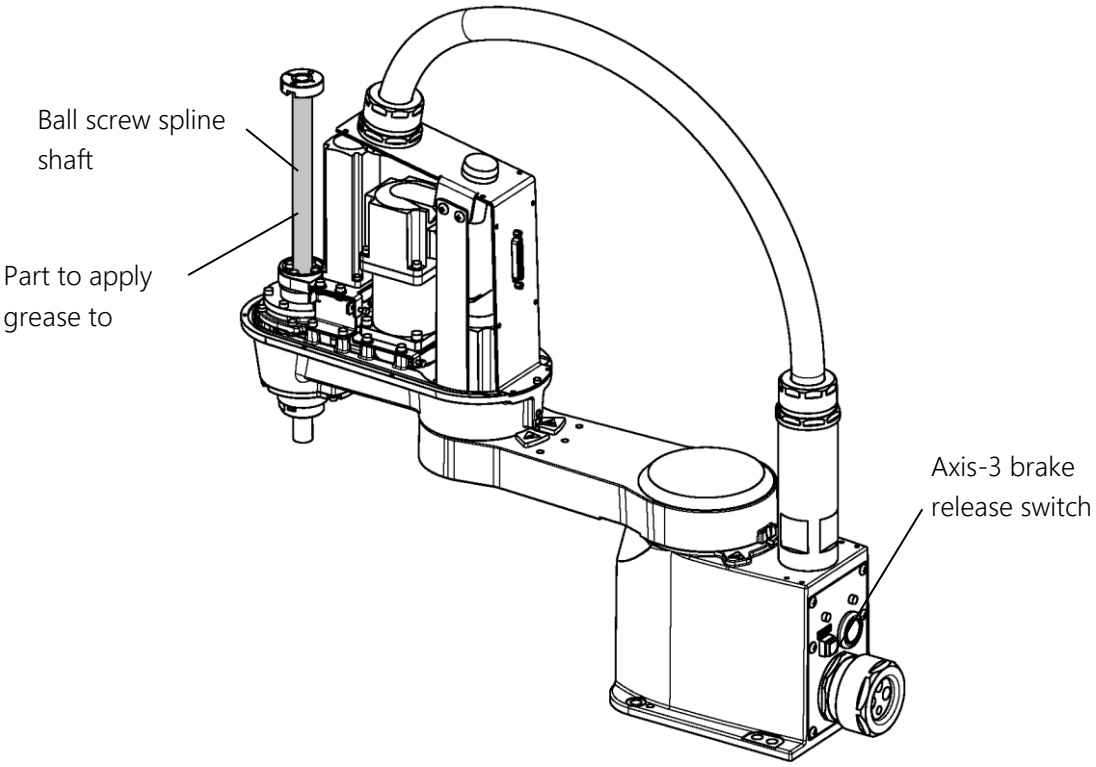


Fig. 7.38 Greasing up the upper side of the ball screw spline unit

8) Move up and down the shaft several times while pressing the axis-3 brake release switch to smooth out the grease. Then, wipe out excess grease to finish the work.

7.6.4 Removing the Ball Screw Spline Unit

⚠ DANGER

- The power plug of the controller must be removed before replacement work.
  If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- Be careful when handling the ball screw spline unit. Drop impact or application of excessive force could ruin the unit.
- Replacement work for the ball screw spline unit requires the fitting and removal of the motors and timing belts of the axes 3 and 4; therefore, the precautions described in each section must be observed.
- The removal of a motor, timing belt, nut, or pulley causes deviation from a mechanical zero position, making normal control impossible. Therefore, it is necessary to restore the zero positions of the axes 3 and 4 after replacing the ball screw spline unit. For how to restore the zero positions, see "8 Robot Zero Point and Position Detector Error."
- Never touch the ball screw spline unit with bare hands. Touching it with bare hands could accelerate corrosion. Be sure to wear gloves.

The description on how to replace the ball screw spline unit does not refer to any replacement procedure for the motor or timing belt of the axis 3 or axis 4. Therefore, see the sections of their respective replacement procedures. (See "7.4.7 Removing the Axis-3 Motor", "7.4.9 Removing the Axis-4 Motor", "7.5.3 Replacing the Axis-3 Timing Belt", "7.5.4 Replacing the Axis-4 Timing Belt", and 7.7.7 Removing the Axis-4 Reduciton Gear.)

1) Remove the axis-2 arm cover. (See "7.3.1 Arm-2 Cover".)
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect the cable connectors of the axis 3, J3AS and J3AP (axis-3 power drive cables), J3BS and J3BP (axis-3 encoder cables) and J3DS and J3DP (axis-3 brake cables) and the cable connectors of the axis-4 motor, J4AS and J4AP (axis-4 power drive cables), J4BS and J4BP (axis-4 encoder cables).
4) Use a tension meter to measure the tension of the axis-3 timing belt. Be sure to record the results of measuring the tension using the tension meter. (For the measurement method, see 4) in "7.4.7 Removing the Axis-3 Motor.")
5) Remove the harness guide secured with the hexagon socket head cap screw (M3×6×1 pieces) and the support plate secured with the hexagon socket head cap screws (M3×6×2 pieces). (See 4) in "7.4.5 Removing the Axis-2 Motor.")
6) Remove the hand, tool, etc., and remove the lower stopper.
7) Remove the axis-3 motor assembly and the axis-3 timing belt. Also, relax the tension of the axis-4 belt.
8) Remove the hexagon socket head cap screws (M4×12×6 pieces), and the pull out the ball screw nut and ball screw spline shaft together upward. Be careful when pulling them out.
9) Remove the hexagon socket head cap screws (M4×16×4 pieces) securing the axis-3 bracket (cast), and remove the axis-3 bracket (cast) from the arm 2.
10) Remove the hexagon socket head cap screws (M4×25×4 pieces) and washers, and remove the upper stopper and the axis-3 nut pulley secured to the ball screw nut.

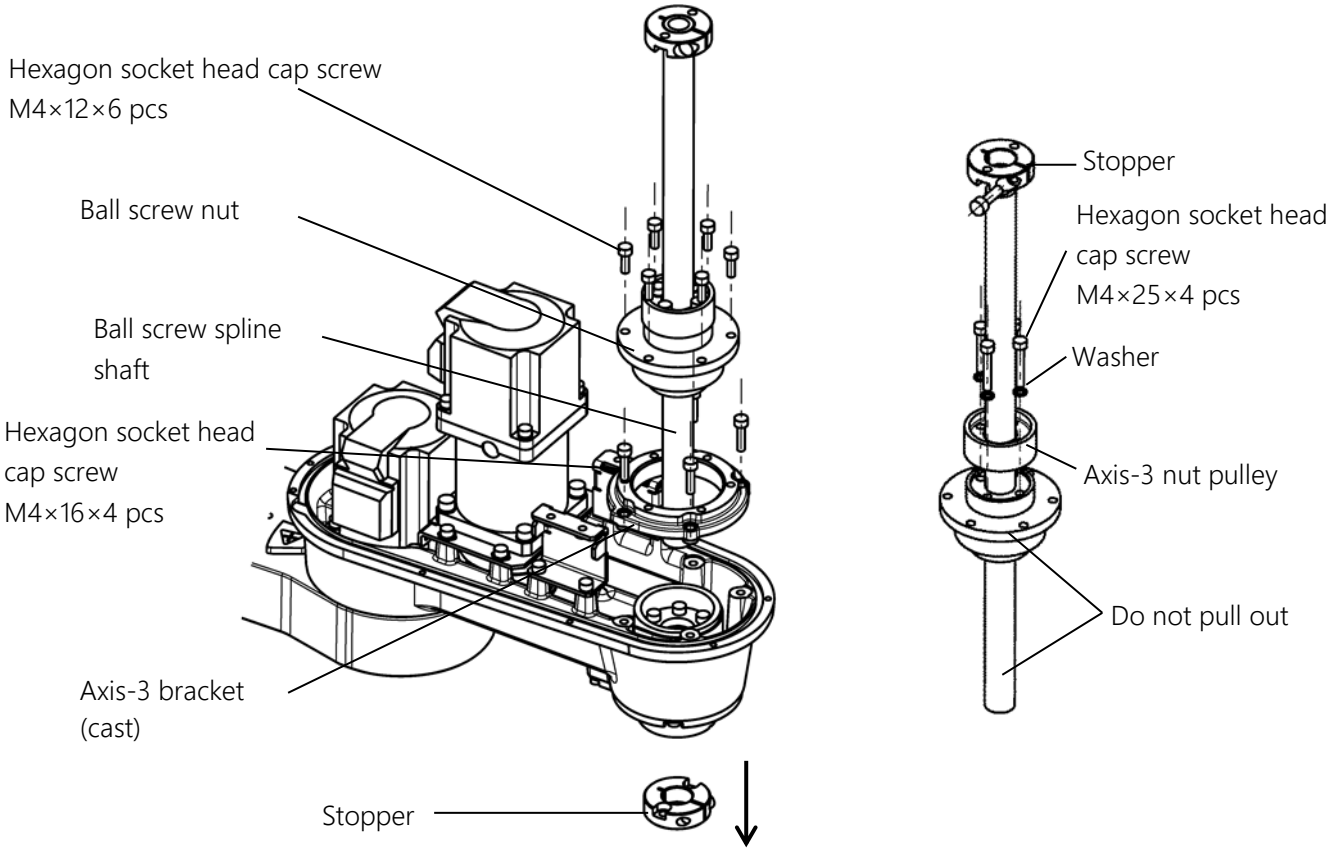


Fig. 7.39 Removing the ball screw spline unit

⚠ CAUTION

- Take care not to pull out the ball screw spline shaft from the ball screw nut; these are kept joined after removal. Otherwise balls will accidentally come out of the ball screw nut, and this will ruin the unit.

11) Use a tension meter to measure the tension of the axis-4 timing belt. Enter the following values as the values input to the tension meter. Be sure to record the results of measuring the tension using the tension meter. For the measurement method, see 6) in "7.7.7 Removing the Axis-4 Reduciton Gear.")
12) Remove the hexagon socket head cap screws (M3×6×2 pieces and M4×12×2 pieces) securing the spline nut cover, and remove the spline nut cover. Then, remove the hexagon socket head cap screws (M4×12×4 pieces) securing the ball spline nut, and pull out the ball spline nut. If the ball spline nut is difficult to come off, hit the pulley softly with a plastic hammer or the like that is unlikely to damage the pulley to remove the ball spline nut. If the pulley is hit strongly with the hammer or the ball spline nut is forcibly pulled out, the arm 2 is deformed and a new ball screw cannot be fitted accurately. Leave the axis-4 timing belt inside the arm 2 unchanged.
13) Remove the axis-4 nut pulley secured to the ball spline nut with the hexagon socket head cap screws (M4×10×6 pieces) and washers.

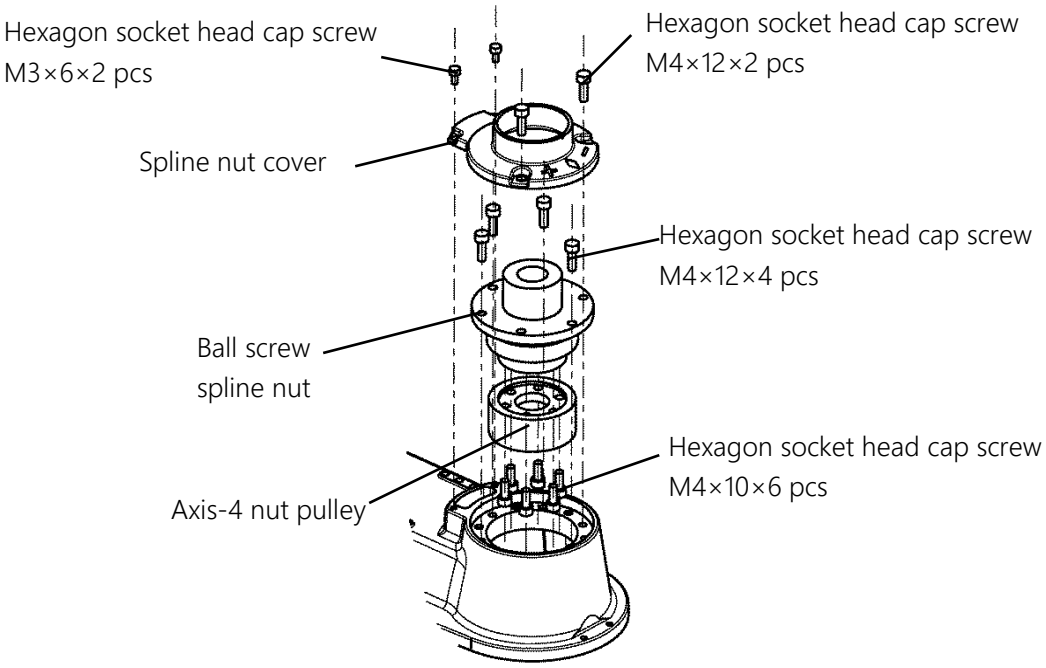


Fig. 7.40 Removing the ball screw spline nut

14) After removing the ball spline nut, insert it into the ball screw spline shaft. When inserting it, match the phases of the marks engraved on both the ball screw spline shaft and the ball spline nut. Wrapping a cable strap around the both ends of the ball screw spline shaft prevents the nut from falling off.

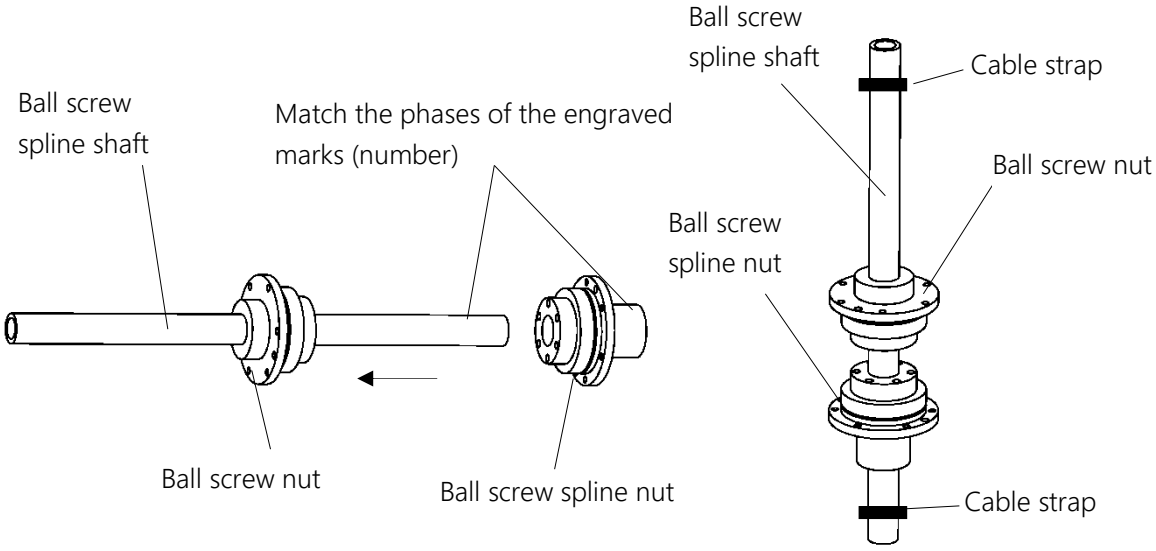


Fig. 7.41 Ball screw spline unit

7.6.5 Fitting the Ball Screw Spline Unit

⚠ DANGER

- The power plug of the controller must be removed before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- Be careful when handling the ball screw spline unit. Drop impact or application of excessive force could ruin the unit.
- Replacement work for the ball screw spline unit requires the fitting and removal of the timing belts of the axes 3 and 4; therefore, the precautions described in each section must be observed.
- The removal of a timing belt, nut, or pulley causes deviation from a mechanical zero position, making normal control impossible.
  Therefore, it is necessary to restore the zero positions of the axes 3 and 4 after replacing the ball screw spline unit.
  For how to restore the zero positions, see "8 Robot Zero Point and Position Detector Error".
- Take care not to pull out the ball screw spline shaft from the ball screw nut. Otherwise balls will accidentally come out of the ball screw nut, and this will ruin the unit.
- Never touch the ball screw spline unit with bare hands. Touching it with bare hands could accelerate corrosion. Be sure to wear gloves.

1) Remove the ball spline nut from the new ball screw spline unit.
2) Fit the axis-4 nut pulley to the ball spline nut with the hexagon socket head cap screws (M4×10×6 pieces). The pulley rotates making it difficult to tighten the screws; therefore, secure the pulley with a plier, etc., while protecting it with a waste cloth so that it is not damaged when tightening the screws.
3) Fit the ball spline nut to the arm 2 with the hexagon socket head cap screws (M4×12×4 pieces). (For the fitting positions of the hexagon socket head cap screws, see Fig. 7.42.) Fit it so that the arm-4 timing belt in the arm 2 is engaged with the pulley.

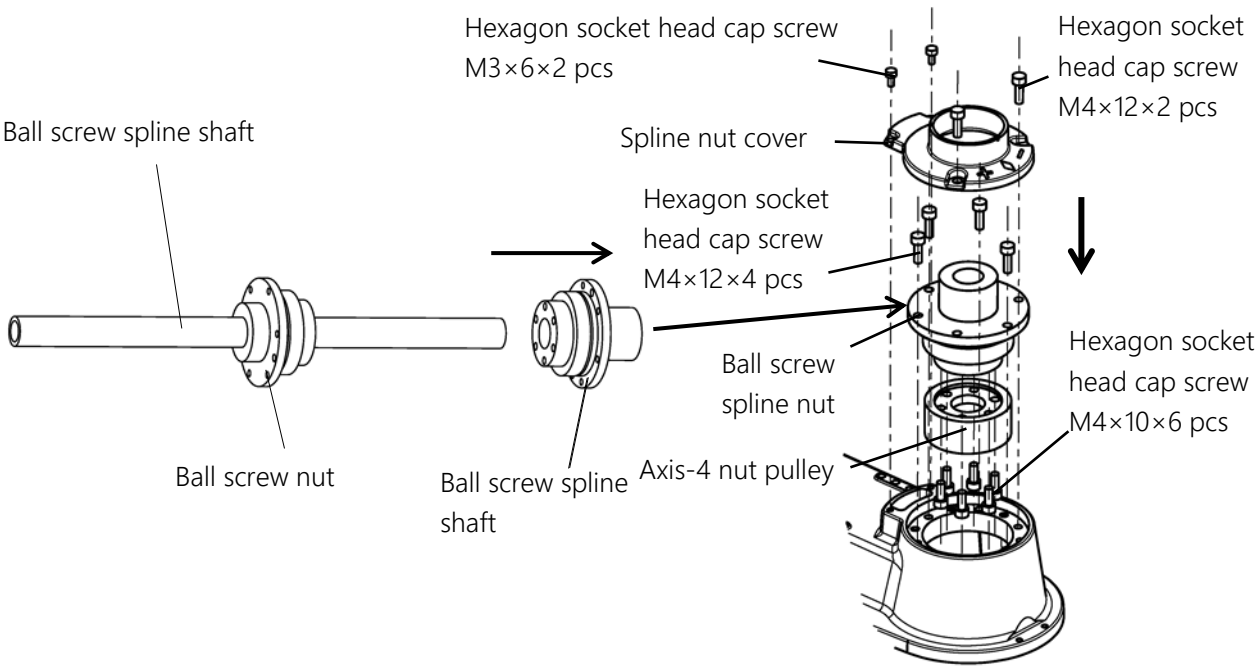


Fig. 7.42 Fitting the ball spline nut

4) Adjust the tension of the axis-4 timing belt. (See 6) in "7.7.8 Fitting the Axis-4 Reduction Gear".)
5) Secure the axis-3 nut pulley and upper stopper to the ball screw nut with the hexagon socket head cap screws (M4×25×4 pieces) and washers. Be careful about the fitting orientation of the upper stopper (see Fig. 7.42).
6) Temporarily fix the axis-3 bracket (cast) to the arm 2 with the hexagon socket head cap screws (M4×16×4 pieces). Secure the ball screw nut to the axis-3 bracket (cast) with the hexagon socket head cap screws (M4×12×6 pieces). At this time, put the axis-4 timing belt on the axis-4 pulley.
7) Fit the stopper to the portion of 27 mm from the lower end of the ball screw spline shaft. When fitting the stopper, align the dividing portion of the stopper with the left end of the spline groove.
8) Move up and down the ball screw spline shaft to adjust it. Then, retighten the hexagon socket head cap screws (M4×16×4 pieces) securing the axis-3 bracket (cast) while pressing the axis-3 bracket to prevent it from moving.

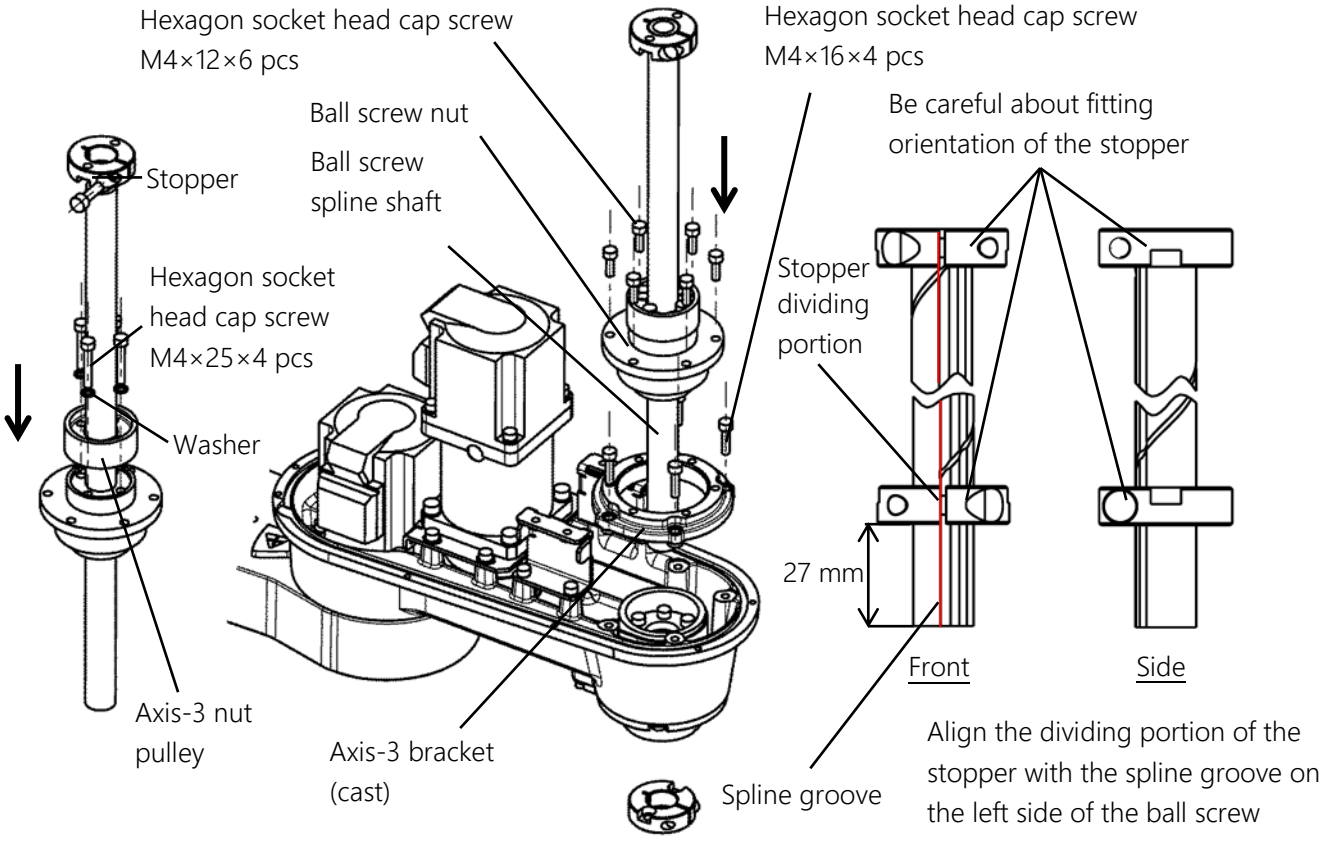


Fig. 7.43 Fitting the ball screw spline unit

9) Adjust the tension of the axis-4 timing belt. (See "7.5.4 Replacing the Axis-4 Timing Belt".)
10) Fit the axis-3 motor assembly and axis-3 timing belt and adjust the belt tension. (See "7.5.3 Replacing the Axis-3 Timing Belt.")
11) Secure the harness guide and support plate with the hexagon socket head cap screws (M3×6×3 pieces, of which one piece on the harness guide does not require application of Loctite). (See 6) in "7.4.6 Fitting the Axis-2 Motor.")
12) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.6.4 Removing the Ball Screw Spline Unit.")
13) Mount the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
14) Turn on the power and set the zero positions of the axes 2, 3 and 4. (See "8 Robot Zero Point and Position Detector Error.") When setting the zero position of the axis 4, align the dividing portion of the stopper with the zero point match-mark. After setting the zero position, attach the match-mark from the old ball spline nut to the new ball spline nut. For the location of the zero point match-mark, see "8.5.1 Locations of Zero Point Match-Marks of the Robot."
15) Move up and down the ball screws while pressing the brake release switch in the servo OFF condition to check that the ball screw moves smoothly.
16) Perform test operation on the axes 3 and 4 to check whether there is any problem with operation of each part.

7.7 Replacing Reduction Gears

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.

Be aware that CKD's warranty does not cover failures and accidents resulting from the replacement of the parts by the customer.

⚠ DANGER

- The power plug of the controller must be removed before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

⚠ CAUTION

- The removal of a reduction gear causes deviation from a mechanical zero position, making normal control impossible.
  Therefore, it is necessary to restore the zero position after replacing the reduction gear.
  For how to restore the zero position, see "8 Robot Zero Point and Position Detector Error".

7.7.1 Types of Reduction Gears

The reduction gears used by this robot are as listed in Table 7.11.

When ordering a replacement reduction gear, specify the robot model name, manufacture number, applicable axis, Shibaura drawing number, and unit code.

For the location of the manufacture number label, see the INSTRUCTION MANUAL "SAFETY MANUAL".

Table 7.11 Types of reduction gears

Part name	Applicable axis	Shibaura Dwg. No.	Unit code
Reduction gear	Axis 1	S948805	Y610D04R0
	Axis 2	S948806	Y610D04S0
	Axis 4	S958005	Y610D05P0

7.7.2 Locations of Reduction Gears

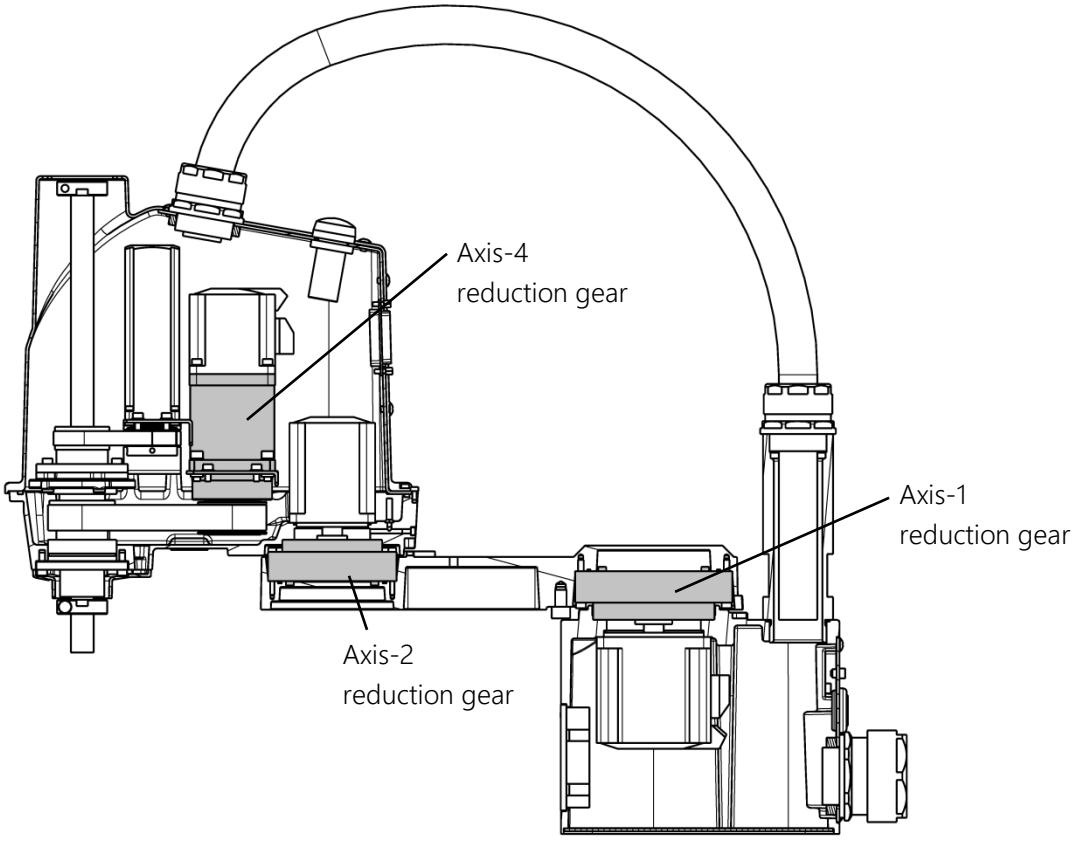


Fig. 7.44 Locations of reduction gears

7.7.3 Removing the Axis-1 Reduciton Gear

1) Remove the base rear cover and base bottom cover. (See "7.3.2 Base Cover.")
   The base rear cover is connected with the connectors inside; therefore, do not pull it forcibly.
2) Remove the axis-1 motor assembly and O ring (CO0534A). (See "7.4.3 Removing the Axis-1 Motor.")
3) Remove the hexagon socket head cap screws (M4×20×16 pieces) securing the arm 1 and remove the arm 1.

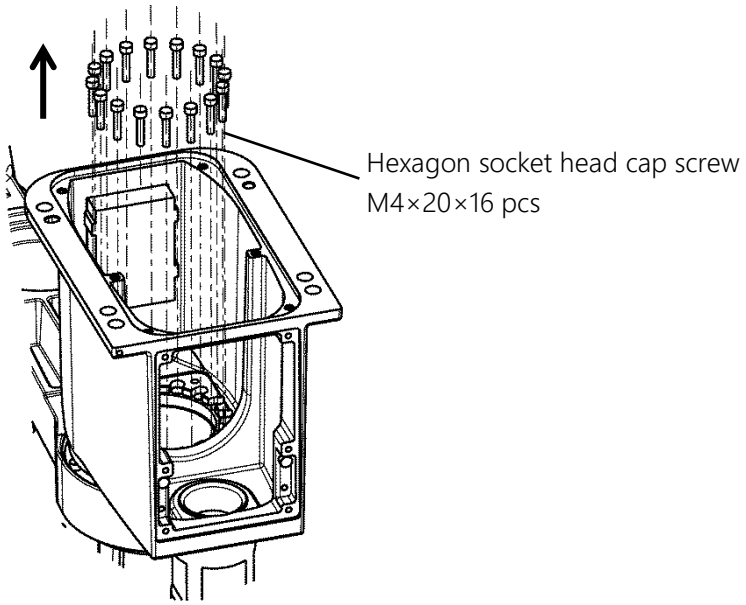


Fig. 7.45 Removing the arm 1

⚠ CAUTION

- When fitting or removing the arm, this must be done by two or more persons. If the screws securing the arm are removed, the arm drops causing danger. Also, excessive impact on the arm may cause a failure.

4) Remove the hexagon socket head cap screws (M4×30×12 pieces) securing the axis-1 reduction gear, and remove the axis-1 reduction gear. At this time, remove the O ring from the groove of the arm 1 as well.
5) Remove the elliptical cam from the axis-1 motor. (See "7.4.3 Removing the Axis-1 Motor.")

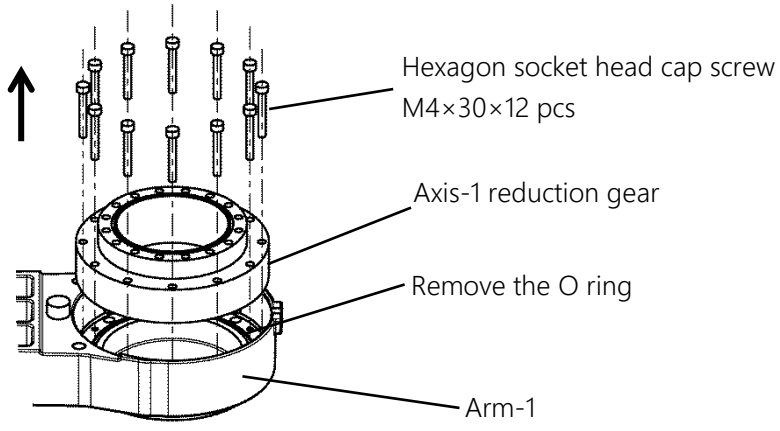


Fig. 7.46 Removing the axis-1 reduction gear

7.7.4 Fitting the Axis-1 Reduction Gear

⚠ CAUTION

- Be careful when handling a reduction gear. Drop impact or application of excessive force could ruin the reduction gear.
- Use the elliptical cam provided with a new reduction gear. There is compatibility between the elliptical cam and the reduction gear; therefore, using an old elliptical cam unchanged causes abnormal sound as well as deteriorates the service life and positioning accuracy.
- Use a new O ring provided with the reduction gear as well. Also, be careful not to forget fitting the O ring. If the O ring is forgotten to be fitted, grease leaks from the fitting surface of the axis-1 reduction gear. Fit the reduction gear carefully to prevent the O ring from being cut.

1) Fit the elliptical cam provided with a new reduction gear. For the fitting procedure, see "7.4.4 Fitting the Axis-1 Motor."
2) Wipe off dust, dirt, etc. from the fitting portion of the axis-1 reduction gear in the arm 1 well. Apply grease to the O ring provided with the new reduction gear, and fit it into the O ring groove of the arm 1.
3) Secure the axis-1 reduction gear with the hexagon socket head cap screws (M4×30×12 pieces).

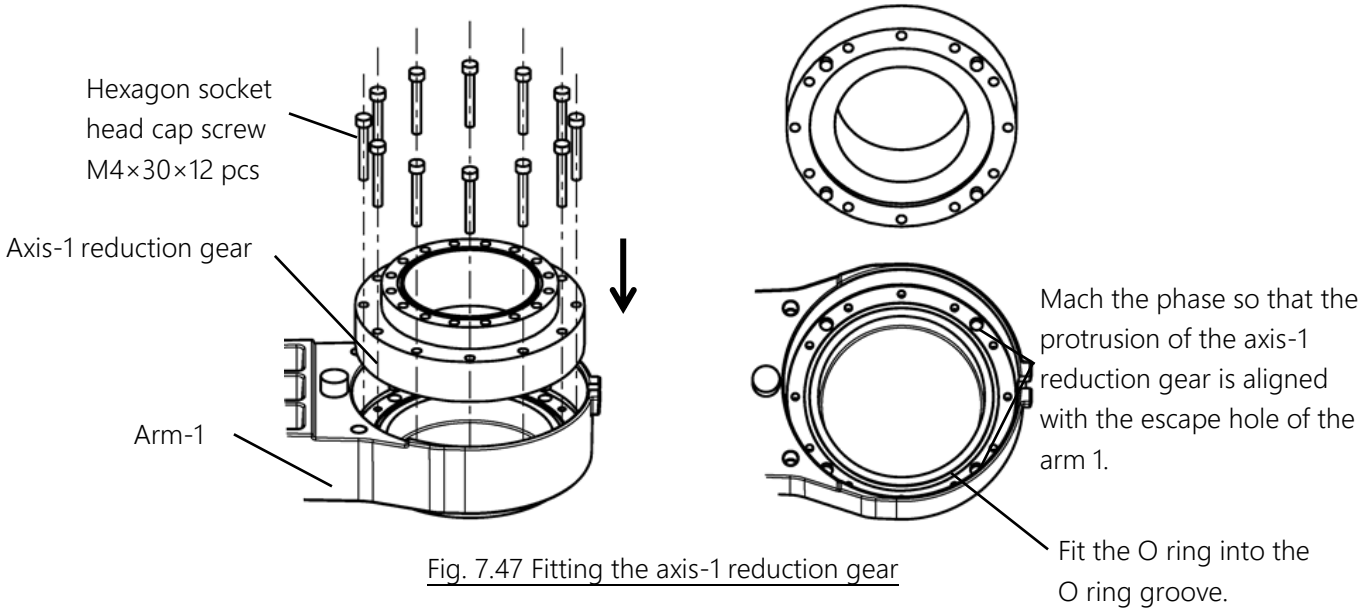


Fig. 7.47 Fitting the axis-1 reduction gear

4) Apply the amount of grease listed in Table 7.12 to the inside of the axis-1 reduction gear body as shown in Fig. 7.48. Similarly, apply grease to the axis-1 motor side as well.

Table 7.12 Application amount of grease

Recommended grease	Maker	Application amount to axis-1 reduction gear side	Application amount to axis-1 motor side
SFB No.1	Nidec-Shimpo Corp.	35 g	27 g

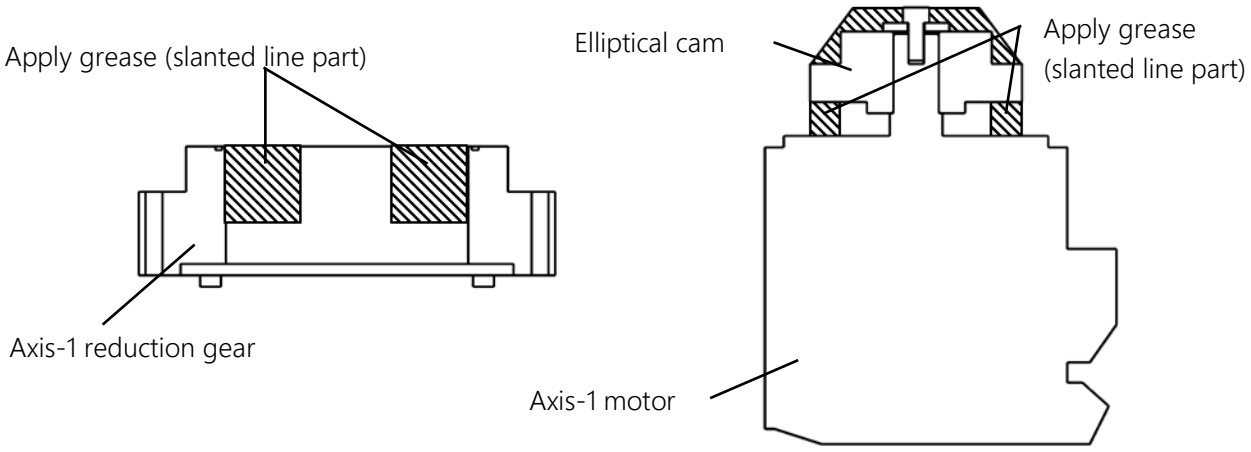


Fig. 7.48 Applying Grease to Axis-1 Reduction Gear

⚠ CAUTION

- Be sure to use the specified types of grease. When the internal pressure becomes high, the starting torque is adversely affected as well as breakage of the internal seal is caused; therefore be sure to observe the application amount of grease.

5) Secure the arm 1 to the base with the hexagon socket head cap screws (M4×20×16 pieces).

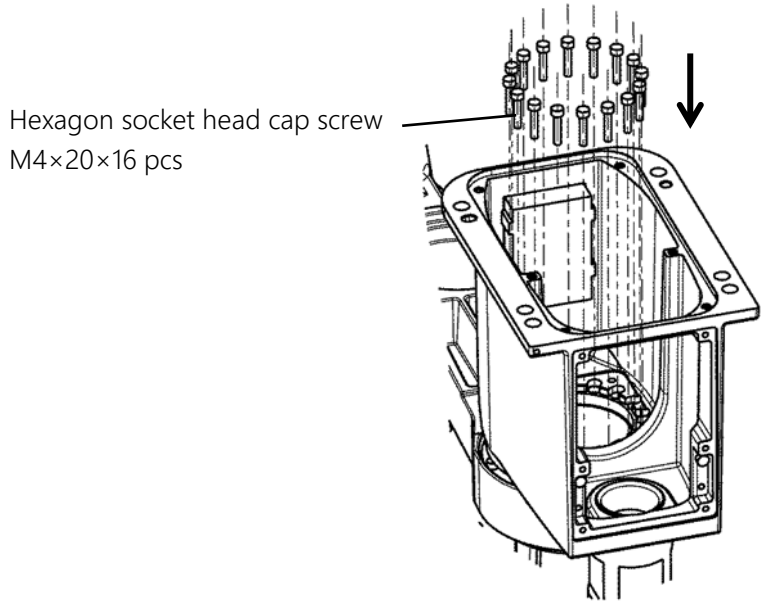


Fig. 7.49 Fitting the Arm 1

6) Apply grease to the O ring (CO0534A) and fit it to the base groove side face. Fit the axis-1 motor

assembly. (See "7.4.4 Fitting the Axis-1 Motor.")

7) Move the arm 1 by hand to make sure that it moves smoothly.
8) Fit the base rear cover and base bottom cover. (See "7.3.2 Base Cover.")
9) Set the zero position of the axis 1 to complete the replacement of the axis-1 reduction gear.
10) Perform test operation on the axis 1 to check whether there is any problem with operation of each part.

7.7.5 Removing the Axis-2 Reduciton Gear

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect J2AS and J2AP (axis-2 power drive cables) and J2BS and J2BP (axis-2 encoder cables).
4) Remove the harness guide and support plate, and remove the axis-2 motor assembly. Also, remove the O ring (CO0538A) from the O ring groove as well. (See "7.4.5 Removing the Axis-2 Motor.")
5) Remove the hexagon socket head cap screws (M3×20×16 pieces) securing the arm 2 and reduction gear.
6) Remove the hexagon socket head cap screws (M3×30×12 pieces) securing the axis-2 reduction gear fitted in the arm 1, and remove the axis-2 reduction gear. Also, remove the O ring (provided with the reduction gear) from the O ring groove as well.
7) Remove the elliptical cam from the axis-2 motor. (See "7.4.5 Removing the Axis-2 Motor.")

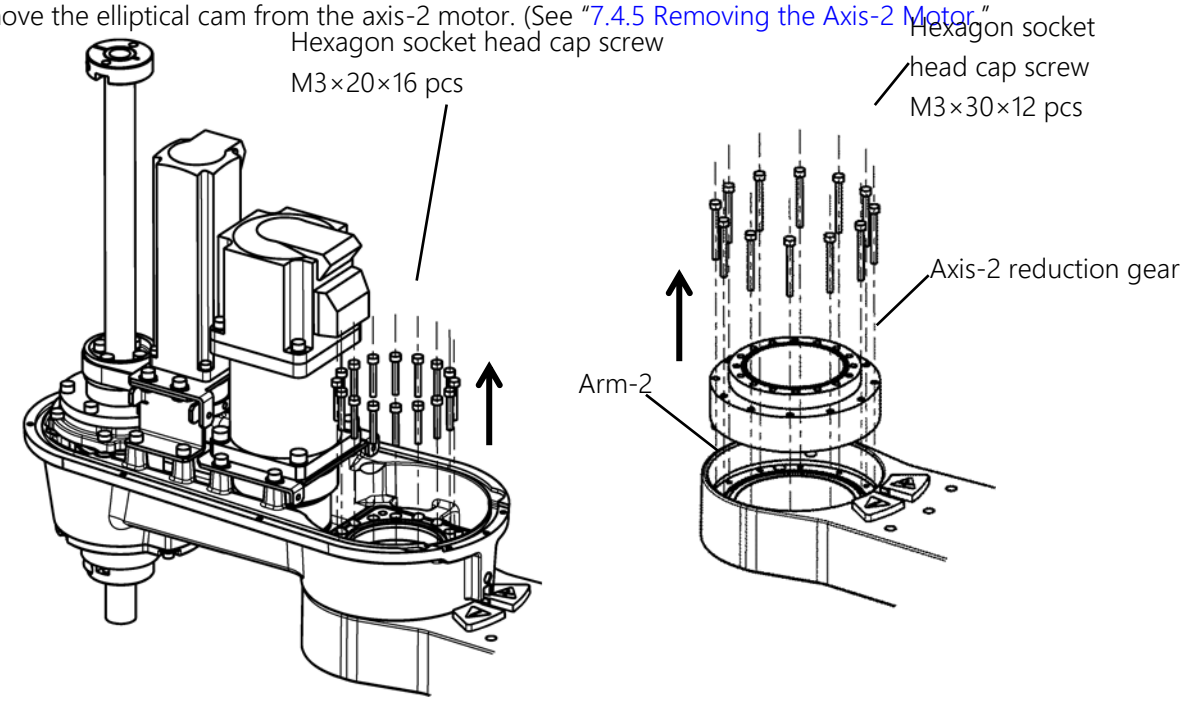


Fig. 7.50 Removing the axis-2 reduction gear

⚠ CAUTION

- When fitting or removing the arm, this must be done by two or more persons.
  If the bolts securing the arm are removed, the arm 1 drops causing danger.
  Also, excessive impact on the arm may cause a failure.

7.7.6 Fitting the Axis-2 Reduction Gear

⚠ CAUTION

- Be careful when handling a reduction gear. Drop impact or application of excessive force could ruin the reduction gear.
- Use the elliptical cam provided with a new reduction gear. There is compatibility between the elliptical cam and the reduction gear; therefore, using an old elliptical cam unchanged causes abnormal sound as well as deteriorates the service life and positioning accuracy.
- Use a new O ring provided with the reduction gear as well. Also, be careful not to forget fitting the O ring. If the O ring is forgotten to be fitted, grease leaks from the fitting surface of the axis-2 reduction gear. Fit the reduction gear carefully to prevent the O ring from being cut.

1) Fit the elliptical cam provided with a new reduction gear to the axis-2 motor. At this time, apply grease to the O ring (CO0538A) and fit it in the spigot joint of the axis-2 motor. (See "7.4.6 Fitting the Axis-2 Motor.")
2) Wipe off dust, dirt, etc. from the fitting portion of the reduction gear in the arm 1 well. Apply grease to the O ring provided with the new reduction gear, and fit it into the O ring groove of the arm 1.
3) Secure the axi-2 reduction gear to the arm 1 with the hexagon socket head cap screws (M3×30×12 pieces).

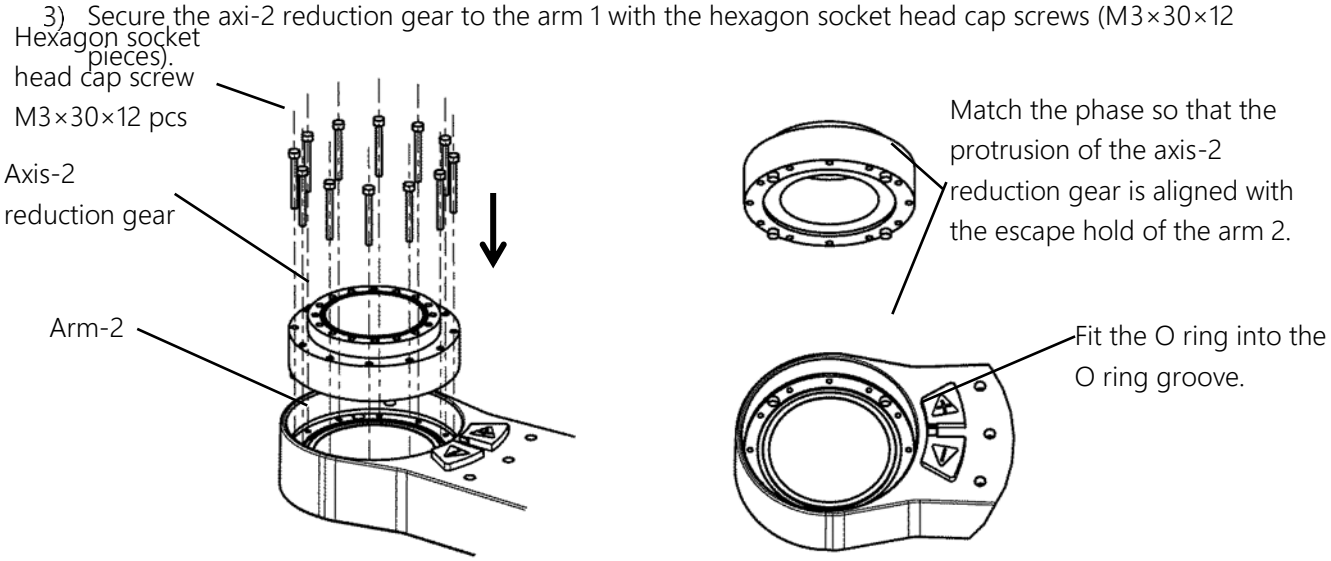
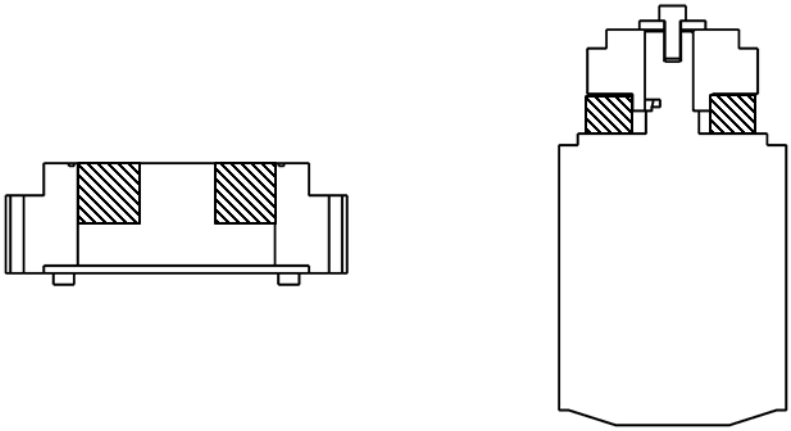


Fig. 7.51 Fitting the Axis-2 Reduction Gear

4) Apply the amount of grease listed in Table 7.13 Application amount of grease to the inside of the axis-2 reduction gear body as shown in

5) Recommended grease	Maker	Application amount to axis-2 reduction gear side	Application amount to axis-2 motor side
SFB No. 1	Nidec-Shimpo Corp.	21 g	19 g



6) Fig. 7.52. Similarly, apply grease to the axis-2 motor side as well.

Table 7.13 Application amount of grease

Recommended grease	Maker	Application amount to axis-2 reduction gear side	Application amount to axis-2 motor side
SFB No. 1	Nidec-Shimpo Corp.	21 g	19 g

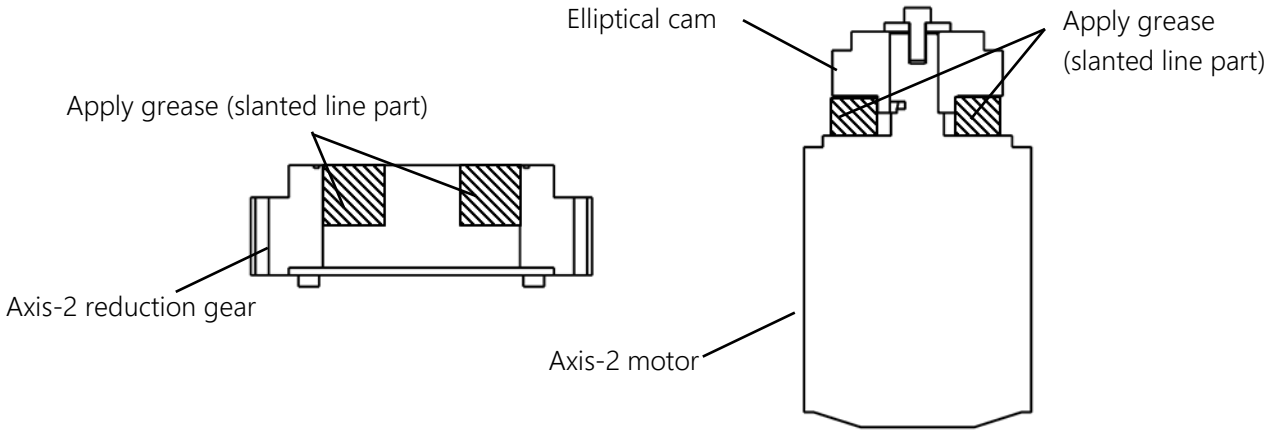


Fig. 7.52 Applying Grease to Axis-2 Reduction Gear

⚠ CAUTION

- Be sure to use the specified types of grease. When the internal pressure becomes high, the starting torque is adversely affected as well as breakage of the internal seal is caused; therefore, be sure to observe the application amount of grease.

7) Secure the arm 2 to the new reduction gear with the hexagon socket head cap screws (M3 ×20×16 pieces).

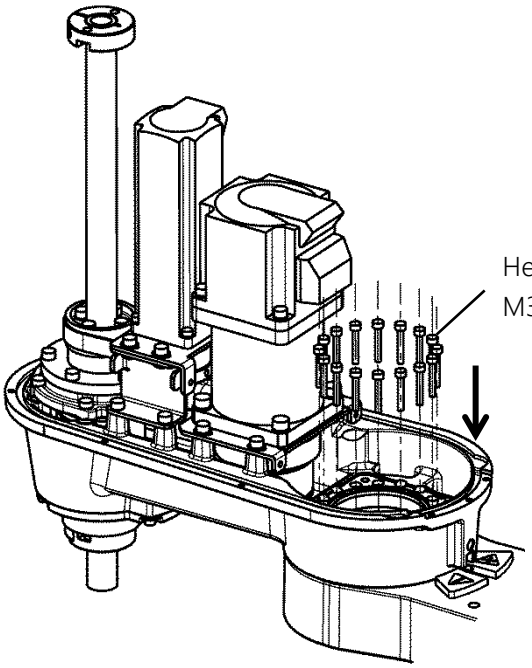


Fig. 7.53 Fitting the Arm 2

8) Fit the axis-2 motor assembly, harness guide and support plate. (See "7.4.6 Fitting the Axis-2 Motor.")
9) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.7.5 Removing the Axis-2 Reduciton Gear")
10) Fit the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
11) Turn on the power and set the zero position of the axis 2 to complete the replacement of the axis-2 reduction gear. (See "8 Robot Zero Point and Position Detector Error.")
12) Perform test operation on the axis 2 to check whether there is any problem with operation of each part.

7.7.7 Removing the Axis-4 Reduciton Gear

⚠ CAUTION

- Be careful when handling a reduction gear. Drop impact or application of excessive force could ruin the reduction gear.
- Be careful not to forget tightening the coupling that fastens the reduction gear and motor shaft.

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Disconnect the cable connectors of the axis-4 motor, J4AS and J4AP (axis-4 power drive cables) and J4BS and J4BP (axis-4 encoder cables).
4) Be sure to record the results of measuring the tension using the tension meter. (For the measurement method, see 4) in "7.4.7 Removing the Axis-3 Motor.")
5) Remove the axis-3 motor assembly, axis-3 timing belt, axis-3 bracket, stopper, ball screw spline shaft, ball screw nut, and axis-3 bracket (cast). (See "7.5.4 Replacing the Axis-4 Timing Belt.")
6) Use a tension meter to measure the tension of the axis-4 timing belt. Enter the following values as the values input to the tension meter. Be sure to record the results of measuring the tension using the tension meter.

Table 7.14 Values Input to Tension Meter

Unit Mass (g/m)	Belt Width (mm)	Span (mm)
2.9	18	105

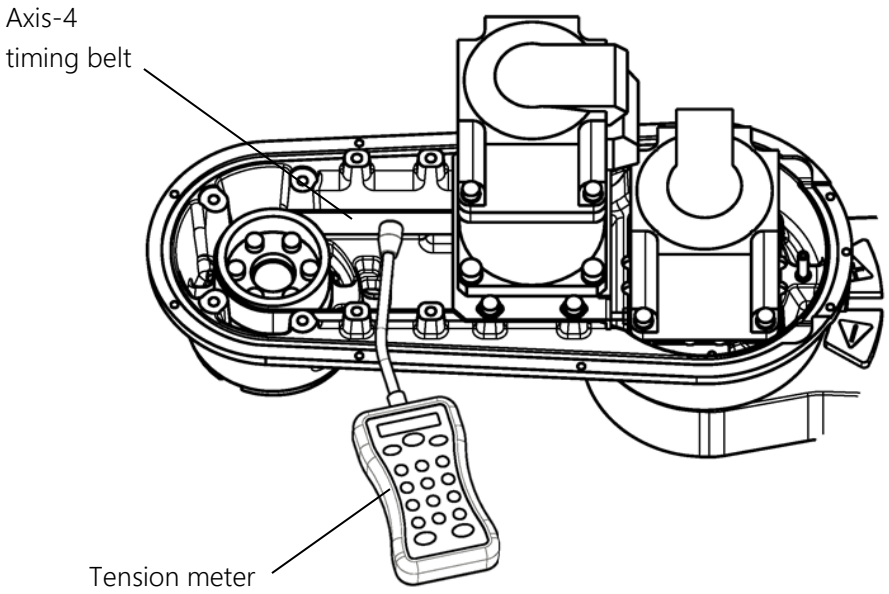


Fig. 7.54 Measuring the Tension of the Axis-4 Timing Belt

7) Remove the axis-4 motor assembly and axis-4 timing belt. (See "7.5.4 Replacing the Axis-4 Timing Belt.")
8) Remove the cap from the side face of the axis-4 reduction gear, and loosen the coupling bolt (M3) that

secures the axis-4 motor shaft and the input shaft of the axis-4 reduction gear.

9) Remove the hexagon socket head cap screws (M4×12×4 pieces) and washers securing the axis-4 motor, and pull out the axis-4 motor upward.
10) Secure the axis-4 motor pulley with a plier, etc., protecting it with a waste cloth so that it is not damaged, remove the hexagon socket head cap screws (M4×14×6 pieces), and remove the pulley.
11) Remove the hexagon socket head cap screws (M5×16×4 pieces) and washers securing the axis-4 motor plate and the reduction gear, and remove the reduction gear.

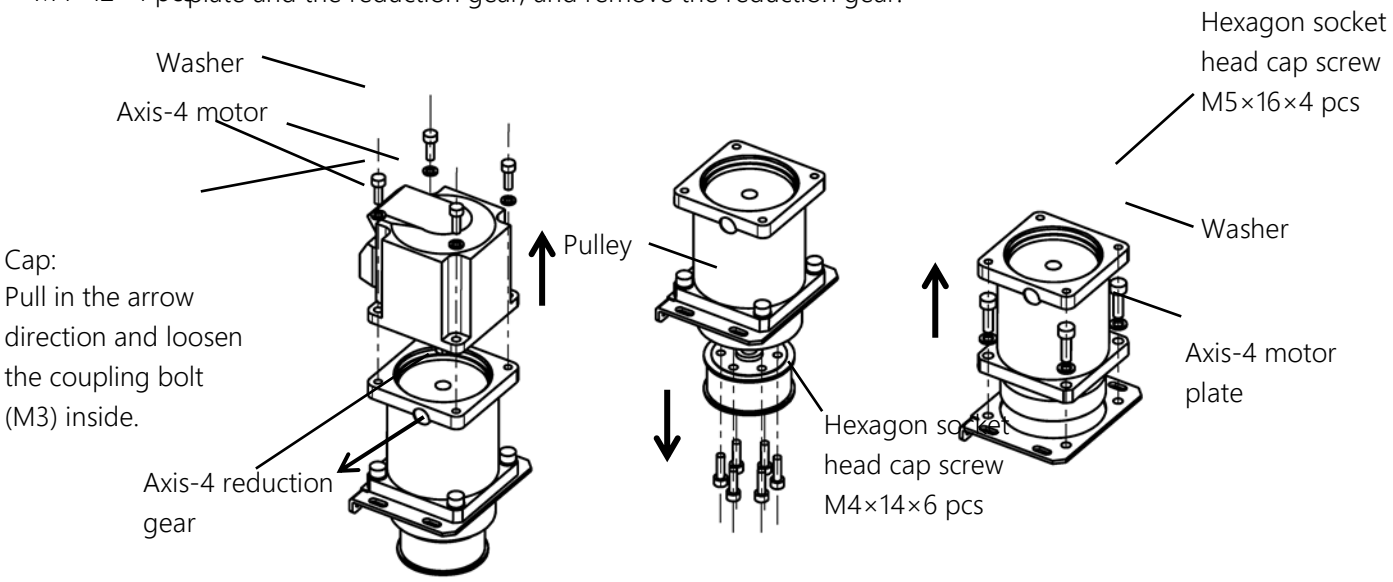


Fig. 7.55 Removing the axis-4 reduction gear

7.7.8 Fitting the Axis-4 Reduction Gear

⚠ CAUTION

- Be careful when handling a reduction gear. Drop impact or application of excessive force could ruin the reduction gear.
- Be careful not to forget tightening the coupling that fastens the reduction gear and motor shaft.

1) Be careful about the phase and secure the axis-4 reduction gear to the axis-4 motor plate with the hexagon socket head cap screws (M5x16x4 pieces) and washers.
2) Secure the axis-4 motor pulley with a plier, etc., protecting it with a waste cloth so that it is not damaged, and secure the axis-4 motor pulley to the axis-4 reduction gear with the hexagon socket head cap screws (M4×12×6 pieces).
3) Be careful about the phase and secure the axis-4 motor to the axis-4 reduction gear with the hexagon socket head cap screws (M4×12×4 pieces).
4) Secure the axis-4 motor shaft and the axis-4 reduction gear with the coupling bolt (M3) and put the cap on the side face of the axis-4 reduction gear.

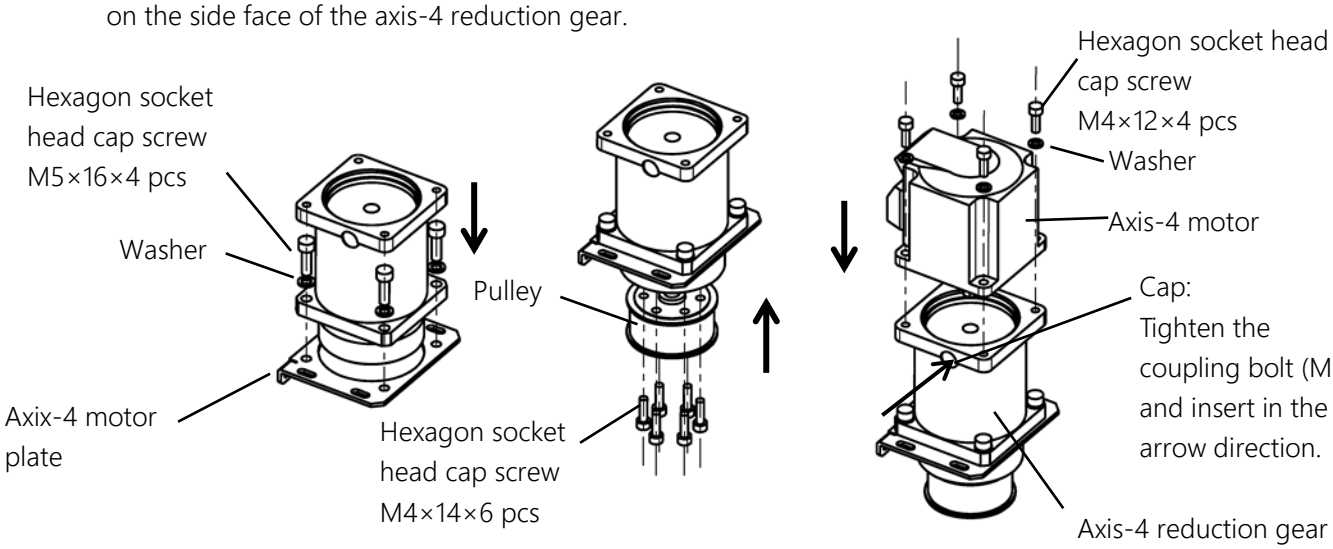


Fig. 7.56 Fitting the axis-4 reduction gear

5) Assemble the axis-4 motor assembly and the axis-4 timing belt. (See "7.5.4 Replacing the Axis-4 Timing Belt.")
6) While using the screws for the tension adjustment of the axis 4 (hexagon socket cap screws M3×12×2 pieces, not requiring application of screw locking adhesive) to pull the axis-4 motor plate, use a tension meter to measure the tension. Tighten the hexagon socket head cap screws at a position where the tension has become a little smaller than the measured value B*(N) (because retightening the hexagon socket head cap screws increases the tension). Make adjustment so that the tension becomes B*×0.95 to B*×1.05(N) when the hexagon socket head cap screws are retightened. After the hexagon socket head cap screws are retightened, remove the screws (hexagon socket head cap screws M3×12×2 pieces) for the tension adjustment of the axis 4.

Table 7.15 Tension of the axis-4 timing belt

Tension (N)	Unit Mass (g/m)	Belt Width (mm)	Span (mm)
B*×0.95 to B*×1.05	2.9	18	105

* B * is the value measured in step 6) of "7.7.7 Removing the Axis-4 Reduciton Gear."

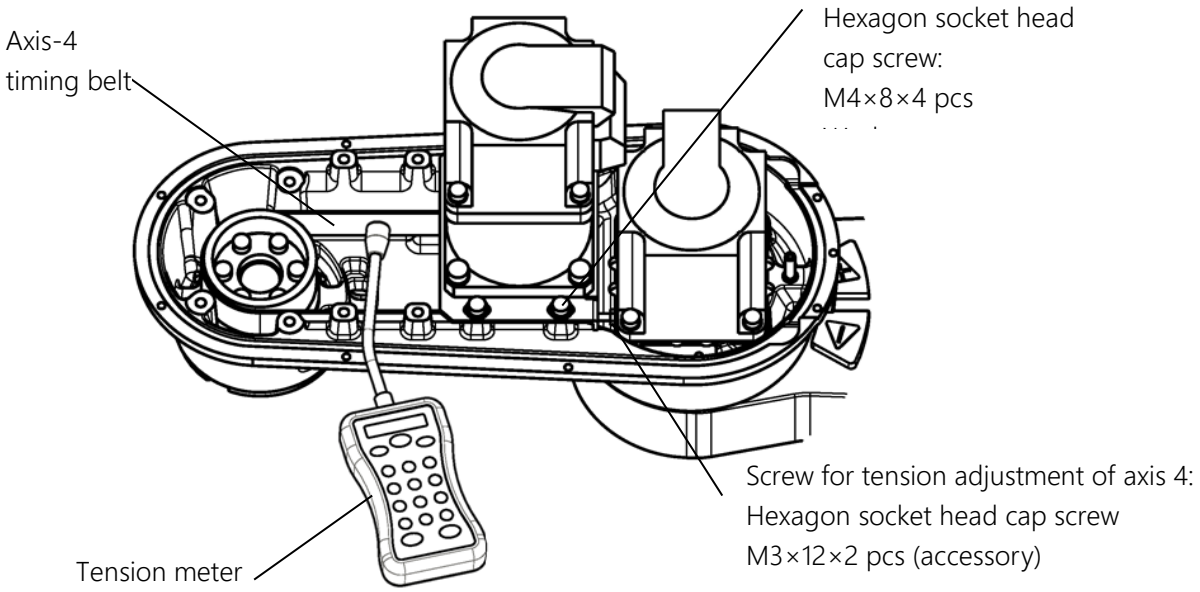


Fig. 7.57 Adjusting the tension of the axis-4 timing belt

7) Fit the axis-3 motor assembly, axis-3 timing belt, axis-3 bracket, stopper, ball screw spline shaft, ball screw nut and axis-3 bracket (cast). (See "7.5.4 Replacing the Axis-4 Timing Belt.")
8) Adjust the tension of the axis-3 timing belt. (See "7.4.8 Fitting the Axis-3 Motor".)
9) Connect the connectors and return the cable to its original state. (See the pictures taken in 2) of "7.7.7 Removing the Axis-4 Reduciton Gear.")
10) Fit the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
11) Turn on the power and set the zero positions of the axes 3 and 4 to complete the fitting of the axis-4 reduction gear. (See "8 Robot Zero Point and Position Detector Error.")
12) Move up and down the ball screw while pressing the brake release switch in the servo OFF condition to make sure that the ball screw moves smoothly.
13) Perform test operation on the axes 3 and 4 to check whether there is any problem with operation of each part.

7.8 Replacing the LED Lamp

The work should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations. CKD Service Department also accepts replacement work at an extra cost.
Be aware that CKD's warranty does not cover failures and accidents resulting from the replacement of the parts by the customer.

⚠ DANGER

- The power plug of the controller must be removed before replacement work. If replacement work is done with the power turned on, this may result in an electric shock or a malfunction, causing great danger.

The LED lamp used by this robot is as listed in Table 7.16.
When ordering the LED lamp, specify the robot model name, manufacture number, Shibaura drawing number and unit code.

Table 7.16 Type of LED lamp

Part name	Voltage	Shibaura Dwg. No.	Unit code
LED lamp	24 V	M332780	Y610AD05H

7.8.1 Location of LED Lamp

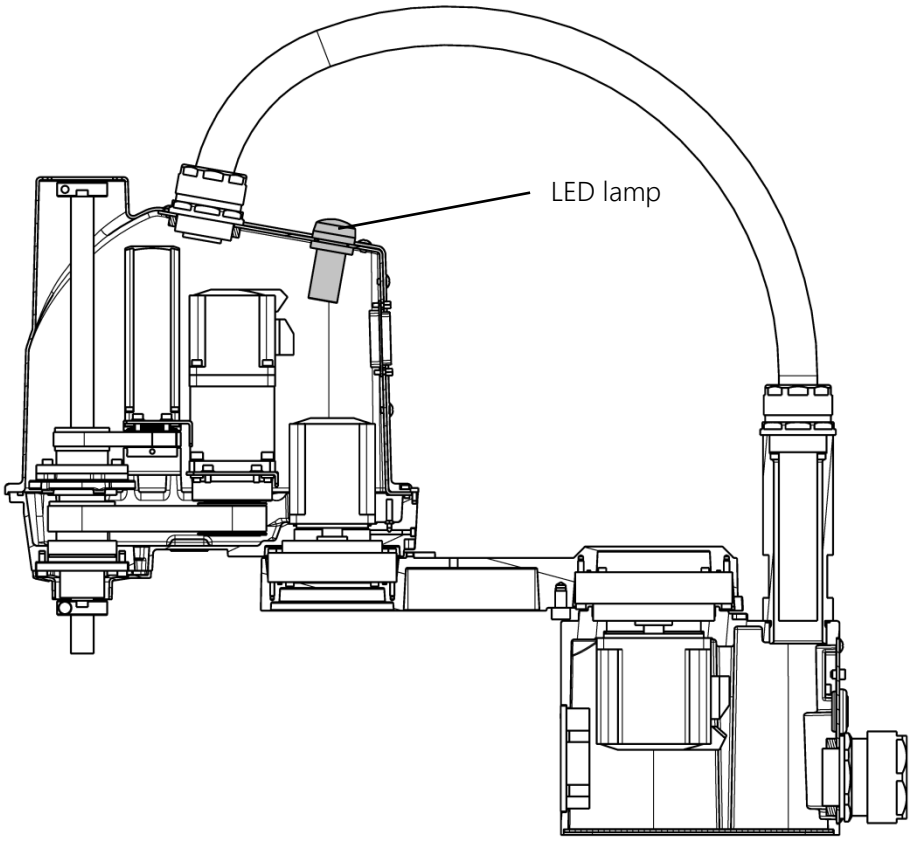


Fig. 7.58 Location of the LED lamp

7.8.2 Removing the LED Lamp

1) Remove the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
2) Use a plier or the like to cut off the cable straps of the cables. It is recommended to take pictures beforehand so that where to route the cables and where to use the cable straps are identifiable in restoration work.
3) Remove the LED lamp cable between J3DS and J3DP (axis-3 brake wires).
4) Remove the harness guide secured with the hexagon socket head cap screw (M3×6×1 piece) and the support plate secured with the hexagon socket head cap screws (M3×6×2 pieces). (See 4) in "7.4.5 Removing the Axis-2 Motor.")
5) Loosen the cross truss screws (M4×2 pieces) on the bottom of the LED lamp and remove the secured LED lamp cable.

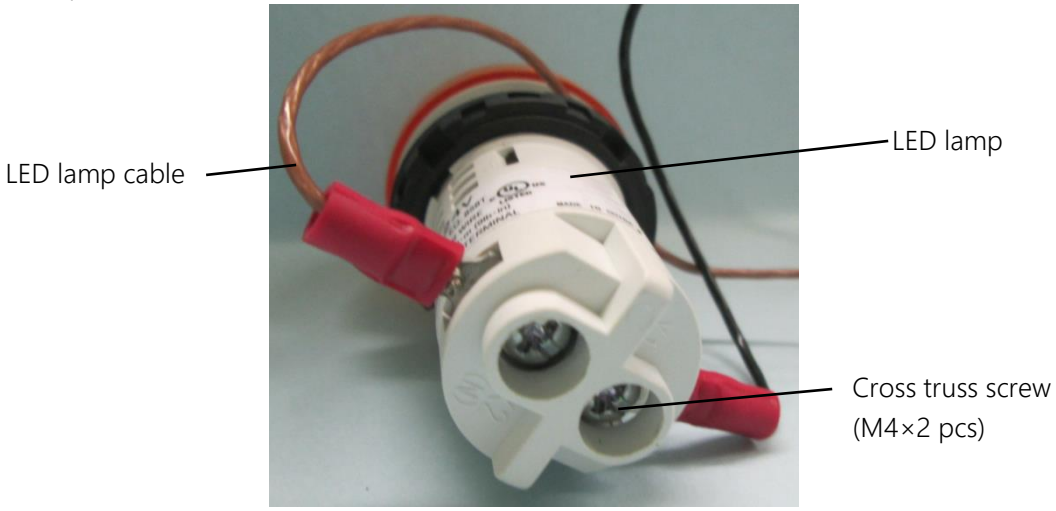


Fig. 7.59 Removing the LED Lamp Cable

6) Remove the LED lamp secured with the clamp.

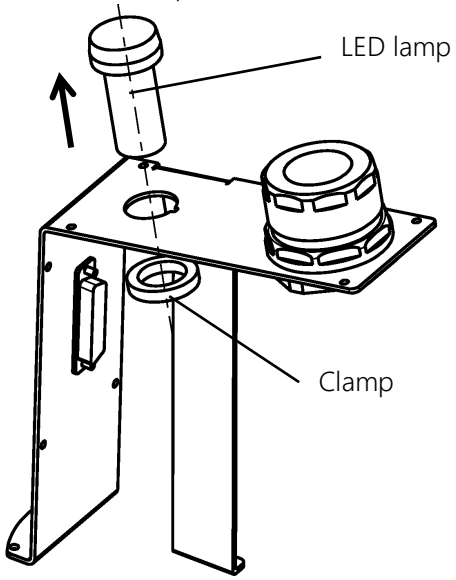


Fig. 7.60 Removing the LED Lamp

7.8.3 Fitting the LED Lamp

1) Secure the LED lamp with the clamp.

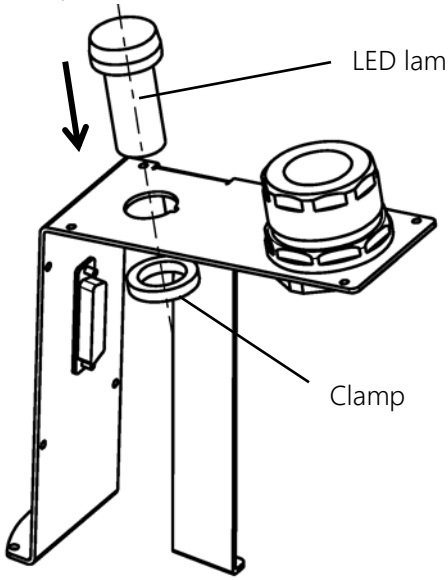


Fig. 7.61 Fitting the LED Lamp

2) Loosen the cross truss screws (M4×2 pieces) on the bottom of the LED lamp, insert the Y-type terminal of the LED lamp cable, and tighten the cross truss screws (M4×2 pieces) to secure the LED lamp cable. (See Fig. 7.59. Any secured combination is acceptable.)
3) Secure the harness guide and support plate with the hexagon socket head cap screws (M3×6×3 pieces, of which one piece on the harness guide side does not require application of Loctite). (See 6) in "7.4.6 Fitting the Axis-2 Motor.")
4) Connect the LED lamp cable between the axis-3 brake wires in the combination of J3DS (LED lamp cable side) and J3DP (axis-3 brake wire) and J3DP (LED lamp cable side) and J3DS (axis-3 brake wire).
5) Return the cable to its original state. (See the pictures taken in 2) of "7.8.2 Removing the LED Lamp.")
6) Fix the arm-2 cover. (See "7.3.1 Arm-2 Cover.")
7) Turn on the power and turn on the servo power to make sure that the LED lamp lights.
8) Perform test operation to check whether there is any problem with operation of each part.

8. Robot Zero Point and Position Detector Error

The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and regulations.
Be aware that CKD's warranty does not cover failures and accidents resulting from the work done by the customer.

Recommended protector:

Type and name	Protection part and use	Recommended example
Helmet	Protection part: Head Use: Protect from a falling object. Protect from collision with the arm.	
Safety glasses	Protection part: Eyes Use: Protect from a flying object. Protect from collision with the arm.	
Protective gloves	Protection part: Hand and fingers Use: Protect hands and fingers when caught in the machine. Prevent a carried object from dropping.	
Protective shoes	Protection part: Feed and toes Use: Protect from a falling object	

8.1 Zero Setting of Robot

Before delivery from our plant, zero setting is performed for the robot after its arm is secured with clamp for zero setting.
At the time of zero setting, position data of the motor position detector (i.e., encoder) is backed up by batteries, and coordinates of the robot need not be set each time the power is turned on.
The position data of the motor position detector comes in the two (2) types; servo offset and multi-turn data.

Servo offset: At zero setting operation of the robot (i.e., ZEROP operation and REORG operation), the data is written into the parameter file. The data is backed up by the batteries; therefore, when replacing the main control substrate, it is necessary to reload the parameters from the attached system disk.

Multi-turn data: The data is backed up in the encoder by batteries different from the backup batteries for the main substrate. If the battery voltage drops, correct multi-turn data cannot be guaranteed, and so the encoder itself outputs an alarm. This data is set to "0" during operation for the zero setting of the robot (ZEROP operation and REORG operation). It is also set to "0" during operation for multi-turn data reset.

8.2 Position Detector Error

If a position detector error (encoder error) occurs, errors listed in the table below are shown on the error screen of the robot controller.

Error code	Description	Remarks
8-601	Axis1 Enc multi count err	
8-602	Axis2 Enc multi count err	
8-603	Axis3 Enc multi count err	
8-604	Axis4 Enc multi count err	

The position detector error is an error detected by the encoder itself. Even if the data in the parameter file is lost (or changed) to change the zero point coordinates of the robot, for instance, a position detector error will not occur. If the machine coordinates have changed without causing a position detector error, the mechanical connecting position of the servo motor and mechanical unit shifted or the data in the parameter file described above was changed. (Ex.: Tooth skip of timing belt)
Errors detected by the encoder itself include the battery voltage drop, error caused by temperature rise in the encoder, counter overflow, and internal counter data inconsistency. Among these errors, the error which occurs most frequently is the battery voltage drop which is caused by the absence of maintenance at specified change intervals due to a long-term shutdown or by cable breakage.
To prevent the position detector error, therefore, replace the batteries on a regular basis. For the battery replacement, see "8.3 Replacing Position Detector (or Encoder) Batteries".
Also, a heavy vibration should not be exerted on the robot or the robot should not be moved suddenly by hand during power OFF. Especially, when transporting and storing the robot, secure the robot in a posture for shipment, using the attached clamps.

Restoration from position detector error

There are the following threw methods to recover from a position detector error. Confirm the occurrence of a position detector error on the error screen, and check the type of the position detector error and position data on the encoder status screen. Then, perform restoring operations. For the encoder status screen, see "8.6 Encoder Status Screen".

① Multi-turn data reset operation: See Para. 8.7.
② ZEROP operation using the zero setting tool: See Para. 8.8.
③ Other zero setting operation: See Para. 8.9.

[1] When zero setting is not required

[1.1] The battery has been replaced at the time of annual inspection or when the battery error code is level-1 alarm (see 8.3.3)
After the battery is replaced, the error must be reset. The error to be reset is displayed on the error message screen by pressing the [EREER] key. The error can be reset by pressing the [F3] key (RESET) on the screen. Then, perform "8.10 Check Work."
If the error is not reset, contact the CKD Service Department.

[2] When ① multi-turn data reset operation is required

[2.1] If the battery is replaced when the battery error code is level-8 alarm (see 8.3.3)
[2.2] If the body harness and capacitor are replaced
[2.3] If the cable connectors of encoder cable and battery cable shown in Fig. 8.1 are removed
After each work is finished, perform ①multi-turn data reset operation (see 8.7).

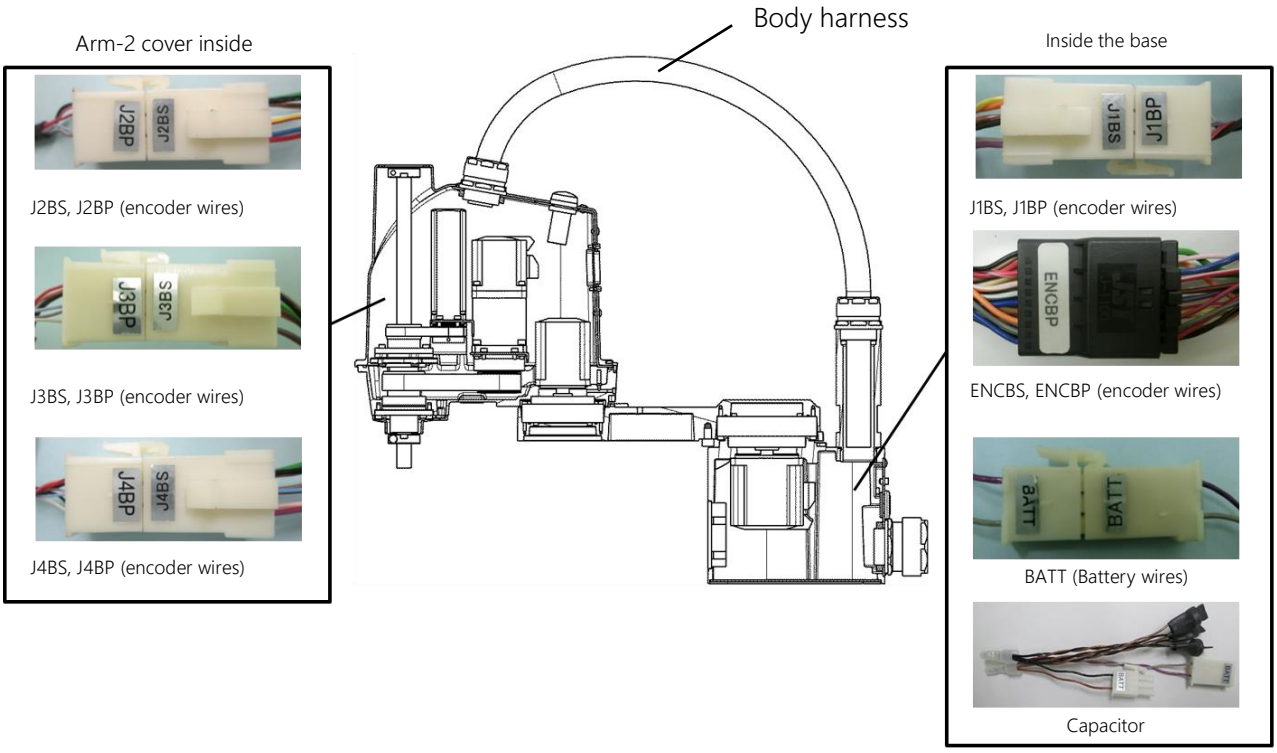


Fig. 8.1 Location where ① Multi-turn Data Reset Operation is Required when the Connectors are Removed

[3] When ② ZEROP operation using the zero setting tool or ③ other zero setting operation is required

[3.1] If the parts shown in エラー! 参照元が見つかりません。 are replaced
After the parts are replaced, perform ② ZEROP operation using the zero setting tool (see 8.8) or ③ other zero setting operation (see 8.9).

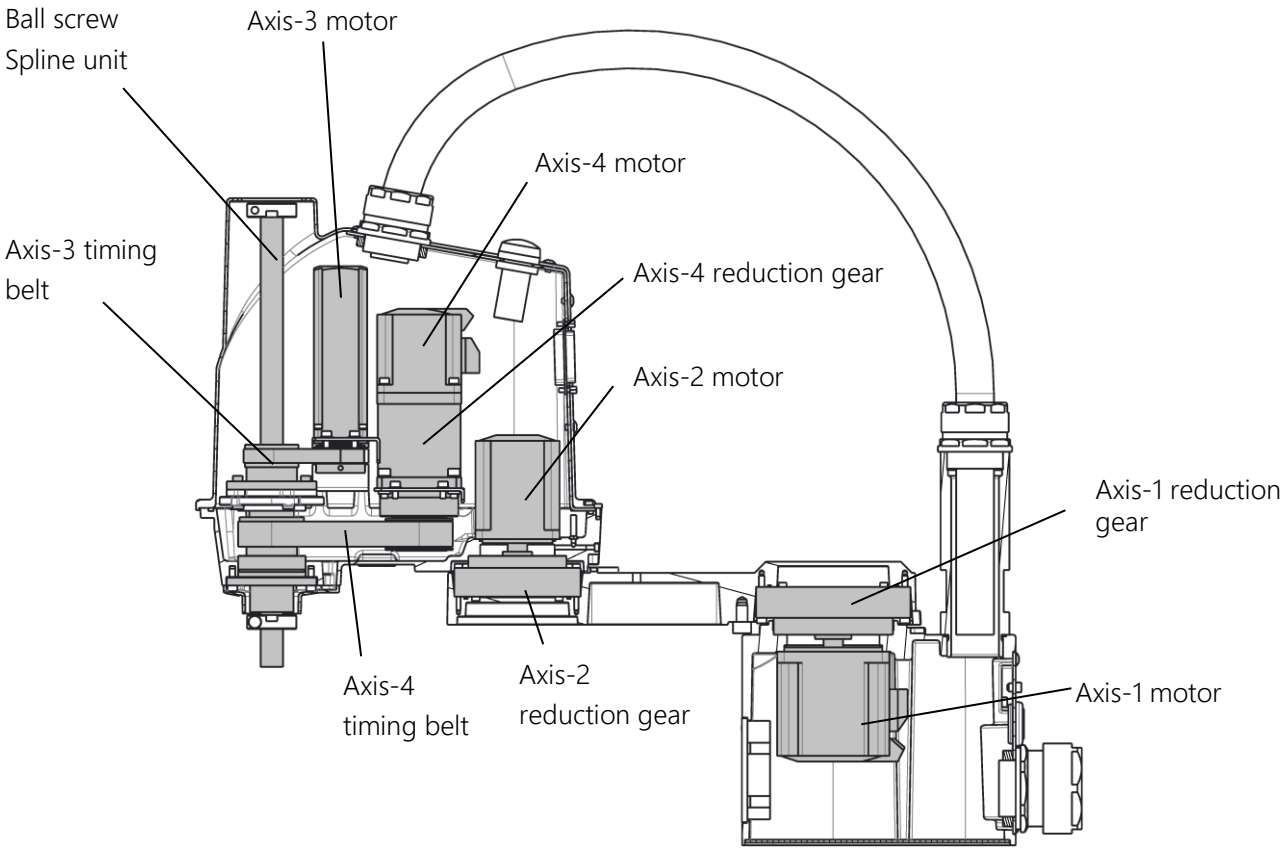


Fig. 8.2 Replacement Parts that Require ② ZEROP Operation Using the Zero Setting Tool or ③ Other Zero Setting Operation

⚠ DANGER

- When manually moving the robot with the power turned on, ensure safety and effect an emergency stop beforehand.
- Then, when performing operations with the axis-3 brake released, this must be done by two persons. One person should perform operations and the other person should observe the operations in a safe location. During the observation of operations, the observer should be ready to immediately cut off the power supply of the controller if a fault occurs. Cutting off the power supply of the controller causes the motor brake to work even when the axis-3 brake is released.
- If the axis-3 brake is released with the robot carrying heavy load, the axis 3 may drop suddenly, and the user must take this into account.

⚠ CAUTION

- Some errors may be caused, depending on how to make adjustments. Re-teaching of teaching points may be required under some circumstances.

8.3 Replacing Position Detector (or Encoder) Batteries

⚠ CAUTION

- The batteries should be disposed of according to the user's in-house regulations. NEVER drop the battery into fire. NEVER short-circuit, charge, disassemble or heat it. Otherwise, liquid leakage or rupture may be caused.

To keep the data of the position detector attached to the motor, they are backed up by batteries.
Be sure to replace the batteries with new ones at the time of annual inspection.
When the robot is not used for a long term (i.e., the batteries are left intact in the power OFF condition), replace the batteries at the time of robot startup. As a yardstick, the shutdown period is two months.
(AA-cell alkaline battery × 3)

⚠ CAUTION

- When the battery voltage has dropped, a battery alarm will occur. If the batteries are replaced just after generation of the battery alarm, the battery voltage returns to normal with the battery alarm reset automatically. Unless the batteries are changed just after generation of the battery alarm, however, the battery voltage will drop further and a battery error will occur. Under this condition, position data detected by the encoder is not reliable. As a result, a position detection error occurs and the robot enters an emergency stop state so that the servo system cannot be turned on. Moreover, if the power is turned off in this condition, the position data will be lost.
  To avoid the above, be sure to replace the batteries with new ones at the time of annual inspection.

8.3.1 Location of Battery Box

The position detector battery box is secured to the base.

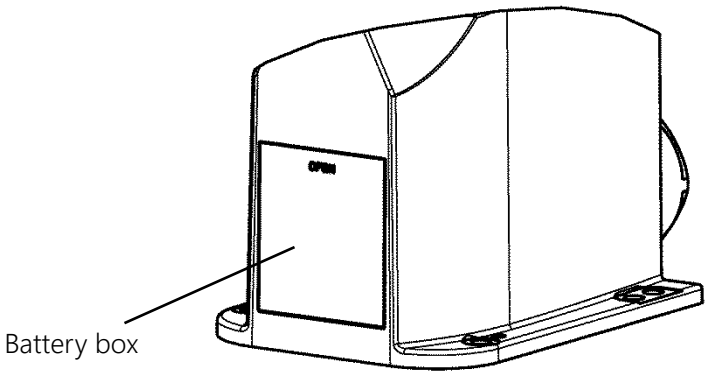


Fig. 8.3 Location of the Battery Box

8.3.2 Replacing Batteries

⚠ CAUTION

- Only after assuring the safe work, replace the batteries with new ones while the power is turned on and an emergency stop is effected on the robot.

1) Assure the safe work. Then keep the power ON and press the EMERGENCY pushbutton switch to effect an emergency stop on the robot.

2) Open the cover of the battery box, and take out the battery. Fit three new batteries, being careful about their polarity. If you replace the batteries with the power turned off, finish the replacement within 5 minutes.

3) If the alarm "1-40* Axis* Enc Battery low (Battery alarm)", which is shown inTable8.1, does not disappear even after the alarm is reset, take step 4). If the alarm disappears, close the lid to finish the replacement.

4) Remove the cover of the battery box (see Fig.8.3 Location of Battery Box). Put the terminals of a tester as shown in the following picture to measure voltage, and make sure that the voltage is about 4.5 V. If the voltage is low, it may be caused by a poor fit. Remove the batteries, wipe the metal battery contact of the battery box with waste cloth, and then fit the batteries again. Measure the voltage again using a tester, and if the voltage is about 4.5 V, take step 3) again. At this time, take care not to remove the connector.

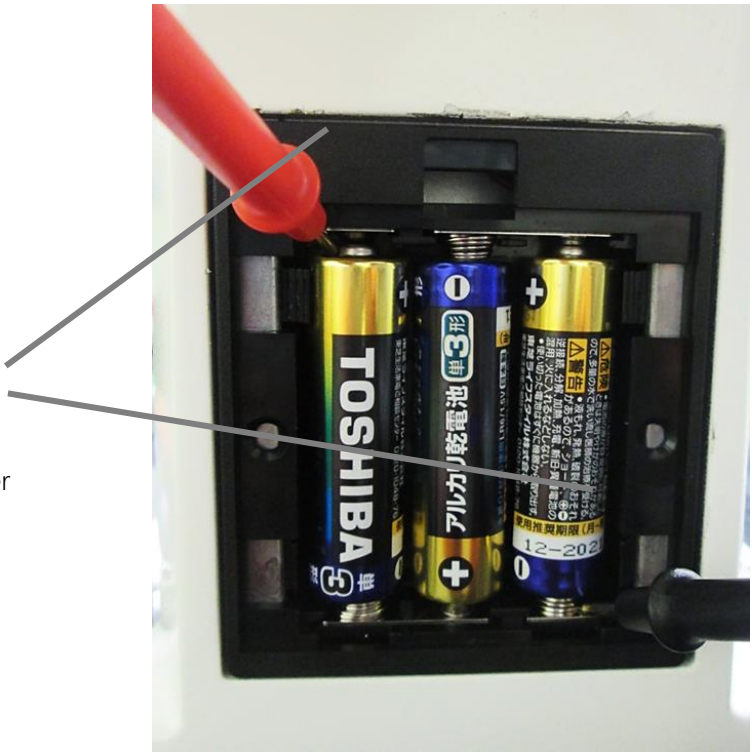


Fig. 8.4 Checking the Battery for Fitting Failure

8.3.3 Battery Error Code

When a position detector error, including a battery error, has occurred, the following error code is shown on the error display.

When the battery voltage has been reduced, the following error code will appear on the error screen. If one of the following error codes has been displayed in the error history due to the error of the position detector, it indicates that a "battery error" has occurred.

Table 8.1 1-40* battery error codes

Error code	Error message	Remarks
1-401	Axis1 Enc Battery low (Battery alarm)	
1-402	Axis2 Enc Battery low (Battery alarm)	
1-403	Axis3 Enc Battery low (Battery alarm)	
1-404	Axis4 Enc Battery low (Battery alarm)	

If an error of level 1 alarm in Table 8.1 has occurred, we recommend you to replace the battery at an early stage. If you leave it as it is without correcting the error, an error of level 8 alarm shown in the Table 8.2 to Table 8.4 will occur. In some cases, the information on the zero position of the robot may disappear. Take care to avoid this.

Table 8.2 8-60* battery error codes

Error code	Error message	Remarks
8-601	Axis1 Enc multi count err	
8-602	Axis2 Enc multi count err	
8-603	Axis3 Enc multi count err	
8-604	Axis4 Enc multi count err	

If an error in Table 8.2 has occurred, counting skips may have occurred due to battery power shortage. In the first place, replace the battery. If the error recurs even after battery replacement, the encoder may be faulty. In this case, the motor needs to be replaced. Please ask CKD Service Department to replace it.

Table 8.3 8-61* battery error codes

Error code	Error message	Remarks
8-611	Axis1 Enc battery empty	
8-612	Axis2 Enc battery empty	
8-613	Axis3 Enc battery empty	
8-614	Axis4 Enc battery empty	

If this error has appeared, the battery voltage may have been reduced below the specified level. Replace the battery. If the battery voltage is reduced below the stipulated value, the information on the zero position of the robot may have disappeared. If the alarm cannot be released after the battery has been replaced, perform zero setting according to "8 Robot Zero Point and Position Detector Error".

Table 8.4 8-40* battery error codes

Error code	Error message	Remarks
8-401	Axis1 Encoder abnormal	
8-402	Axis2 Encoder abnormal	
8-403	Axis3 Encoder abnormal	
8-404	Axis4 Encoder abnormal	

Among 8-level battery errors, the two types of errors listed in Table 8.2 and Table 8.3 are displayed. However, the errors listed in Table 8.4 may be displayed. If these errors are displayed, replace the battery. If the battery voltage is reduced below the specified level, the information on the zero position of the robot may have disappeared. If the alarm cannot be released after the battery has been replaced, perform zero setting according to "Section 8 Robot Zero Point and Position Detector Error".

The battery error is one of the position detector errors (i.e., encoder errors), and there is other cause leading to the position detector error. The restoring method from the position detector error varies with the error contents generated. To properly execute the restoring method from the position detector error, therefore, read through and completely understand the descriptions carried in "Section 8 Robot Zero Point and Position Detector Error ".

8.4 Backing up Data

Connect the personal computer in which TSAssist (optional) has been installed to the controller, and save all parameters in the robot controller onto a hard disk, etc. Also, Zero position data is robot-specific data, and varies depending on each robot. The parameters of a different robot cannot be used; therefore, be sure to save data for each robot. The factory-set parameters are saved on the instruction manual DVD. Use the data as well.

8.5 Zero Position

This section describes the zero position required for zero setting. When moving the axes 1, 2, and 4 of the robot to the zero position, see "8.5.1 Locations of Zero Point Match-Marks of the Robot", and align the zero point match-mark of each axis. The axis 3 does not have a zero point match-mark. See "8.5.2 Axis-3 Zero Position" to move it to the zero position. The installation of the zero setting tool (optional) is explained in "8.5.3 Installing the Zero Setting Tool (Optional)."

8.5.1 Locations of Zero Point Match-Marks of the Robot

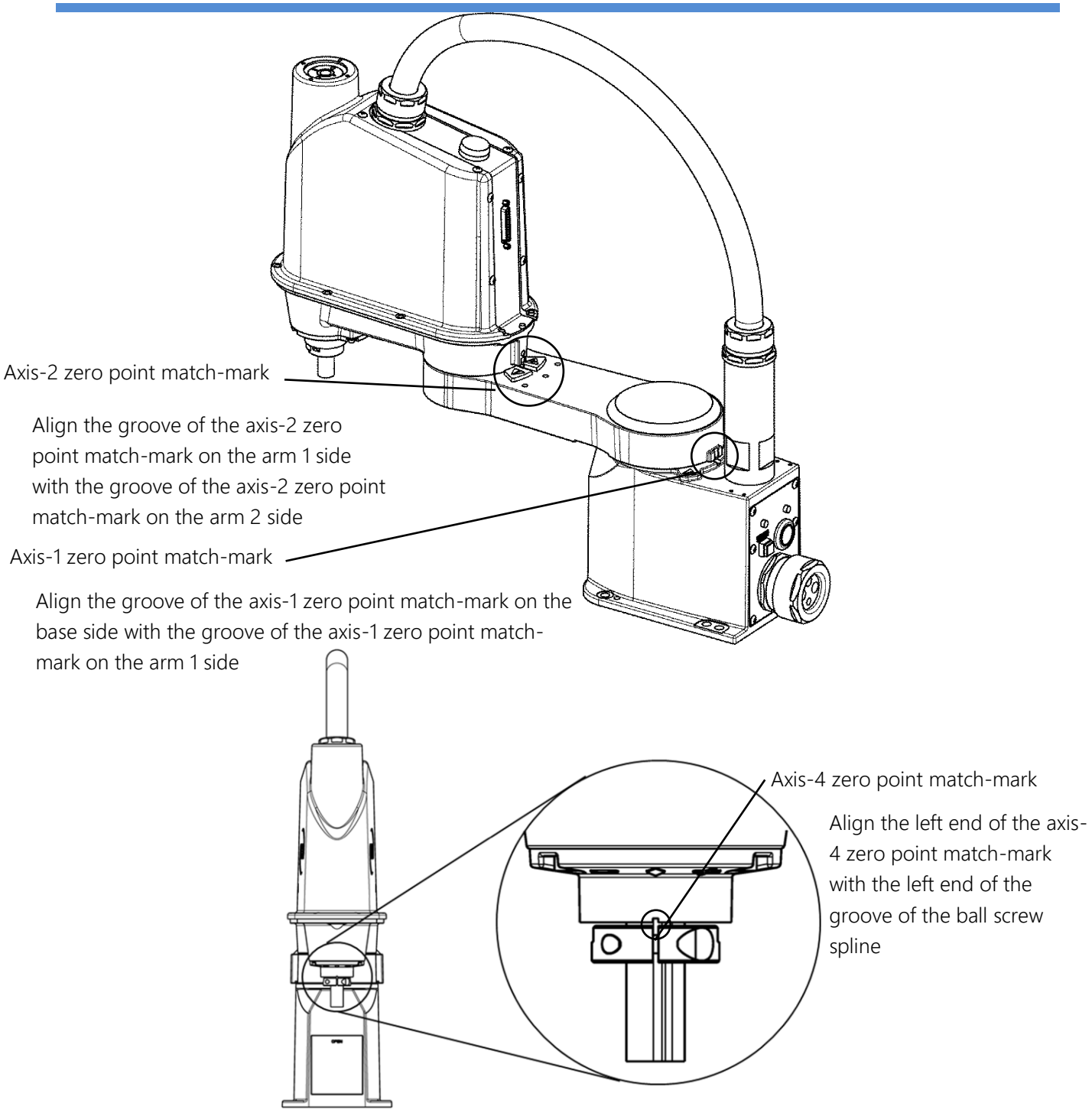


Fig. 8.5 Locations of zero point match-marks

8.5.2 Axis-3 Zero Position

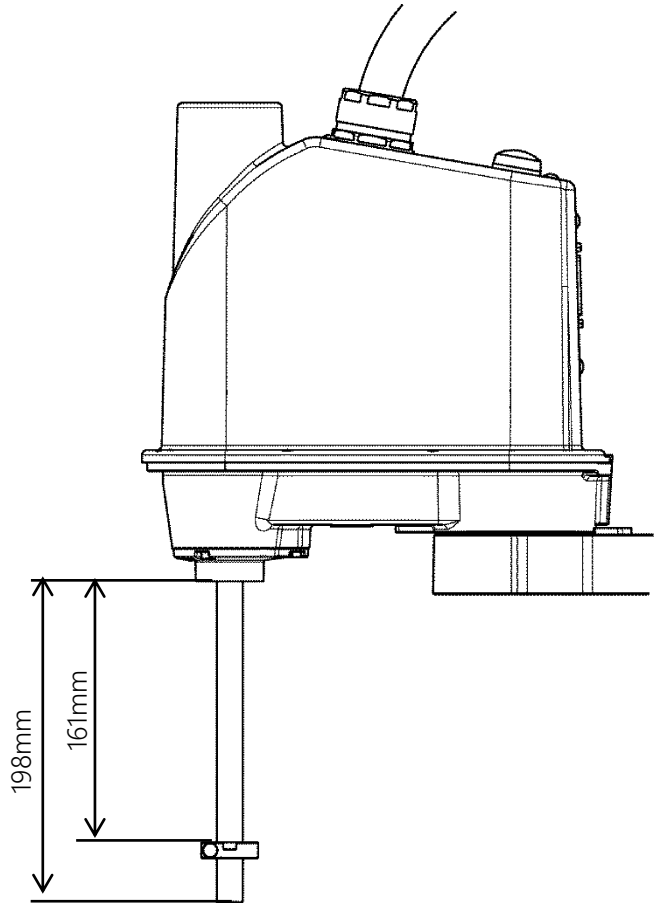


Fig. 8.6 Dimensions of the Axis-3 Zero Point

8.5.3 Installing the Zero Setting Tool (Optional)

This paragraph shows the installation location of the zero setting tool (optional) meter described in "8.8 ②Restoring Zero Position Data by ZEROP Function Using the Zero Setting Tool." For the procedure for attaching/detaching the axes-3 and-4 zero setting tool, see "8.5.4 Attaching/Detaching the Axes-3 and -4 Zero Setting Tool." The zero setting tools, etc. used in this paragraph are as listed in Table 8.5. When ordering a zero setting tool, specify the robot model name, Shibaura drawing number, and unit code.

Table 8.5 Types of Zero Setting Tools, etc.

Part name	Model	Shibaura Dwg. No.	Unit code
Axes-1 and -2 zero setting tool		M332826	Y610D0690
Axes-3 and -4 zero setting tool		L15389G01	Y610D06A0
Tool flange*		S753022	

* When the tool flange is fitted, the hexagon socket head cap screws (M4×16×4 pieces) must be prepared or arranged separately.

The parallel pin and parallel key used by the axes-3 and -4 zero setting tool are as listed in Table 8.6.

Table 8.6 Types of Parallel Pin and Parallel Key

Part name	Model	Size	Material
Parallel pin	Type B	4×8	SUS
Parallel key	Round	□4×16	S45C

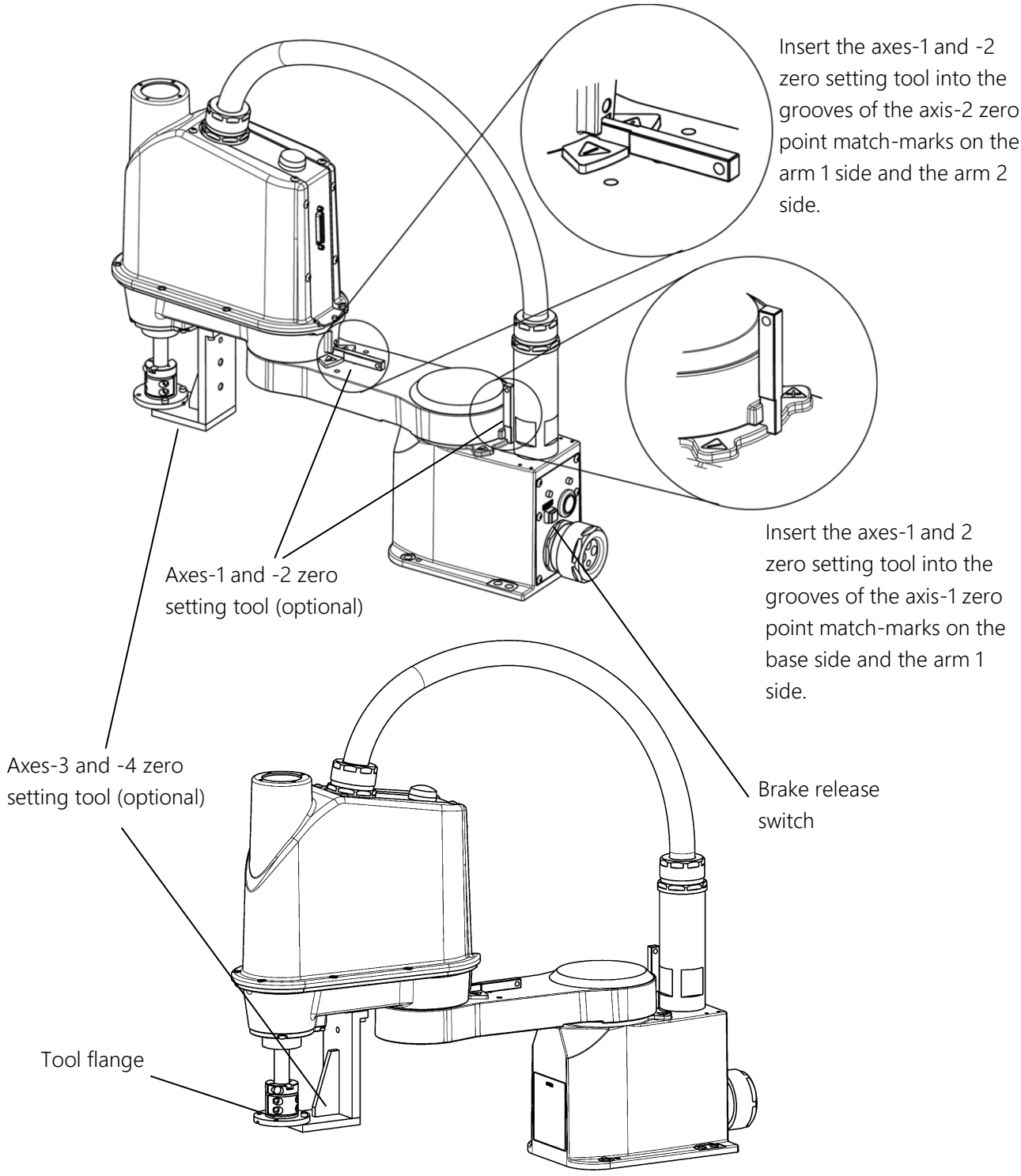


Fig. 8.7 Installing the Zero Setting Tool (Optional)

8.5.4 Attaching/Detaching the Axes-3 and -4 Zero Setting Tool

1) Fit the tool flange (optional) so that the left side of the dividing portion of the stopper is aligned with the left side of the tool flange as shown in Fig. 8.8

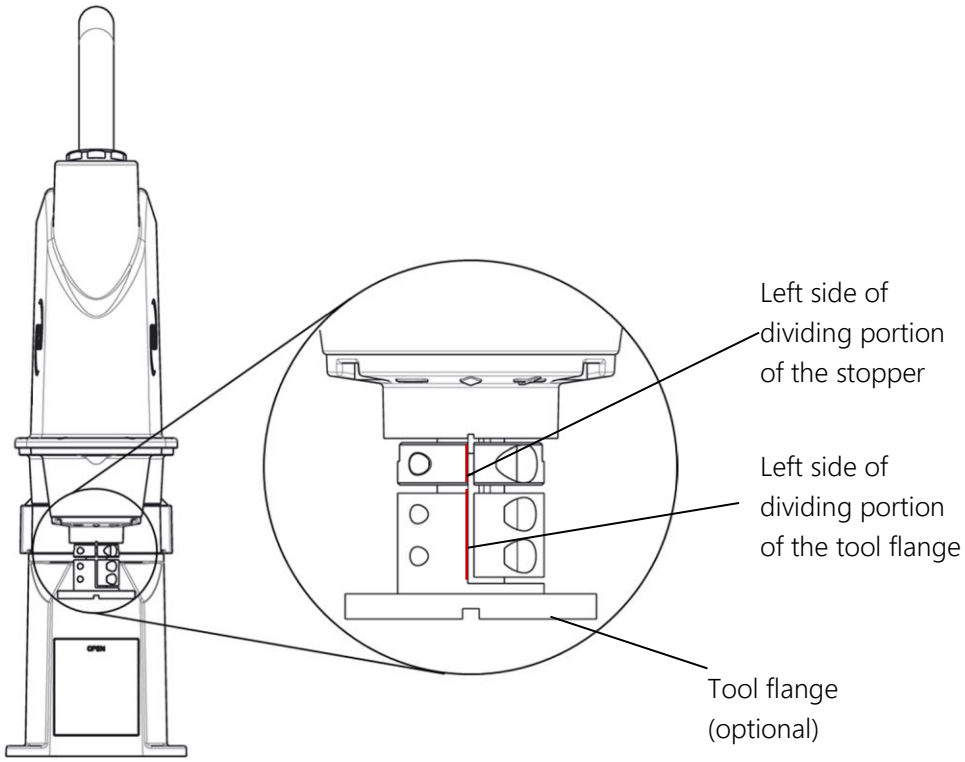


Fig. 8.8 Fitting the Tool Flange

2) Insert the parallel pins of the axes-3 and -4 zero setting tool (optional) into the pinholes on the lower side of the arm 2, and secure it with the hexagon socket head cap screws (M4×12×2 pieces).

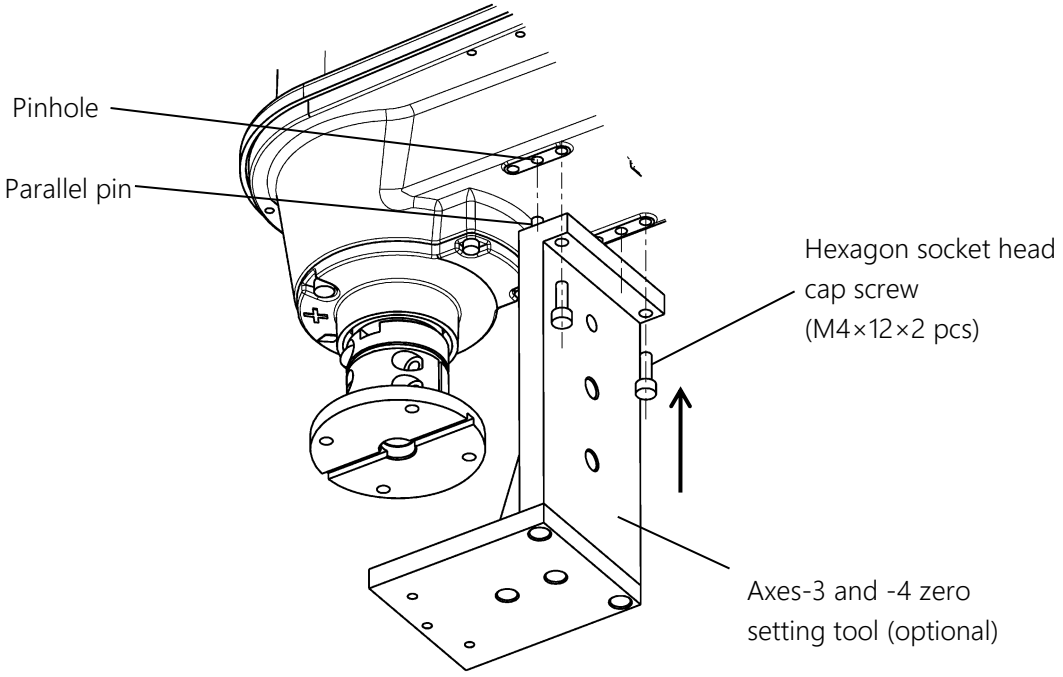


Fig. 8.9 Secure the Axes-3 and -4 Zero Setting Tool

3) Press the brake release switch to rotate the ball screw spline so that the parallel key of the axes-3 and -4

zero setting tool fits into the lower key groove of the tool flange. If the orientation is matched, lower the tool flange while pressing the brake release switch so that it comes into contact with the axes-3 and -4 zero setting tool.

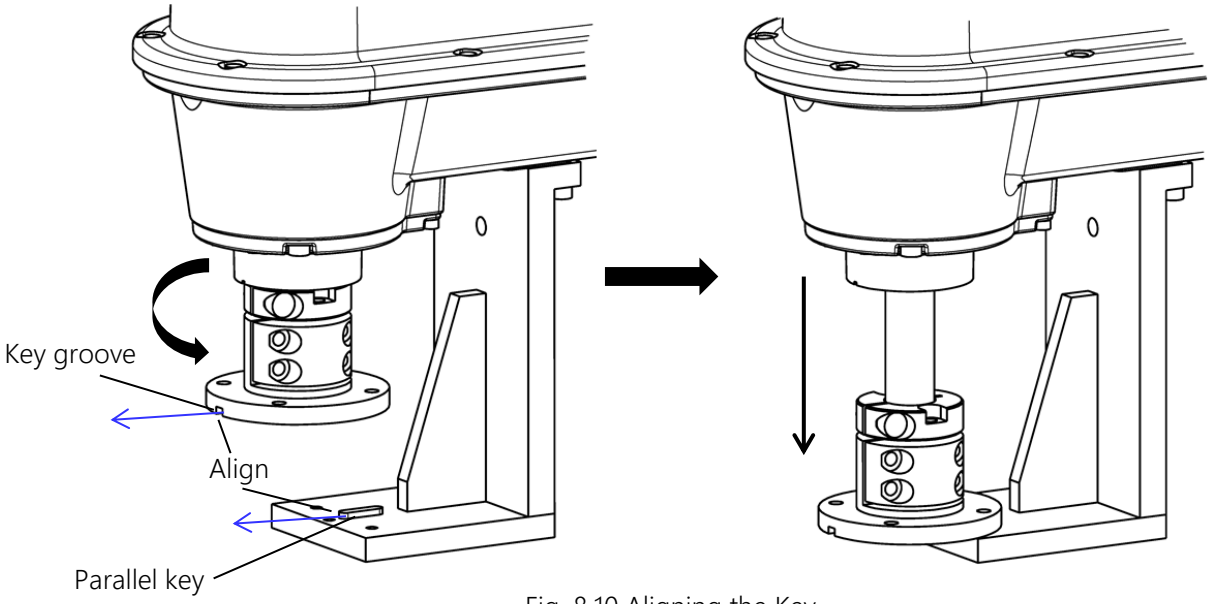


Fig. 8.10 Aligning the Key

4) Secure the tool flange to the axes-3 and -4 zero setting tool with the hexagon socket head cap screws (M4×12×2 pieces).

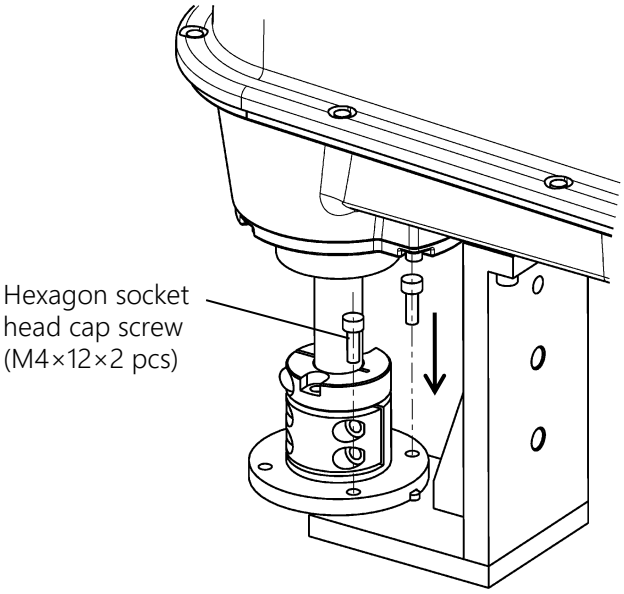


Fig. 8.11 Securing the Tool Flange

5) Set the zero position according to the procedure explained in "8.8 ②Restoring Zero Position Data by ZEROP Function Using the Zero Setting Tool."
6) Reversing the fitting procedure, remove the axes-3 and -4 zero setting tool.

8.6 Encoder Status Screen

Call the encoder status screen on the teach pendant display, and make sure of the position data and the type of position detector error there. Types of position detector errors are expressed as error statuses shown below along with a bit graph. The motor multi-turn data, zero position data within one (1) full turn of motor and error status are displayed under the column of [MULTI], [SINGLE] and [Err-df] on the encoder status screen, respectively.

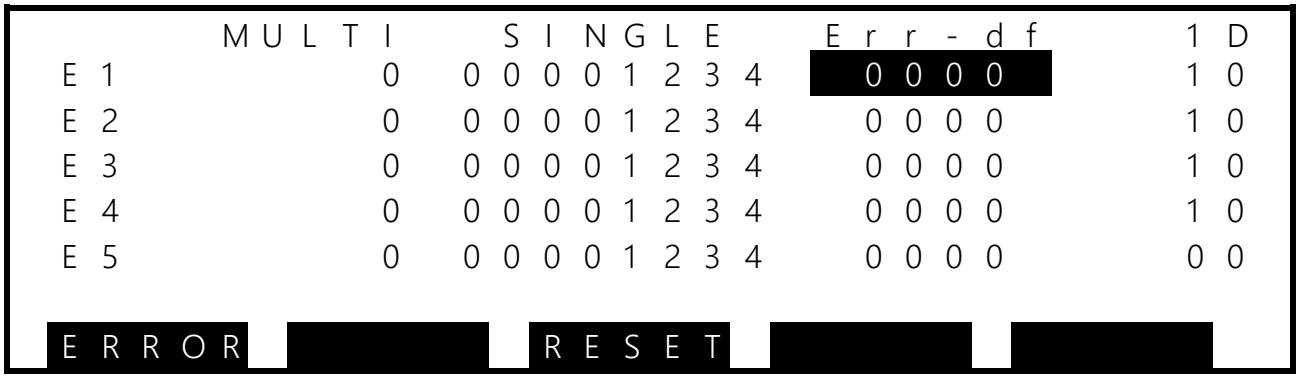
To call the encoder status screen, observe the following procedures.

Table 8.7 Error status table

Error status	Description
0000	Signifies the normal condition.
0100	This error occurs when a heavy vibration has been exerted on the robot or when the robot has been moved fast by hand while the power drive cable was disconnected during power OFF. The multi-turn data has possibly shifted.
8000	The battery voltage has dropped. Replace the batteries.
4000	The battery voltage has dropped further than the above. An error has possibly occurred in the multi-turn data.
C000	Error statuses 8000 and 4000 have occurred at the same time.

① Press the [UTILITY] key on the teach pendant, and press the [NEXT] key until [ENC] appears in the function menu.

② Press [ENC] ([F5] key). This shows the encoder status screen.



If an error status shown in the error status table above is displayed, the system can be restored from the position detector error by the user.

8.7 Restoring Zero Position Data by ① Multi-turn Data Reset

When the mechanical connection position of the servo motor and mechanical unit remains unchanged, execute this operation after battery replacement due to battery voltage drop or cable replacement due to cable breakage, for example.

1) See "8.5 Zero Position", and move the robot to the zero position by hand.
2) Change the operating mode to TEACH, and see "8.6 Encoder Status Screen" to show the encoder status screen.
3) After the encoder status screen is shown, press the [ALT] and [0] (numerical character for zero) keys simultaneously to disable editing lock.
4) After editing lock is disabled, press the [←] key to move to the MULTI column.
5) Move the cursor onto the axis for which you want to reset multi-turn data (to zero), and press [RESET] ([F3] key).
6) Turn on the controller.
7) Before operating the robot, be sure to perform "8.10 Check Work." Move the robot to a teaching point, etc. to check that zero setting is performed correctly. (In this operation, the original zero position is restored completely.)

8.8 ②Restoring Zero Position Data by ZEROP Function Using the Zero Setting Tool

If there is a change in mechanical connection due to motor replacement, etc., and the re-teaching of teaching points is assumed, then perform this operation.

⚠ CAUTION

- No original zero position data can be restored by the method of restoring zero positon data by ZEROP function. Use this method when performing re-teaching without fail.

8.8.1 Restoring Zero Position Data for All Axes

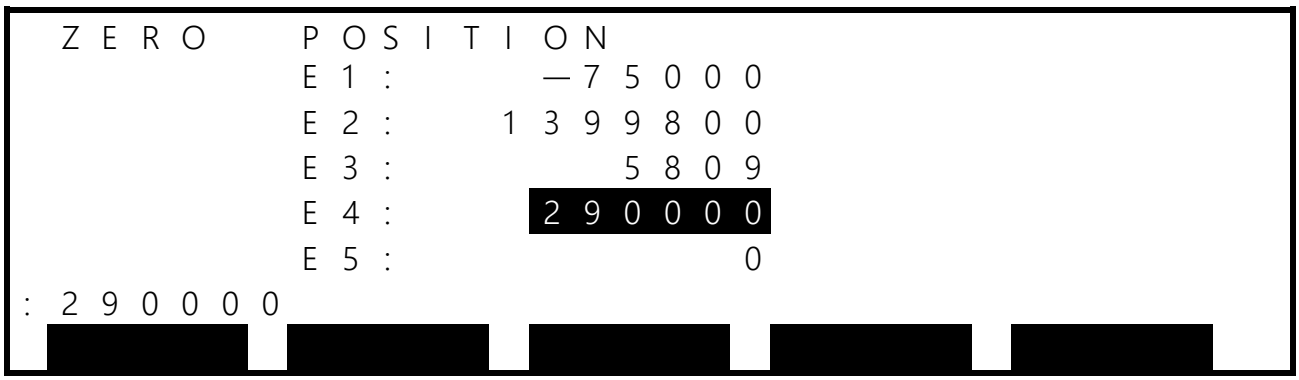
1) Change the master mode to TEACHING mode.
2) Fit the zero setting tool (optional) as described in "8.5.3 Installing the Zero Setting Tool (Optional)."
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key twice on the teach pendant.
5) Press the [F3] key twice on the teach pendant to select ZEROP mode.
6) The following screen for zero setting is displayed.

```
ZERO      POSITION
          E1:      -75000
          E2:    13998000
          E3:        5809
          E4:    29000000
          E5:           0
```

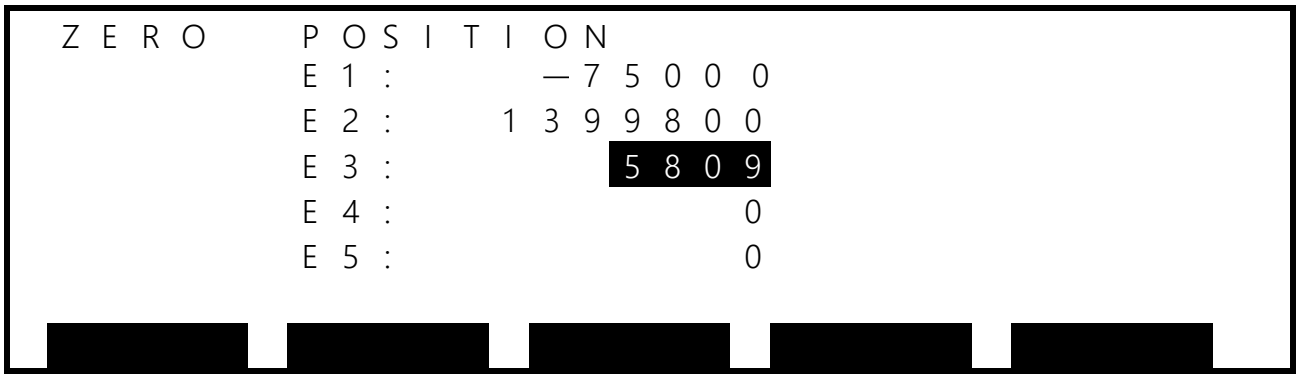
7) Press the [ALT] and [0] (numerical character for zero) keys simultaneously on the teach pendant.
8) The screen capable of zero position editing is displayed.
9) The numerical value of E1 (axis 1) is highlighted.
10) Press the [↓] key three times to highlight the numerical value of E4 (axis 4), as shown below.

```
ZERO      POSITION
          E1:      —75000
          E2:    13998000
          E3:        5809
          E4:    29000000
          E5:           0
```

11) Pressing the [EXE] key on the teach pendant shows the numerical value of E4 on the bottom left of the screen, as shown below. Setting this numerical value to 0 and pressing the [EXE] key change the numerical value of E4 to 0.



12) Pressing the [↑] key on the teach pendant highlights the numerical value of E3, as shown below. Then, configure setting in the same way. Note that the number to be input for E3 (axis 3) only is 1200000 instead of 0.



⚠ CAUTION

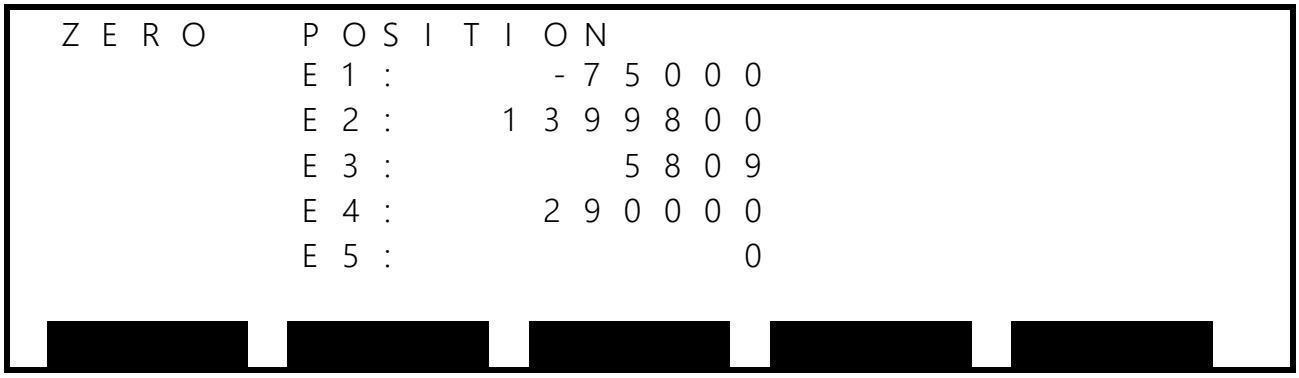
- The axes 3 and 4 of the robot operate simultaneously with each other. Therefore, the order of zero setting must be as follows:
  E4(Axis 4) → E3(Axis 3) → E2(Axis 2) → E1(Axis 1)

13) Turn on the controller.
14) Remove the zero setting tool (optional) that has been fitted in step 2).
15) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

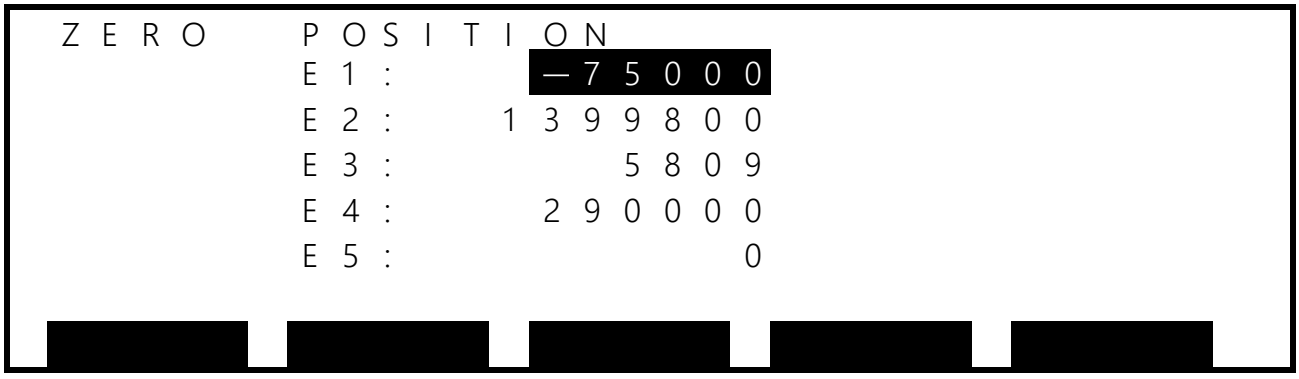
8.8.2 Restoring Axes-1 and -2 Zero Position Data

This paragraph describes the procedure for restoring axes-1 and -2 zero position data.
A typical example of restoring axis-1 zero position data is described. For axis-2 zero position data, replace axis 1 with axis 2 to restore zero position data.

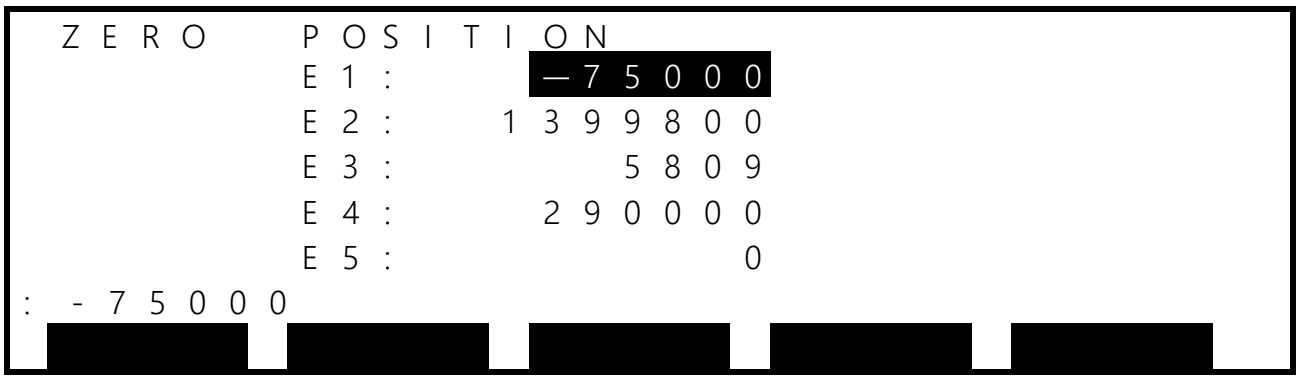
1) Change the master mode to TEACHING mode.
2) Fit the axis-1 zero setting tool (optional) as described in "8.5.3 Installing the Zero Setting Tool (Optional)."
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key twice on the teach pendant.
5) Press the [F3] key twice on the teach pendant to select ZEROP mode.
6) The following screen for zero setting is displayed.

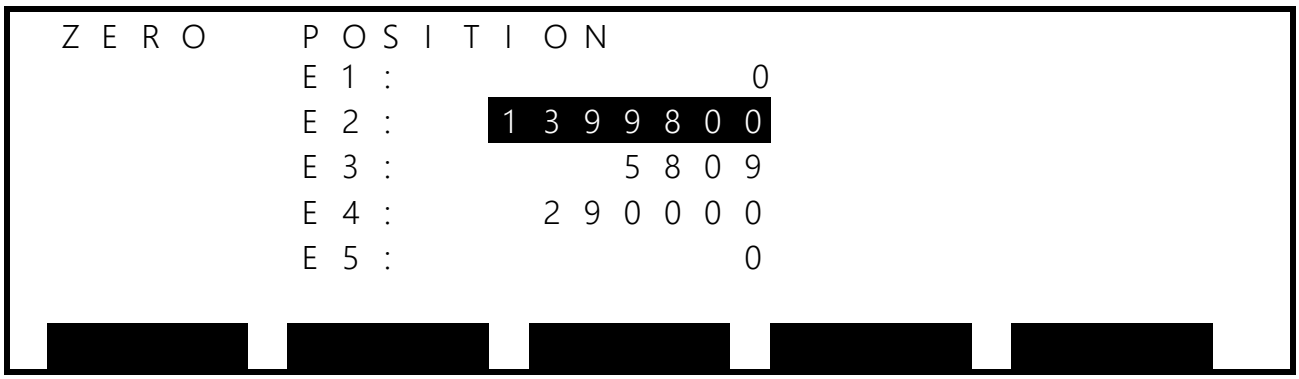


7) Press the [ALT] and [0] (numerical character for zero) keys simultaneously on the teach pendant.
8) The following screen capable of zero position editing is displayed.
9) The numerical value of E1 (axis 1) is highlighted.



10) Pressing the [EXE] key on the teach pendant shows the numerical value of E1 on the bottom left of the screen, as shown below. Setting this numerical value to 0 and pressing the [EXE] key change the numerical value of E1 to 0.



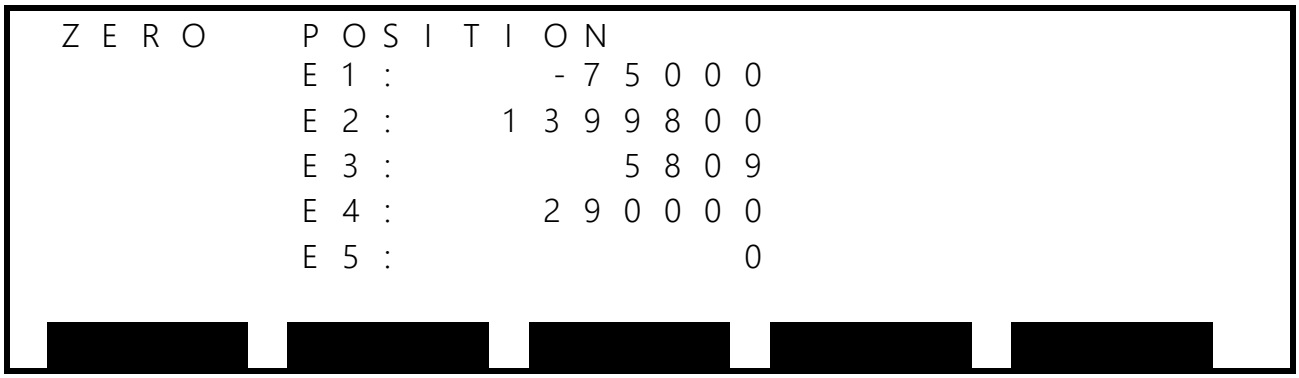


11) Turn on the controller.
12) Remove the zero setting tool (optional) that has been fitted in 2).
13) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

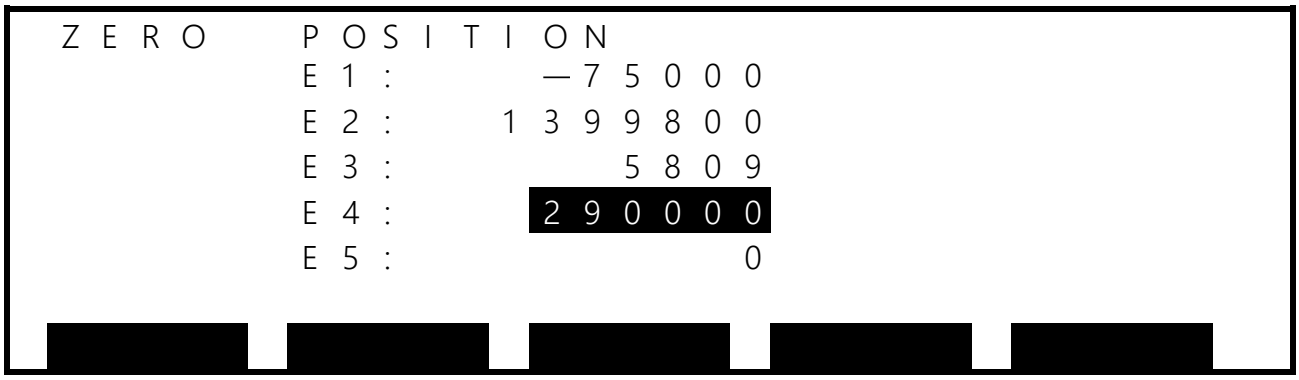
8.8.3 Restoring Axes-3 and -4 Zero Position Data

This paragraph describes the procedure for restoring axes-3 and -4 zero position data.

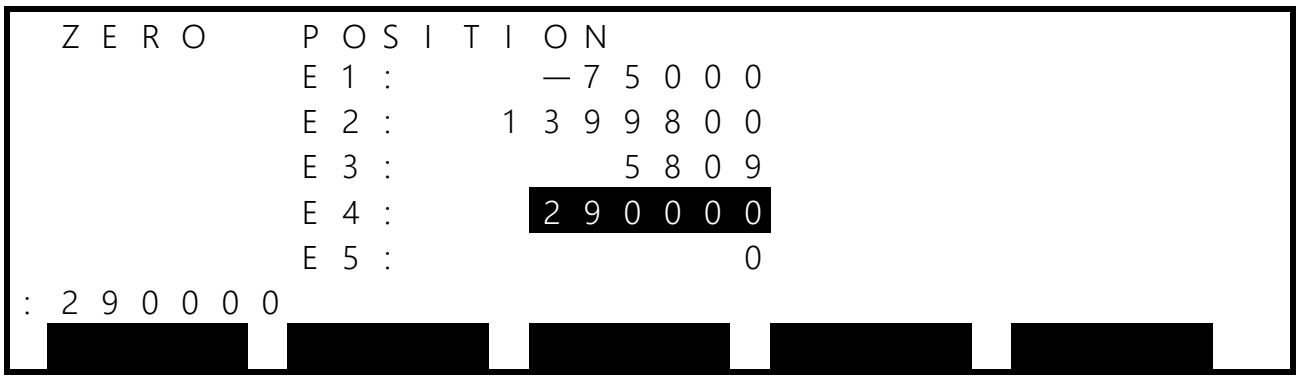
1) Change the master mode to TEACHING mode.
2) Fit the axes-3 and -4 zero setting tool (optional) as described in "8.5.4 Attaching/Detaching the Axes-3 and -4 Zero Setting Tool."
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key twice on the teach pendant.
5) Press the [F3] key twice on the teach pendant to select ZEROP mode.
6) The following screen for zero setting is displayed.



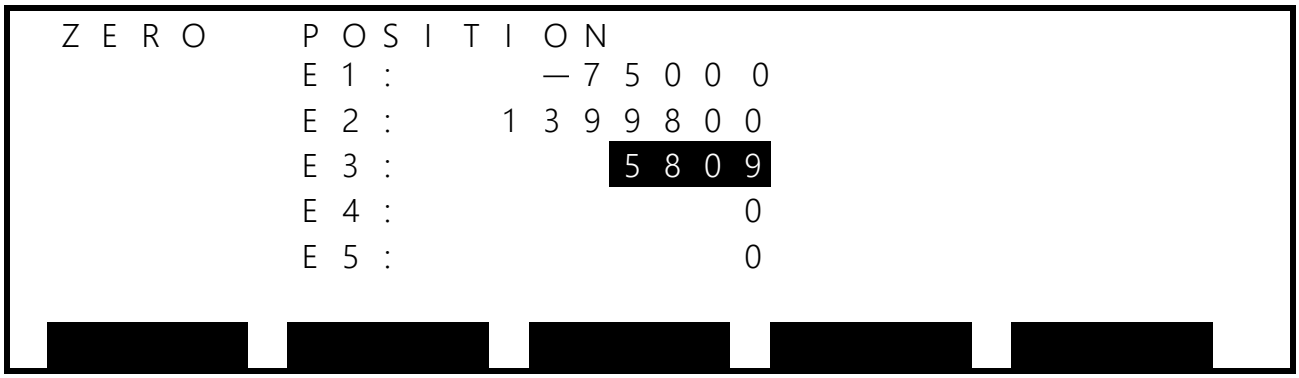
7) Press the [ALT] and [0] (numerical character for zero) keys simultaneously on the teach pendant.
8) The screen capable of zero position editing is displayed.
9) The numerical value of E1 (axis 1) is highlighted.
10) Press the [↓] key three times to highlight the numerical value of E4 (axis 4), as shown below.



11) Pressing the [EXE] key on the teach pendant shows the numerical value of E4 on the bottom left of the screen, as shown below. Setting this numerical value to 0 and pressing the [EXE] key change the numerical value of E4 to 0.



12) Pressing the [↑] key on the teach pendant highlights the numerical value of E3, as shown below. Then, configure setting in the same way. Note that the number to be input for E3 (axis 3) only is 1200000 instead of 0.



⚠ CAUTION

- The axes 3 and 4 of the robot operate simultaneously with each other. Therefore, the order of zero setting must be as follows:
  E4(Axis 4) → E3(Axis 3)

13) Turn on the controller.
14) Remove the zero setting tool (optional) that has been fitted in 2).
15) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

8.9 ③ Other Zero Setting

8.9.1 Restoring Zero Position Data by HOME Function

[1] Outline of HOME Function

This function memorizes a specific coordinate value in each axis and restores the original zero position data by using the HOME function when the machine zero position data has been destroyed.
The set points are provided for HOME1 to HOME4, and the plus (+) side mechanical stopper positions of the axis 1 to axis 3 are set in HOME3, and the minus (–) side mechanical stopper positions of the axis 1 to axis 3 in HOME4. The axis 4 is set at the 0° position according to the zero point match-mark.
For HOME1 and HOME2, you can specify any values. It is recommended that when building up a system, you specify the place for securing the robot end. Two patterns can be set: pattern 1 in HOME1 and pattern 2 in HOME2.

(Page 1)

USER	HOME 1	HOME 2	
(J 1)	0	0	[deg]
(J 2)	0	0	[deg]
(J 3)	0	0	[mm]
(J 4)	0	0	[deg]
(J 5)	0	0	[mm]

SET TEACH

(Page 2)

USER	HOME 3	HOME 4	
(J 1)	1313347	-1313140	[deg]
(J 2)	14740644	-14746622	[deg]
(J 3)	1621183	-19330	[mm]
(J 4)	0	0	[deg]
(J 5)	0	0	[mm]

SET TEACH

Caution: This function is used to restore the machine zero point of each axis. NEVER use the function at other than the setting for restoration.

[2] Setting HOME1 and HOME2

⚠ CAUTION

- Operations in "[2] Setting HOME and HOME2" should be performed when position data that does not require zero setting is correct. The operations cannot restore the zero point even if they are performed when zero setting is required.

1) Operate the robot to fix the tool shaft at any position. Fig. 8.12 shows an example of securing the tool shaft. Fig. 8.13 shows an example of the shape that should be prepared by the customer when the tool flange (optional) is secured.

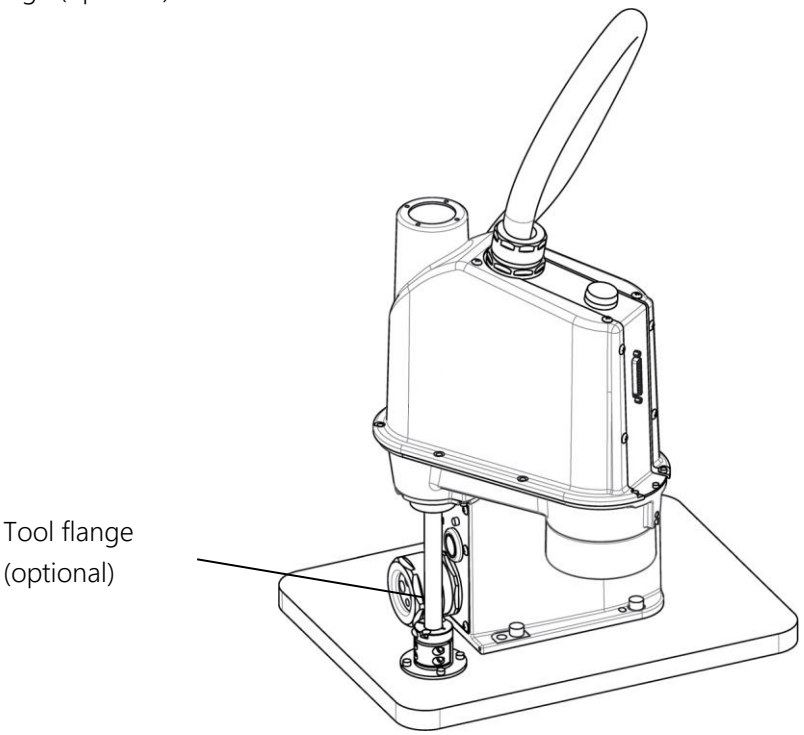


Fig. 8.1 Example of Fixing the Tool Shaft

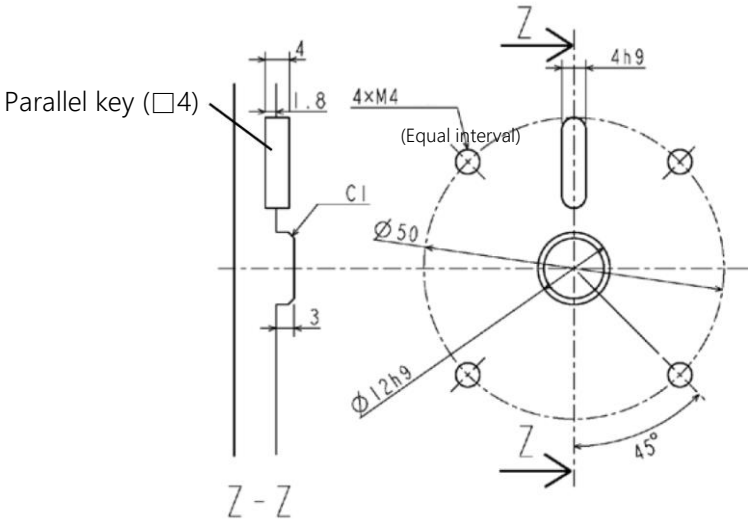
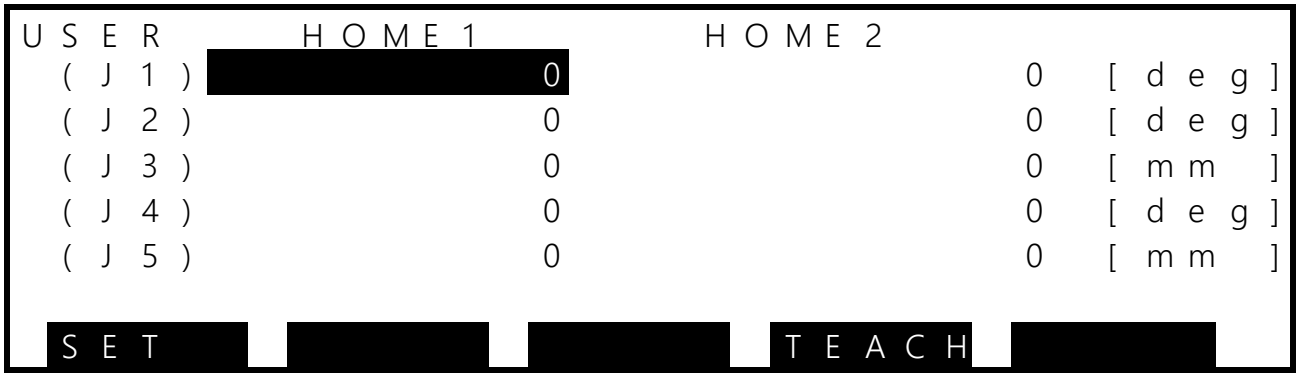


Fig. 8.2 Example of Shape of Securing the Tool Flange (Optional)

2) Turn off the servos.
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key until [REORG] is shown, and press [REORG] ([F1] key).



5) The screen above appears. Then, for each axis, have the system memorize the position where the robot is fixed, moving the cursor and using [TEACH] ([F4] key).

[3] How to Restore Data by HOME1 or HOME2

If there is a change in mechanical connection due to motor replacement, etc., and the re-teaching of teaching points is assumed, then perform this operation. This paragraph shows the method of restoring data using HOME1. If HOME2 is used, data is also restored in the same way.

⚠ CAUTION

- Some error may be caused, depending on how to make adjustments. Re-teaching of teaching points may be required under some circumstances.

1) Move the robot to the position set by HOME1, and fix it at the position. (See Fig. 8.12)
2) Turn off the servos.
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key until [REORG] is shown, and press [REORG] ([F1] key).
5) Move the cursor to each axis in HOME1 on the REORG screen, and press [SET] ([F1] key) to rewrite the position where the robot is fixed to the coordinates set in HOME1.
6) Even after HOME 1 is performed, the robot can be used, but the data format is different from the factory default setting. If you continue to use it along with the data format, then no normal zero setting can be performed even by clearing multi-turn data when the batteries run out. See "[5] Rewriting Zero Position Data", and rewrite zero position data.
7) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

⚠ CAUTION

- In the robot, there is interference between the axes 3 and 4.
  Therefore, if a specified procedure is not followed, the current position of the painted workpiece conveyer may deviate. When using this function, REORG, to restore the zero point of the axis 3 (axis 4), be sure to restore the zero point of the axis 4 (axis 3) as well.

  Operation procedure
  1) Fix the axes 3 and 4 at the position of the specified position.
  2) Move the cursor onto J3 on the screen, and press the [SET] (F1) key to restore the zero point of the axis 3.
  3) Move the cursor onto J4 on the screen, and press the [SET] (F1) key to restore the zero point of the axis 4.

[4] How to Restore Data by HOME3 or HOME4

If there is a change in mechanical connection due to motor replacement, etc., and the re-teaching of teaching points is assumed, then perform this operation. By factory default, the plus (+) direction side mechanical stopper positions of the axes 1 to 3 are set in HOME3, and the minus (-) direction side mechanical stopper positions of the axes 1 to 3 are set in HOME4. The axis 4 is initially set to the position of the zero point match-mark. (Therefore, the axis 4 may be unable to be restored completely.)
This section describes a restoration procedure that uses HOME3.

⚠ CAUTION

- Some error may be caused, depending on how to make adjustments. Re-teaching of teaching points may be required under some circumstances.

1) Turn off the servos.
2) Press the [UTILITY] key on the teach pendant.
3) Press the [NEXT] key until [REORG] is shown, and press [REORG] ([F1] key).
4) Press the [NEXT] key to display page 2.

USER	HOME3	HOME4	
(J1)	1 3 1 3 3 4 7	- 1 3 1 3 1 4 0	[deg]
(J2)	1 4 7 4 0 6 4	- 1 4 7 4 6 6 2	[deg]
(J3)	1 6 2 1 1 8 3	- 1 9 3 3 0	[mm]
(J4)	0	0	[deg]
(J5)	0	0	[mm]

SET TEACH

1) Manually rotate the axis-1 arm in the plus (+) direction to bring the mechanical stopper into contact with the axis 1.

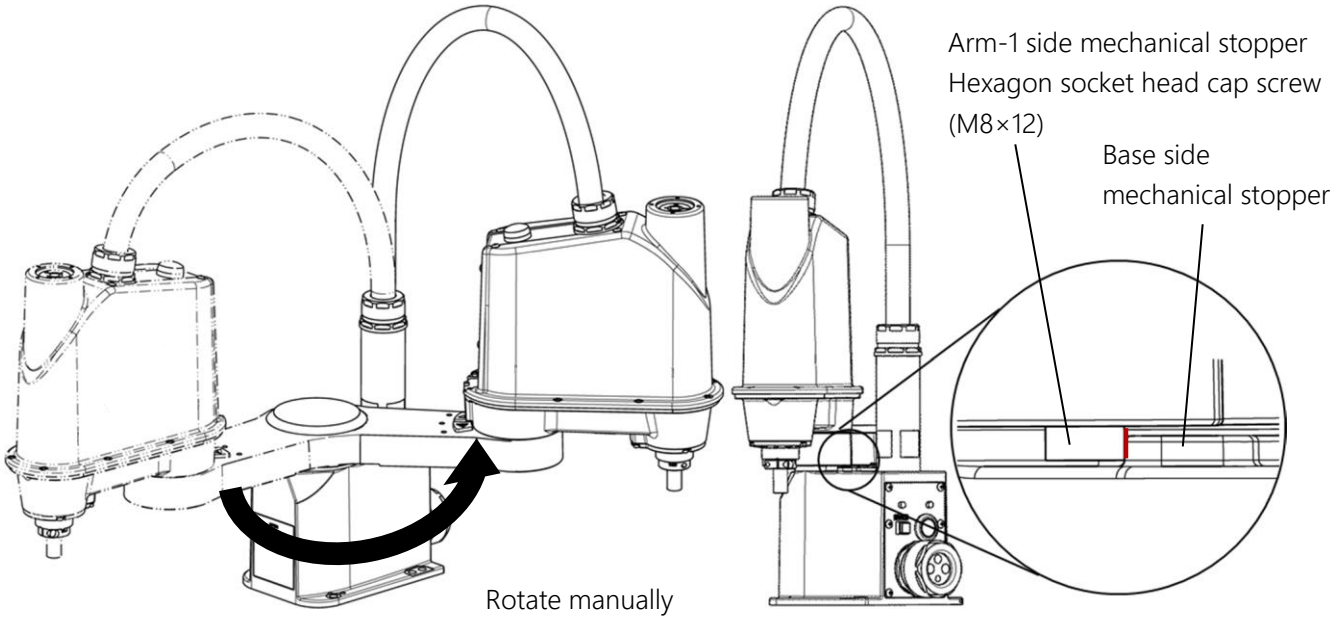


Fig. 8.3 Work to Bring the Mechanical Stopper into Contact with the Axis 1 (HOME3)

1) Move the cursor onto (J1) in HOME3, and press [SET] ([F1] key). This restores the machine zero point of

the axis 1.

2) Similarly, manually rotate the arm 2 in the plus (+) direction to bring the mechanical stopper into contact with the axis 2.
3) Move the cursor onto (J2) in HOME3, and press [SET] ([F1] key). This restores the machine zero point of the axis 2.
4) Align the axis 4 with the axis-4 zero point match-mark while pressing the brake release switch. (See Fig. 8.5.)
5) Move the cursor onto (J4) in HOME3, and press [SET] ([F1] key). This restores the axis 4.
6) Bring the mechanical stopper into contact with the spline nut while pressing the brake release switch.

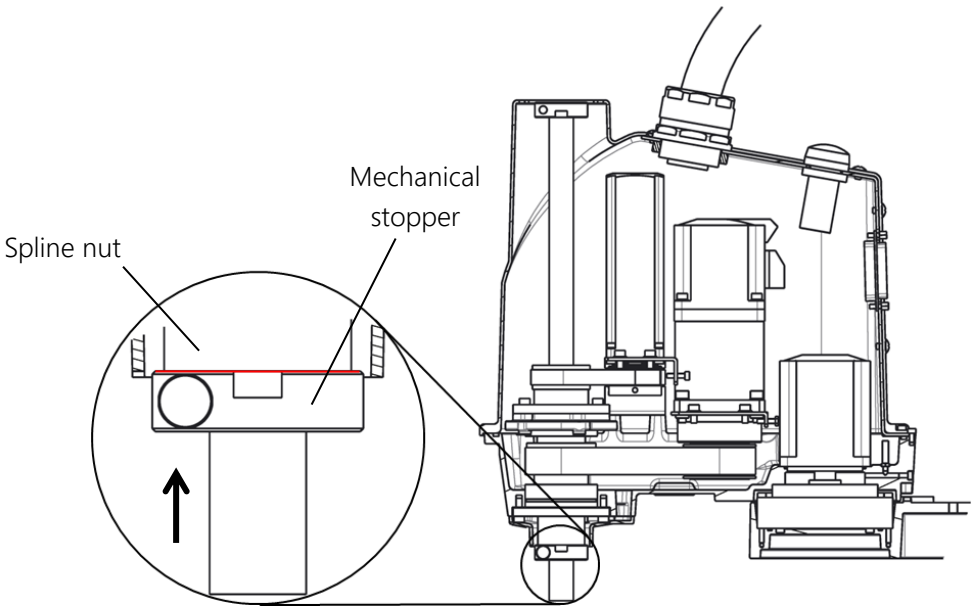


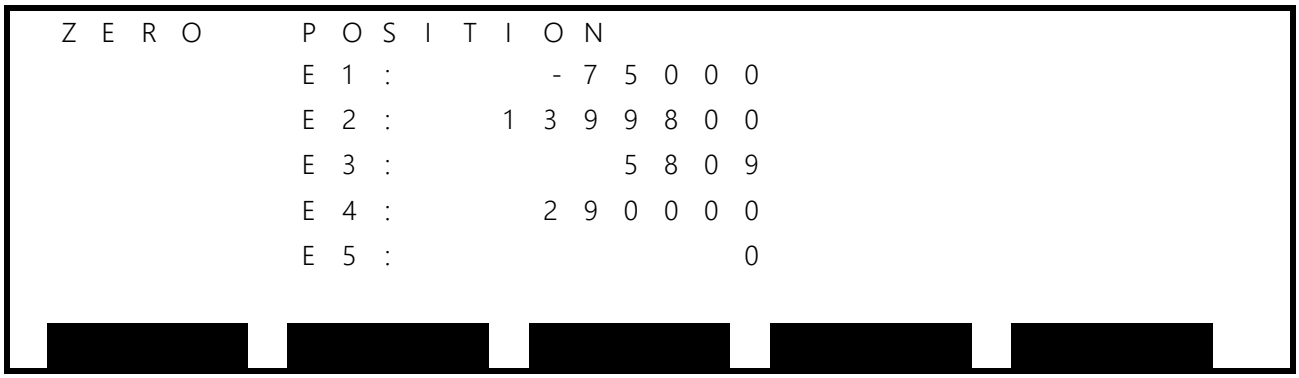
Fig. 8.4 Work to Bring the Mechanical Stopper into Contact with the Axis 3 (HOME3)

7) Move the cursor onto (J3) in HOME3, and press [SET] ([F1] key). This restores the axis 3.
8) Use the [ESC] key to exit the HOME screen.
9) Even after HOME 3 and 4 are performed, the robot can be used, but the data format is different from the factory default setting. If you continue to use it along with the data format, then no normal zero setting can be performed even by clearing multi-turn data when the batteries run out. See "[5] Rewriting Zero Position Data", and rewrite zero position data.
10) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

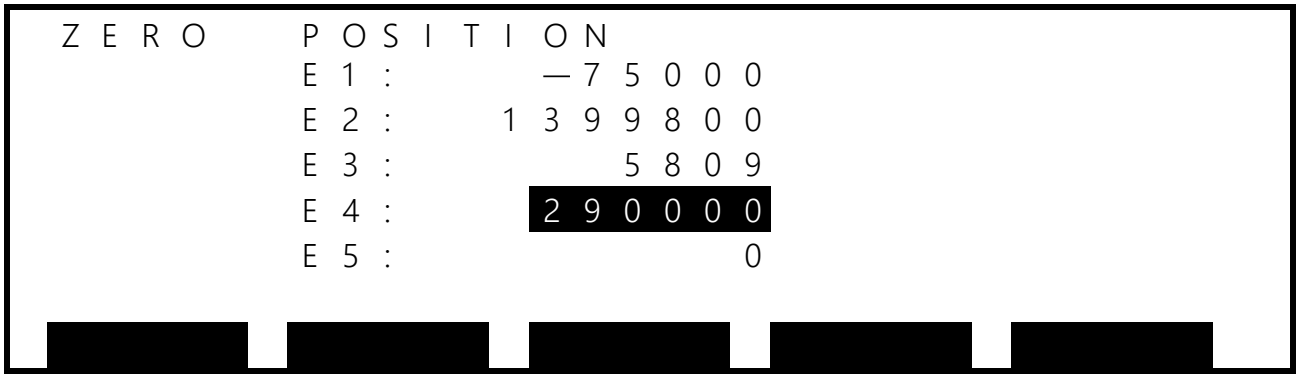
[5] Rewriting Zero Position Data

After HOME operation is performed, the format of servo offset and multi-turn data is different from the factory default setting. Even if this opration is not performed, the robot operates normally; however, in that case, no normal zero setting can be performed even by clearing multi-turn data when the batteries run out. After HOME operation, perform this operation to return zero point data to the factory default setting.

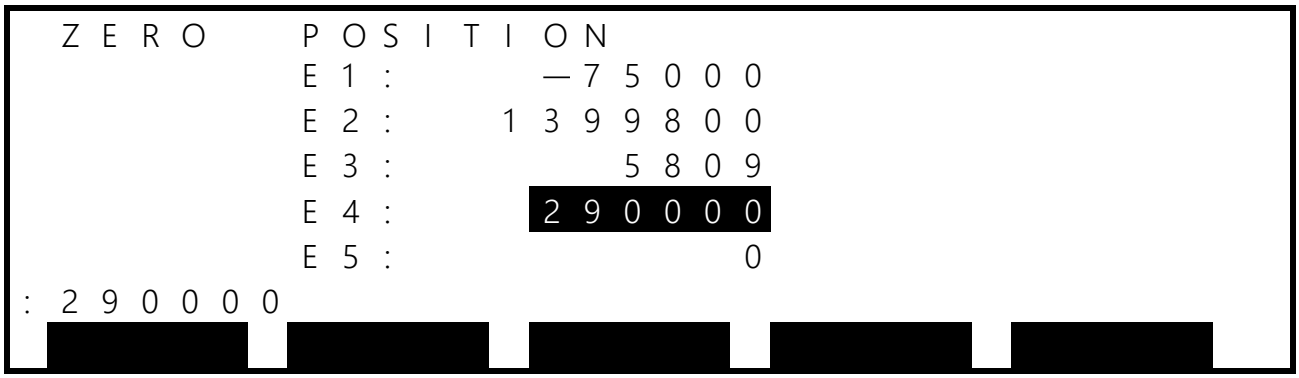
1) Change the master mode to TEACHING mode.
2) Use the MOVEA instruction in the DO function to move to "0" on each axis. At this time, execute OVRD, ensuring safety at a low speed. For the DO function, see the OPERATOR'S MANUAL.
3) Press the [UTILITY] key on the teach pendant on the initial screen.
4) Press the [NEXT] key twice on the teach pendant.
5) Turn off the servos.
6) Press the [F3] key on the teach pendant, and select ZEROP mode.
7) The following screen for zero setting is displayed.



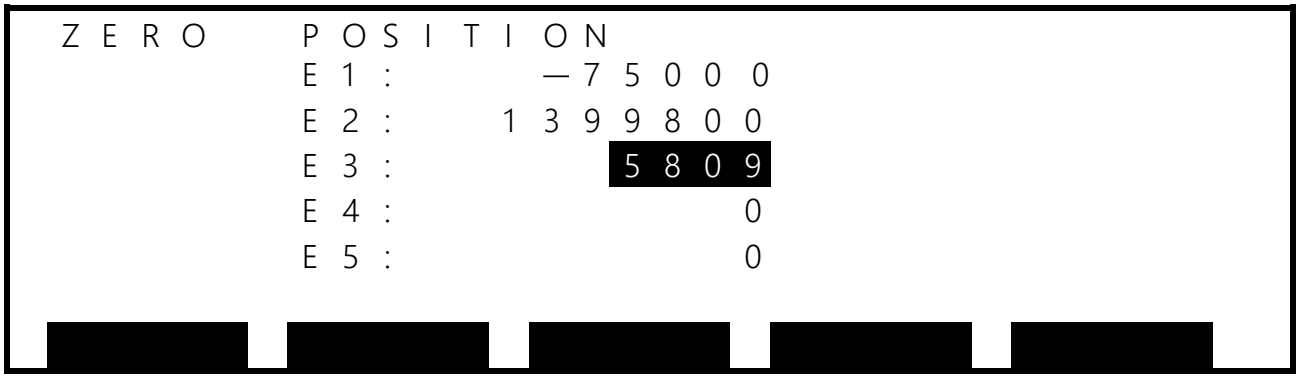
8) Simultaneously press the [ALT] and [0] (numerical character for zero) keys on the teach pendant.
9) The screen capable of zero position editing is displayed.
10) The numerical value of E1 (axis 1) is highlighted.
11) Press the [↓] key three times to highlight the numerical value of E4 (axis 4), as shown below.



12) Pressing the [EXE] key on the teach pendant shows the numerical value of E4 on the bottom left of the screen, as shown below. Setting this numerical value to 0 and pressing the [EXE] key change the numerical value of E4 to 0.



13) Pressing the [↑] key on the teach pendant highlights the numerical value of E3, as shown below. Then, configure setting in the same way.



⚠ CAUTION

- The axes 3 and 4 of the robot operate simultaneously with each other. Therefore, the order of zero setting must be as follows:
  E4(Axis 4) → E3(Axis 3) → E2(Axis 2) → E1(Axis 1)

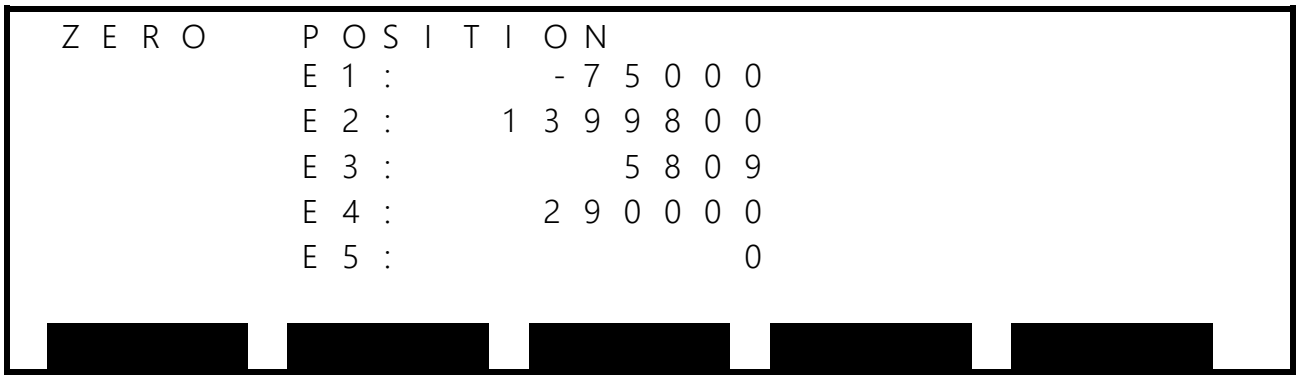
14) Turn on the controller.
15) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

8.9.2 Restoring Zero Position Data by Zero Point Match-Mark

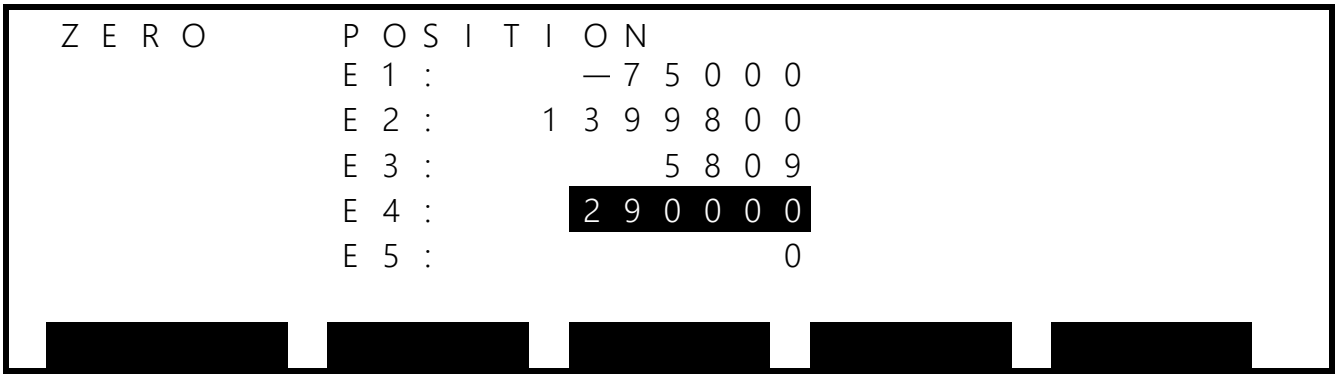
⚠ CAUTION

- No original zero position data can be restored by the method of restoring zero position data by the zero point match-mark. Use this method when performing re-teaching without fail.

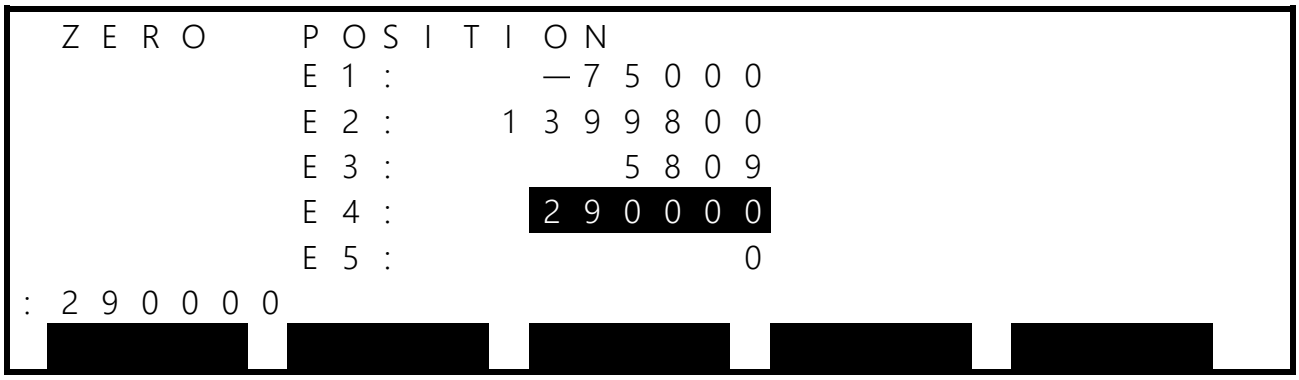
1) Change the master mode to TEACHING mode.
2) See "8.5.1 Locations of Zero Point Match-Marks of the Robot" and "8.5.2 Axis-3 Zero Position," and move the robot to the zero position.
3) Press the [UTILITY] key on the teach pendant.
4) Press the [NEXT] key twice on the teach pendant.
5) Turn off the servos.
6) Press the [F3] key twice on the teach pendant to select ZEROP mode.
7) The following screen for zero setting is displayed.



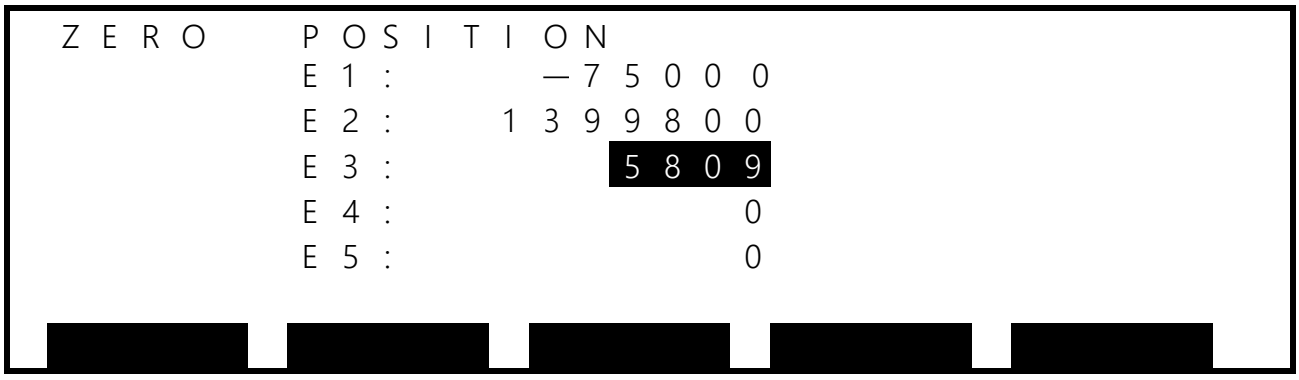
8) Press the [ALT] and [0] (numerical character for zero) keys simultaneously on the teach pendant.
9) The screen capable of zero position editing is displayed.
10) The numerical value of E1 (axis 1) is highlighted.
11) Press the [↓] key three times to highlight the numerical value of E4 (axis 4), as shown below.



12) Pressing the [EXE] key on the teach pendant shows the numerical value of E4 on the bottom left of the screen, as shown below. Setting this numerical value to 0 and pressing the [EXE] key change the numerical value of E4 to 0.



13) Pressing the [↑] key on the teach pendant highlights the numerical value of E3, as shown below. Then, configure setting in the same way.



⚠ CAUTION

- The axes 3 and 4 of the robot operate simultaneously with each other. Therefore, the order of zero setting must be as follows:
  E4(Axis 4) → E3(Axis 3) → E2(Axis 2) → E1(Axis 1)

14) Turn on the controller.
15) Before operating the robot, be sure to perform "8.10 Check Work". Move the robot to a teaching point, etc. to check that zero setting has been performed correctly.

8.10 Check Work

Carry out check work in order of the axis 1, axis 2, axis 3 and axis 4. After all axes are checked completely, check whether there is a deviation in teaching points as well.

8.10.1 Checking the Axis 1 and Axis 2

Manually move the axes 1 and 2 to the travel limit in an emergency stop state, and check that a soft limit error occurs. Also, when manually bringing an arm into contact with the mechanical stopper, check on the POS screen of the utility that the position is not largely deviated from the values of axis 1 and axis 2 in HOME3 or HOME4 used in [4] How to Restore Data by HOME3 or HOME4 in "8.9.1 Restoring Zero Position Data by HOME Function."Fig. 8.16 shows check work that rotates the arm 1 in the plus (+) direction to bring the mechanical stopper into contact with the arm 1. Rotate the arm 1 in the minus (-) direction and check the axis 2 similarly.

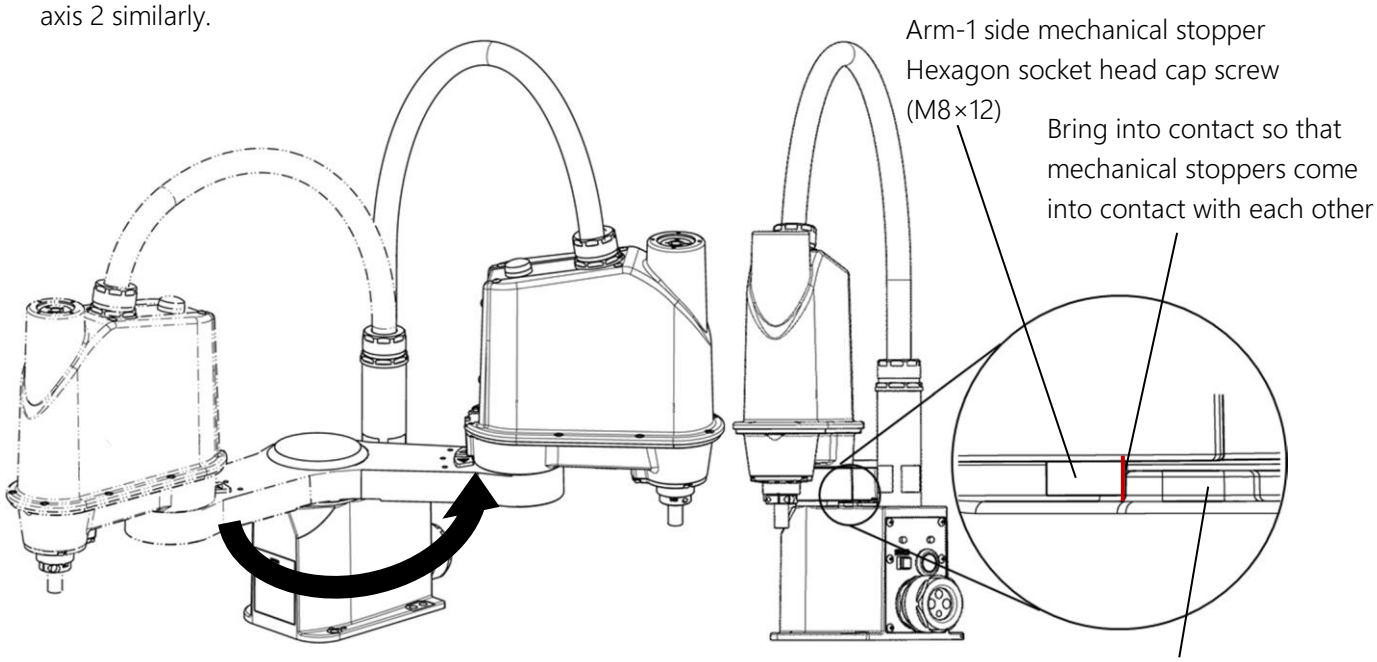


Fig. 8.5 Check Work (Axis 1 in Plus (+) Rotation Direction)

8.10.2 Checking the Axis 3

While pressing the brake release switch in an emergency stop state, manually move the axis 3 to the travel limit to check that a soft limit error occurs. Also, when manually bringing an arm into contact with the mechanical stopper, check on the POS screen of the utility that the value of the axis 3 is not largely deviated from the value of axis 3 in HOME3 or HOME4 used in [4] How to Restore Data by HOME3 or HOME4 in "8.9.1 Restoring Zero Position Data by HOME Function." Fig. 8.6 shows check work for the axis 3.

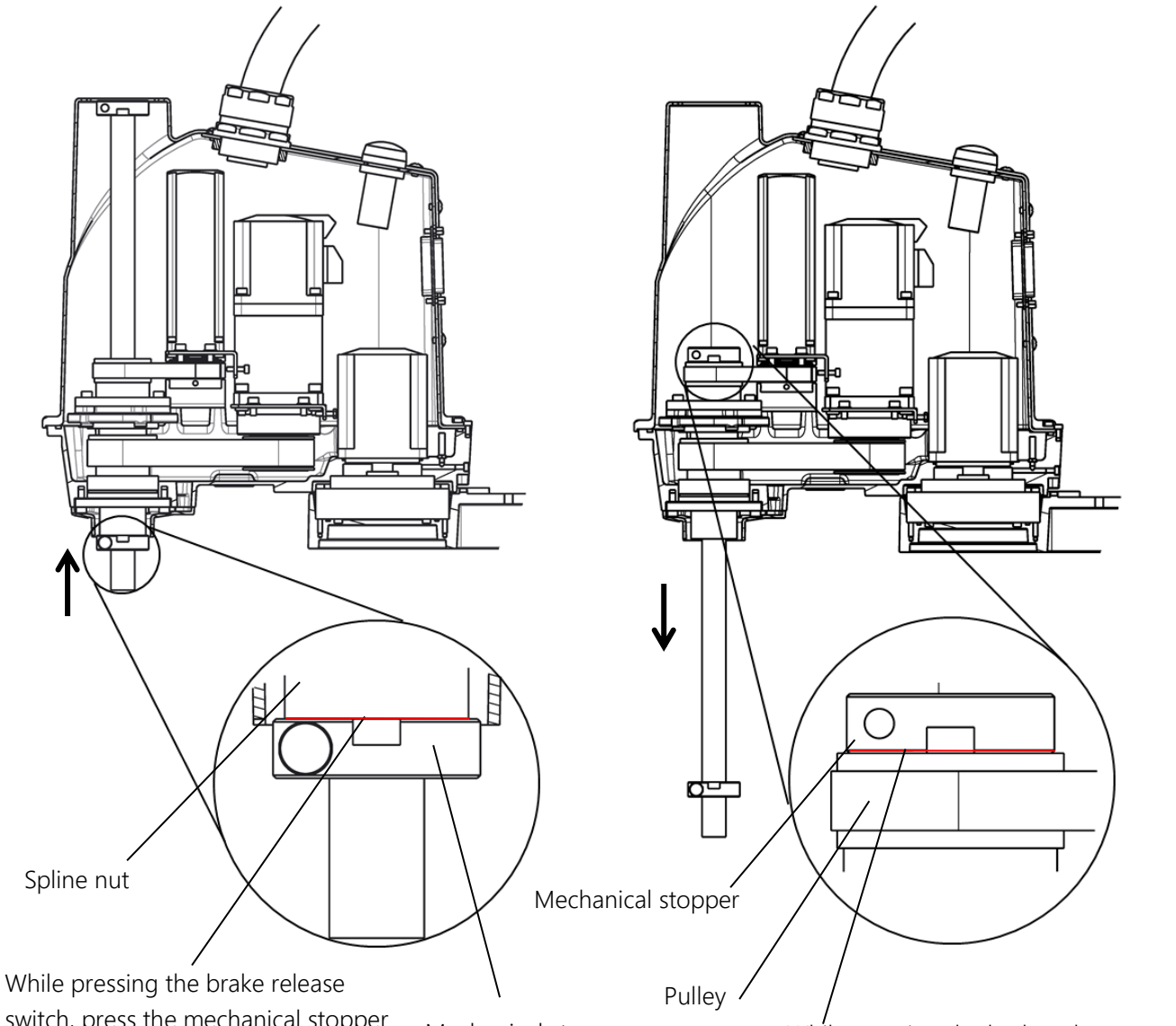


Fig. 8.6 Check Work (Axis 3)

8.10.3 Checking the Axis 4

While pressing the brake release switch in an emergency stop state, manually align the axis 4 with the zero position as shown in Fig. 8.7. At this time, check on the POS screen of the utility that the value of the axis 4 is not deviated from 0.

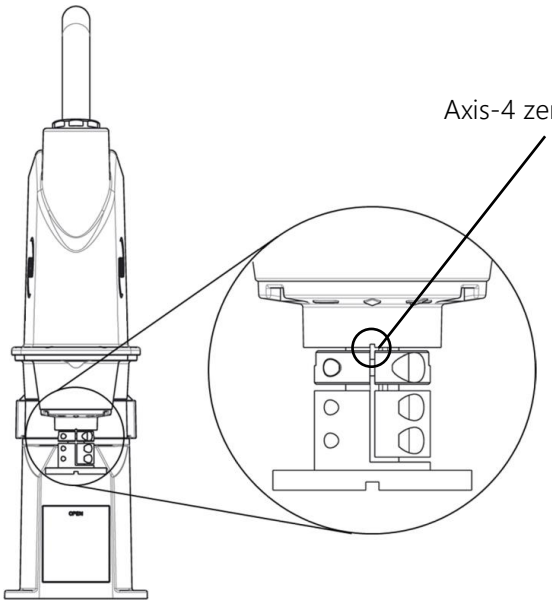


Fig. 8.7 Check Work (Axis 4)

⚠ CAUTION

- This is important work to check whether zero setting has been performed correctly. This check work must be carried out after the zero position is restored using any zero setting method. If the zero setting is not set correctly and the robot is operated without carrying out this check work, then it may collide with the mechanical stopper.

9. Replacement Parts for Maintenance

9.1 Notes on Replacement Parts for Maintenance

⚠ CAUTION

- In the list of maintenance and replacement parts for the robot, items other than encoder backup battery is all special-specification products; therefore, when purchasing or ordering them, be sure to contact CKD.
- The worker should receive safety training for laborer engaged in industrial robot-related work defined by each country's laws and restrictions. CKD Service Department also accepts replacement work at an extra cost.
- Be aware that CKD' warranty does not cover failures and accidents resulting from the replacement of parts by the customer.

9.2 List of Replacement Parts – Robot

No	Part name	Model	Drawing No.	Unit code	Manufacturer	Q'ty	Remarks
1	AC servo motor		S948801	Y610D04M0	SHIBAURA MACHINE	1	Axis 1
2			S948802	Y610D04N0		1	Axis 2
3			S948803	Y610D04P0		1	Axis 3
4			S948804	Y610D04Q0		1	Axis 4
5	Reduction gear		S948805	Y610D04R0	SHIBAURA MACHINE	1	Axis 1
6			S948806	Y610D04S0		1	Axis 2
7			S958005	Y610D05P0		1	Axis 4
8	Timing pulley		S958020 * (B side)	Y610D04T0	SHIBAURA MACHINE	1	Axis 3
9			S958021 * (M side)			1	Axis 3
10			S958022 * (B side)			1	Axis 4
11			S958023 * (M side)			1	Axis 4
12	Timing belt		S958024			1	Axis 3
13			S958025			1	Axis 4
14	Ball screw spline unit		H852810	Y610A3NE0	SHIBAURA MACHINE	1	
15	Body harness		F113089	Y610A3Q70	SHIBAURA MACHINE	1	
16	LED Lamp		M332780	Y610D05H0	SHIBAURA MACHINE	1	
17	Grease	SFB No.1 (For reduction gear)			Nidec-Shimpo Corp.		Axis 1 Axis 2
18		AFF grease (For ball screw)			THK		Axis 3
19	Encoder backup battery	Alkaline AA-cell battery				3	All axes

*(B side) means the ball screw side, and (M side) means the motor side.