EPSON

SCARA ROBOT

ES/EL series

MANIPULATOR MANUAL

Rev.9   EM019R893F

MANIPULATOR MANUAL   ES/EL series   Rev.9

SCARA ROBOT

ES / EL series   Manipulator manual
Rev.9

WARRANTY

The robot and its optional parts are shipped to our customers only after being subjected to the strictest quality controls, tests and inspections to certify its compliance with our high performance standards.

Product malfunctions resulting from normal handling or operation will be repaired free of charge during the normal warranty period. (Please ask your Regional Sales Office for warranty period information.)

However, customers will be charged for repairs in the following cases (even if they occur during the warranty period):

1. Damage or malfunction caused by improper use which is not described in the manual, or careless use.

2. Malfunctions caused by customers' unauthorized disassembly.

3. Damage due to improper adjustments or unauthorized repair attempts.

4. Damage caused by natural disasters such as earthquake, flood, etc.

Warnings, Cautions, Usage:

1. If the robot or associated equipment is used outside of the usage conditions and product specifications described in the manuals, this warranty is void.

2. If you do not follow the WARNINGS and CAUTIONS in this manual, we cannot be responsible for any malfunction or accident, even if the result is injury or death.

3. We cannot foresee all possible dangers and consequences. Therefore, this manual cannot warn the user of all possible hazards.

TRADEMARKS

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NOTICE

◆ No part of this manual may be copied or reproduced without authorization.

◆ The content of this manual is subject to change without notice.

◆ We ask that you please notify us if you should find any errors in this manual or if you have any comments regarding its content.

SAFETY PRECAUTIONS

Please carefully read this and other related manuals before and while using the equipment. Keep this manual in a handy location for easy access at all times.

⚠	WARNING	■ This sign indicates that a danger of serious injury or death will exist if theses instructions are not followed.
⚠	CAUTION	■ This sign indicates that ignoring these instructions may cause harm to people or physical damage to equipment and facilities.

⚠ **WARNING**

■ The robot system manufacturer/supplier must design and construct robot systems in accordance with the principles described in the *Safety* chapter of the "User's Guide" or "SRC5**/SPEL 95 Introduction manual" or "User's manual". Please read these manual first.

■ This robot has been designed and manufactured strictly for use in a normal indoor environment. Do not use the robot in an environment that exceeds the conditions set forth in the manuals for the manipulator and controller.

■ Do not use the robot outside of the usage conditions and product specifications described in the manuals. Doing so will not only adversely affect the life of the product, but may also present a serious safety problem.

■ Only trained personnel should be allowed to design, install, operate, perform function testing, and maintain this manipulator and the robot system.

■ Trained personnel are those who have taken a robot training course (held by the dealer on a regular basis) or those who have carefully read the manuals and have equivalent knowledge and skill.

FOREWORD

This manual contains information that you need to know to use the ES / EL series manipulator correctly. Please thoroughly read this and other related manuals before using the equipment.

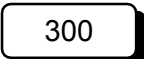This manipulator can be used with the following EPSON robot controllers:
- EPSON RC+
- SPEL 95 / SRC5**
- SRC-3**

Use the descriptions for the controller used with your manipulator, indicated by the following icons:

| RC+ | Procedure when using EPSON RC+ Robot Control System. |

| SPEL 95 | Procedure when using SPEL 95 / SRC5** controllers. |

| 300 | Procedure when using SRC-3** controllers. |

If the manipulator is a Clean model, refer to the chapters *Clean Model* and *Clean Model Maintenance*, which provide a summary of differences between the Clean and Standard specifications.

If the manipulator is a Protected model, refer to the chapters *Protected Model* and *Protected Model Maintenance*, which provide a summary of differences between the Protected and Standard specifications.

| 300 | An "axis" of the manipulator is referred to as a "joint" in this manual. |

SERVICE CENTER

Contact the following service center for robot repairs, inspections or adjustments.

Please have the model name, "Serial No." or "M.CODE", software version and a description of the problem ready when you call.

If service center information is not indicated here, please contact the supplier office for your region as listed in the following SUPPLIERS section.

SUPPLIERS

Japan & Others **SEIKO EPSON CORPORATION**
Okaya Plant No. 2
1-16-15, Daiei-cho
Okaya-shi, Nagano-ken, 394-0025
Japan

TEL: 81-266-23-0020 (switchboard)
81-266-24-2004 (direct)
FAX: 81-266-24-2017

North & South **EPSON AMERICA, INC.**
America Factory Automation/Robotics
18300 Central Avenue
Carson, CA 90746

TEL: (562) 290-5900
FAX: (562) 290-5999
E-MAIL: info@robots.epson.com

Europe **EPSON DEUTSCHLAND GmbH**
Factory Automation Division
Zuelpicher Str. 6 D-40546 Duesseldorf

TEL: (++) 49 - 211 - 5603 391 (Inside Sales)
FAX: (++) 49 - 211 - 5603 444
E-MAIL: robot.infos@epson.de

TABLE OF CONTENTS

Part 1: Setup & Operation

Part 2: Maintenance

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Part 1
Setup & Operation

Part 1 contains information for setup and operation of the EPSON
ES and EL Series Manipulators, including:

- Installation
- Safety
- User wiring and pneumatics
- Attaching external devices
- Motion range adjustments
- Specifications

1. Manipulator Part Names

The model name of the ES / EL series Manipulator is specified as follows:

ES 55 1 S

Option	S:	Standard model
	C:	Clean model *[1]
	P:	Protected model *[2]
Joint #3 stroke	1:	170 mm
	3:	320 mm
Arm length	45:	450 mm
	55:	550 mm
	65:	650 mm
	85:	850 mm
Series name	ES, EL	
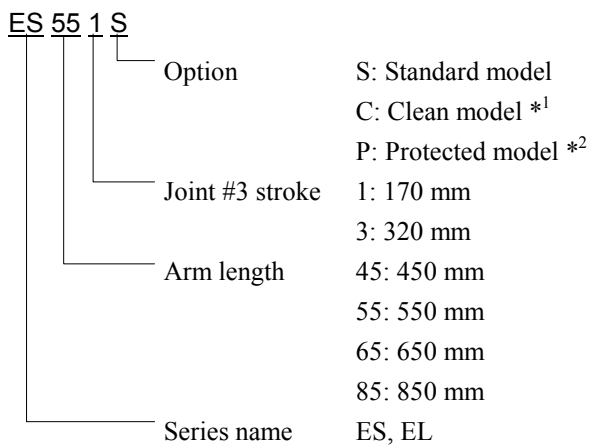
*1   If the Manipulator is a Clean model, refer to chapter *11. Clean Model*.

*2   If the Manipulator is a Protected model, refer to chapter *12. Protected Model*.

Manipulator parts
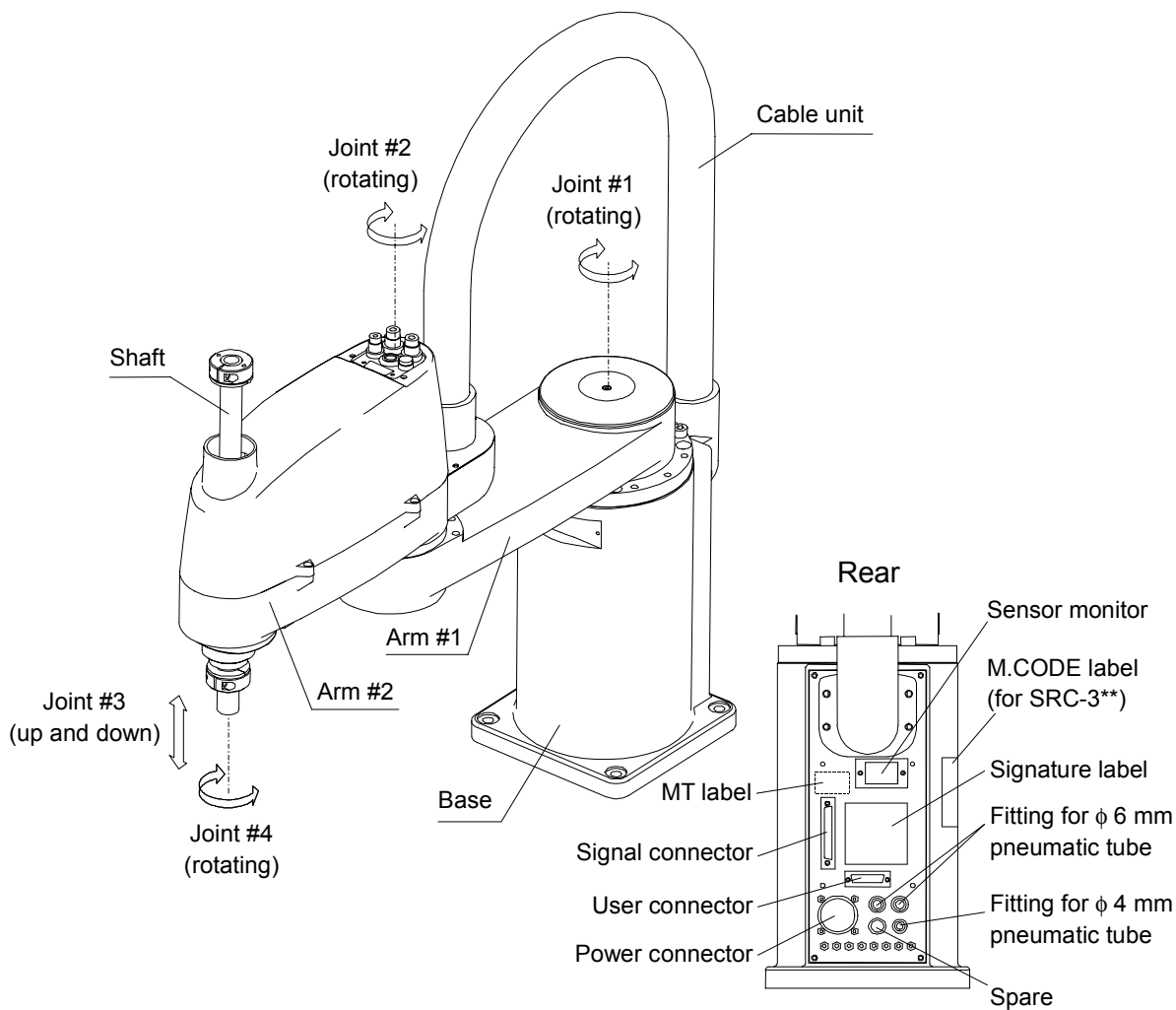
Figure 1.   Manipulator

2. Installation Requirements

2.1 Environmental conditions

A suitable environment is necessary for the manipulator to function properly and safely. Please install the robot in a place that meets the following requirements.

Ambient temperature	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80% (no condensation)
First transient burst noise	2kV max.
Electrostatic noise	6kV max.
Environment	• Install indoors. • Place in a well-ventilated area. • Keep away from direct sunlight. • Keep away from dust, oily smoke, salinity, metal powder or other contaminants. • Keep away from flammable or corrosive solvents and gases. • Keep away from water. • Keep away from shocks or vibrations. • Keep away from sources of electric noise. The standard manipulator is not suitable for operation in harsh environments such as painting, etc. Contact the service center or the suppliers for details.

2.2 Installation area

In addition to the space necessary for installing the manipulator, controller and peripheral devices, you will need to have, at a minimum, the following:

◆ Space for teaching points.

◆ Space for performing maintenance and inspections.

◆ Space for cables.

NOTE
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The minimum bend radius of the power cable is 130 mm.   When you install the manipulator make certain to maintain sufficient distance from obstacles. Leave enough space for other cables also, so that they don't have to be bent at extreme angles.

2.3 Base Table

A base table for anchoring the manipulator is not supplied. Users must make or obtain such a table independently. The size and shape of the base table differs depending on the robot's application. For your reference, when designing or obtaining a base table, we have listed some manipulator requirements.

If the controller will be mounted inside the table, please refer to the controller manual or user's guide, which describes space requirements and environmental conditions.
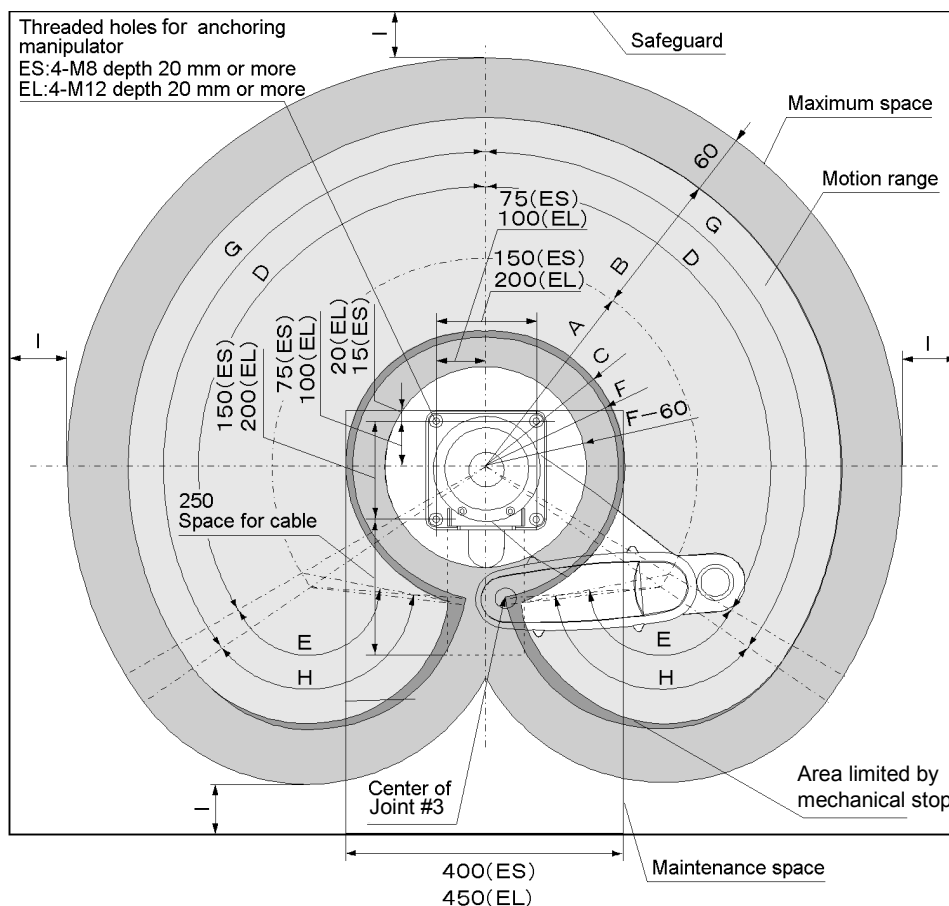
Standard range of the manipulator	ES45**	ES55**	ES65**	EL65**	EL85**
A (arm #1 length)	215 mm	315 mm	415 mm	300 mm	500 mm
B (arm #2 length)	235 mm	235 mm	235 mm	350 mm	350 mm
C	156 mm	203 mm	280 mm	228 mm	324 mm
D (motion range of the Joint #1)	125 °	125 °	125 °	130 °	130 °
E (motion range of the Joint #2)	140 °	140 °	140 °	140 °	140 °
F	136 mm	182 mm	260 mm	201 mm	292 mm
G (range to the stop of Joint #1)	130 °	130 °	130 °	132 °	132 °
H (range to the stop of Joint #2)	145 °	145 °	145 °	145 °	145 °
I (range to the safeguard)	approx. 100 mm *				

* In this case the safeguard completely prevents a person from touching the robot, such as a transparent acrylic cover, for example. Refer to the *Safety* chapter in the "User's Guide" or "SRC5**/SPEL 95 Introduction manual" or "User's manual" for the actual dimension of "I".

Figure 2.   Manipulator installation dimensions [unit: mm]

NOTE

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Maximum space in Figure 2 shows the radius of end effector equal to or less than 60 mm. If the radius of the end effector exceeds 60 mm, such as when using a camera or electromagnetic valve, increase the radius to allow proper clearance.

M8 (ES) / M12 (EL) steel bolts are used for anchoring the manipulator to the base table. The bolts conform to "ISO898-1 property class 10.9 or 12.9". The locations of these threaded holes for anchoring are shown in Figure 2.

The base of the manipulator must be bolted securely to the surface of the base table. Using a table with a steel surface is recommended. The steel surface plate should be at least 20 mm thick to reduce vibration. The surface roughness of the steel plate should be 25μm or less.
The table must not only be able to bear the weight of the manipulator, it must also be able to withstand the dynamic movement of the manipulator when the manipulator is operating at maximum acceleration.

The table must be anchored to the floor or wall to prevent it from moving.

The manipulator must be installed horizontally.

Bolts on the table legs that are used for leveling the table should have a diameter of M16 or more.

You may want to make holes in the base table through which you can pass cables.

(Refer to chapter *7. External Dimensions* for connector dimensions.)

In addition to the table, users are also responsible for creating and installing the safeguard and end effector. Refer to the sections *2.4 Pre-installation safety precautions* and *5. End Effector*.

2.4 Pre-installation safety precautions

⚠ **WARNING** ■ The manipulator can easily tip over if it is not properly bolted to its mounting surface.

Transporting the manipulator

Transport the manipulator in the delivered condition. After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift, or have it carried by two or more people. (Refer to section *3.1 Opening the box*.) If you are using a hoist or a similar apparatus to lift the equipment, make certain that the manipulator is well balanced in the belt.

Be certain to secure the manipulator's arms before transporting it. (Refer to section *3.5 Relocating the manipulator*.)

Safeguard design

For safety reasons, it is necessary to equip robot systems with safeguards.

RC+   Refer to the *Safety* chapter in the EPSON RC+ User's Guide.

SPEL 95   Refer to the *Safety* section of the SRC5**/SPEL 95 Introduction manual.

300   Refer to the *Safety* section of the User's manual for SRC-300/320.

Base table design

Make certain the base table is sufficiently strong and stable. (Refer to section *2.3 Base table*.)

End effector design

An end effector equipped with a gripper or chuck should hold its object when the power is off. (Refer to section *5.1 Attaching an end effector*.)

The end effector should be within the specified weight and within Joint #4's allowable moment of inertia. (Refer to section *5.2 The end effector and acceleration / deceleration*.)

3. Installation

3.1 Unpacking

Contents

Manipulator		
Standard accessories	Power cable	(1)
	Signal cable	(1)
	Connector and clamp hood for user wiring	(2 sets)
	Ball screw spline grease	(70g)

⚠ CAUTION	■ Transport the manipulator in the delivered condition. After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift, or have it carried by two or more people. The manipulator weighs approximately 20kg (ES) or 31kg (EL). ■ Be careful not to get hands or fingers caught when holding the manipulator by hand.

Hold here when lifting and transporting the manipulator
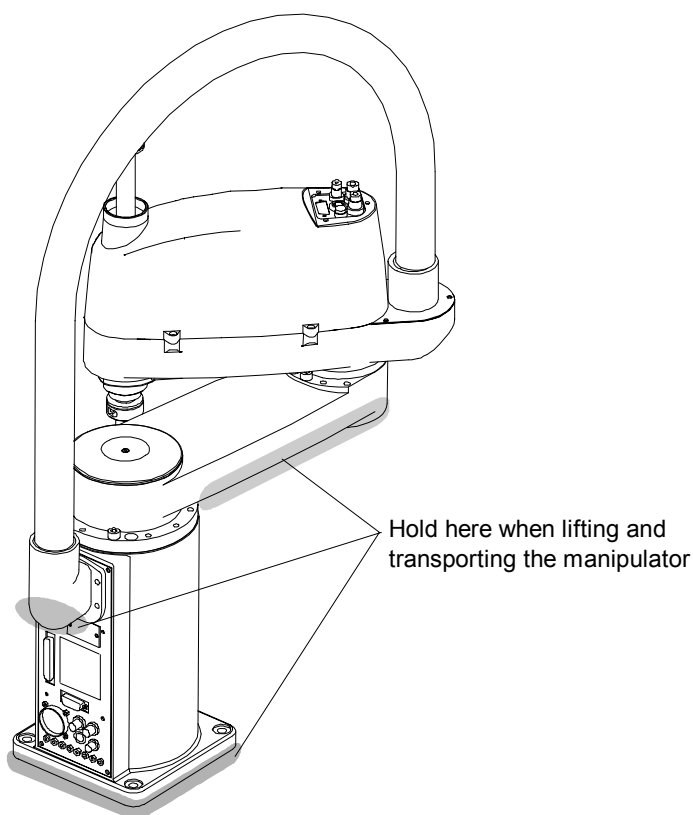
Figure 3. Lifting the manipulator

NOTE

☞ Leave the manipulator's arms secured until you have finished installing.

3.2 Installation method

> *   If the manipulator is a Clean model, refer to the chapter *Clean Model*.

(1)   Anchor the base of the manipulator to the base table using the four steel bolts. Use the steel bolts (M8 for ES or M12 for EL) conform to "ISO898-1 property class 10.9 or 12.9".
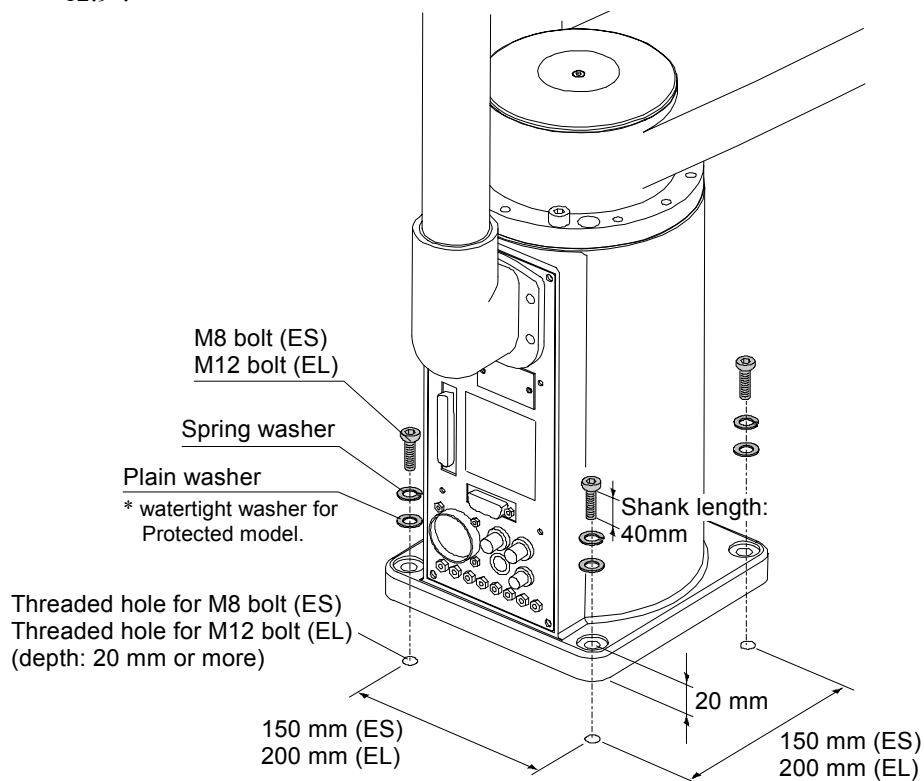
Figure 4. Manipulator installation

(2)   Cut off the wire tie binding the bottom of the shaft and arm retaining bracket.
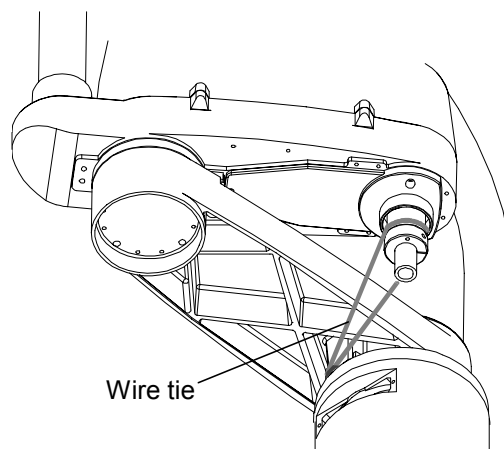
Figure 5. Cut the wire tie

(3) Push Arm #1 slowly in the direction shown by the arrow in Figure 6. Remove the arm retaining bracket and bolt (ES: M8×10, EL: M12×20) from the base. If they are not removed, the motion range of Joint #1 will be limited.

Arm retaining bracket

M8×10 bolt (ES)
M12×20 bolt (EL)
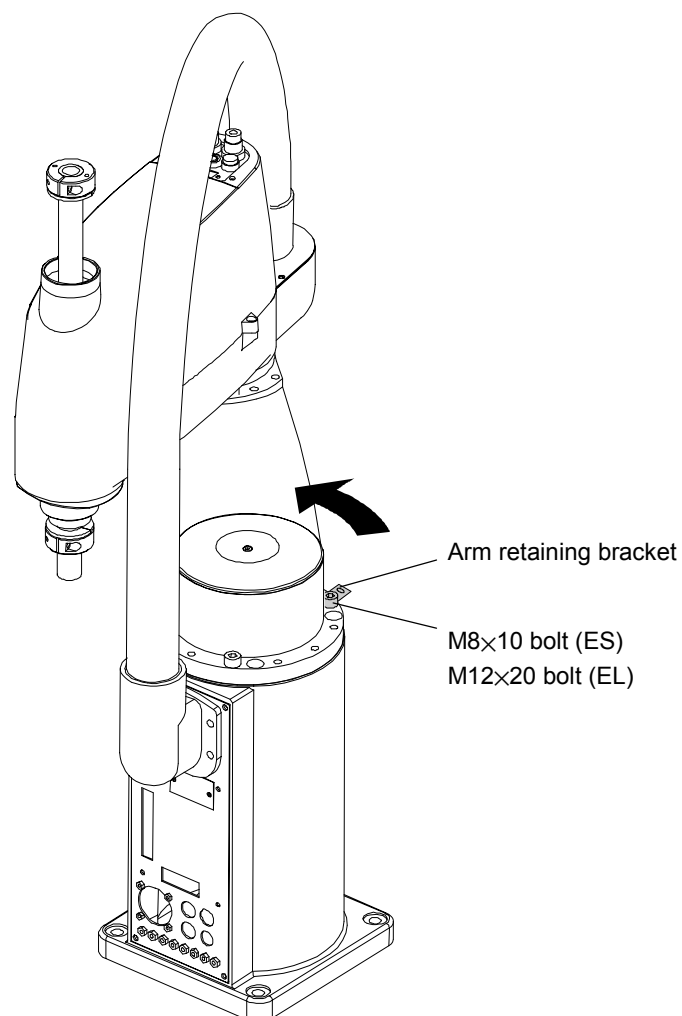
Figure 6. Removing the arm retaining bracket

NOTE

☞

The arms of the manipulator must be secured to prevent them from moving when transporting. (Refer to *3.5 Relocating the manipulator*.) Please keep the arm retaining bracket and bolt in case you need them in the future.

3.3 Connecting the cables

Cable connections are shown in Figure 7. This figure shows the minimum connections necessary for operating the robot. Refer to the controller manual for information on how to connect the cables.

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.

* If the manipulator is a Protected model, refer to chapter *12. Protected Model*.

⚠ WARNING

■ For safety, the power supply cable must be connected to a factory power receptacle using the plug provided so it can be easily disconnected. Never connect the cable directly to the factory power supply.

■ Be sure to turn off the power before connecting/disconnecting the cables. Failure to do so may cause electrical shock and/or malfunction.

⚠ CAUTION

■ Plug the manipulator signal cable securely into the jack. Do not damage the signal cable by placing heavy objects on it or by bending it at extreme angles. A damaged signal cable may cause the robot's abnormal operation.

RC+   NOTE ☞

■ When connecting the manipulator and Drive Unit cables, make sure the serial number on the Drive Unit matches the serial number on PC Control Unit.

SPEL 95   NOTE ☞

■ When connecting the manipulator and Drive Unit cables, make sure the serial number on the Drive Unit matches the serial number on Control Unit.

300   NOTE ☞

■ When installing the cables for a manipulator and its corresponding controller, make sure the M.CODEs (matching codes) match. The M.CODE is written on the yellow label of the manipulator base and the controller's rear panel. Also, make sure that the lengths of the power cable and signal cable correspond to the length on the yellow labels mentioned above.

RC+

SPEL 95

Drive unit

M/C power	M/C power cable
M/C signal	M/C signal cable
MOTION	MOTION interface cable
D-I/O (STD)	D-I/O
EMERGENCY	EMERGENCY
AC OUTLET	PC power cable
INPUT	AC power cable

Manipulator

I/O equipment

E-STOP switch
safeguard

AC 200 V

Control unit

MOTION

D-I/O (option) — I/O equipment

MONITOR — Monitor

MOUSE — Mouse

KEYBOARD — Keyboard

ACIN

OPTIONAL DEVICE — Optional Devices

300

Power supply

Controller

M/C power cable — Manipulator

M/C signal cable

REMOTE1 — Safeguard ,etc

REMOTE2 — Operating unit

TEACH — Programming unit
(Personal computer)
or
Teaching pendant
(option)

RS-232C #20

RS-232C #21

I/O-1

Figure 7. Cable connections

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3.4 Safety precautions after installation

<table>
<tr>
<td rowspan="3">⚠ WARNING</td>
<td>■ Carefully read the Safety section of the User's manual before operation.</td>
</tr>
<tr>
<td>■ Do not enter the motion range of the manipulator when the power is ON even if the manipulator seems to be stopped. It is extremely hazardous to put any part of your body in the motion range.</td>
</tr>
<tr>
<td>■ Be sure to turn off power before connecting/disconnecting the cables. Failure to do so may cause electrical shock and/or malfunction.</td>
</tr>
</table>

Safety during operation

◆ Make sure that no one is inside the safeguarded area when operating the robot.

◆ If the manipulator moves abnormally during operation, immediately press the emergency stop switch.

◆ Generally only one person should operate the robot at a time. When, for unavoidable reasons, two or more people operate the robot, they should be certain to tell each other what they are doing and take all necessary safety precautions.

◆ Only trained personnel should teach and operate the robot and the robot system.

◆ Teaching operations should be performed in the automatically set condition (low power condition).

◆ The work area should be well lighted (over 750 lx) during teaching operations.

RC+ ◆ If entering the safeguarded area for some reasons during teaching operations, first lock ATTEND mode to ON to prevent another person changing the operating mode. Use the Enable switch when operating in the safeguarded area.

SPEL 95 ◆ Confirm that Jog Pad / Operating Pendant functions normally before operations. If entering the safeguarded area for some reasons during teaching operations, first lock the mode switch of the Jog Pad / Operating Pendant in the ATTEND position. Bring the Jog Pad/Operation Pendant when operating in the safeguarded area to prevent another person changing the operating mode.

300 ◆ If entering the safeguarded area during teaching operations, first lock the mode switch in the TEACH position. If using the optional operating unit, put the mode switch in the TEACH position and bring the key when operating in the safeguard to prevent another person changing the operating mode.

Other safety recommendations

◆ Perform daily inspections carefully before starting operation.

(Refer to *Part 2: Maintenance.*)

◆ Perform inspections and maintenance periodically in accordance with the instructions in Part 2: Maintenance.

◆ Joint #3, with an end effector mounted to it, descends under its own weight while the joint #3 brake release button is pushed. (Refer to *5.1 Attaching an end effector.*)

3.5 Relocating the manipulator

Please follow the procedures below when moving the manipulator to a new location.

NOTE
☞
The arms of the manipulator must be secured to prevent them from moving when transporting the manipulator.

(1) Turn OFF the power and unplug the cables.

NOTE
☞
Remove the mechanical stops if using them to limit the motion range of Joint #1 and #2. (Refer to *8.3 Changing the motion range*.)

(2) Gently push Arm #1 in the plus direction (counterclockwise direction) until the threaded hole for the retaining bracket appears.

(3) Fasten the arm retaining bracket with an M8×10 (ES) / M12×20 (EL) bolt as shown below.
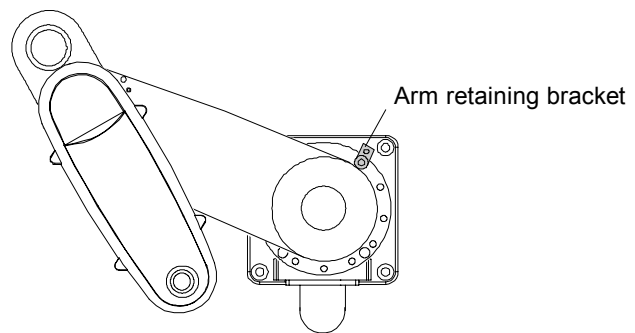
Figure 8. Arm retaining bracket fastening position

(4) Gently push Arm #1 in the minus direction (clockwise direction) until it touches the previous bolt.

(5) Gently push Arm #2 in the plus direction (counterclockwise direction) until it touches the mechanical stop. Tie the bottom of the shaft to the arm retaining bracket with a wire tie. (See *Figure 5*.) Be careful not to tie too tight. It may bend the shaft.

(6) To prevent the manipulator from falling, hold the arm #1 with the hand and remove the manipulator from the base table.

⚠ **CAUTION**

■ Transport the manipulator in the delivered condition. After unpacking, to prevent the manipulator from falling, secure the manipulator to a transporter such as a cart or lift. Stabilize the manipulator with your hands when you hoist it so that it does not tip over. To transport, hold Arm #1 by hand and support both the main cable elbow fitting and the underside of the base using two or more people. The manipulator weighs approximately 20kg (ES) or 31kg (EL).

■ Be careful not to get hands or fingers caught when holding the manipulator by hand.

4. User Wires and Pneumatic Tubes

Electrical wires and pneumatic tubes have been incorporated into the cable unit for your use.

Electrical wires

Rated voltage	Allowable current	Number of cables	Nominal sectional area	Outer diameter	Note
AC/DC30 V	1 A	15	0.211 mm^2	ϕ 8.3±0.3 mm	Shielded

Compatible connector: 15-pin D-sub connector.   Pins with the same number are connected.

Pneumatic tubes

Max. usable pneumatic pressure	Number of pneumatic tubes	Outer diameter × Inner diameter
0.59MPa (6kgf/cm^2)	2	ϕ 6 mm × ϕ 4 mm
	1	ϕ 4 mm × ϕ 2.5 mm

The ends of each pneumatic tube are equipped with fittings for connecting pneumatic tubes having an outer diameter of ϕ 6 mm and ϕ 4 mm.
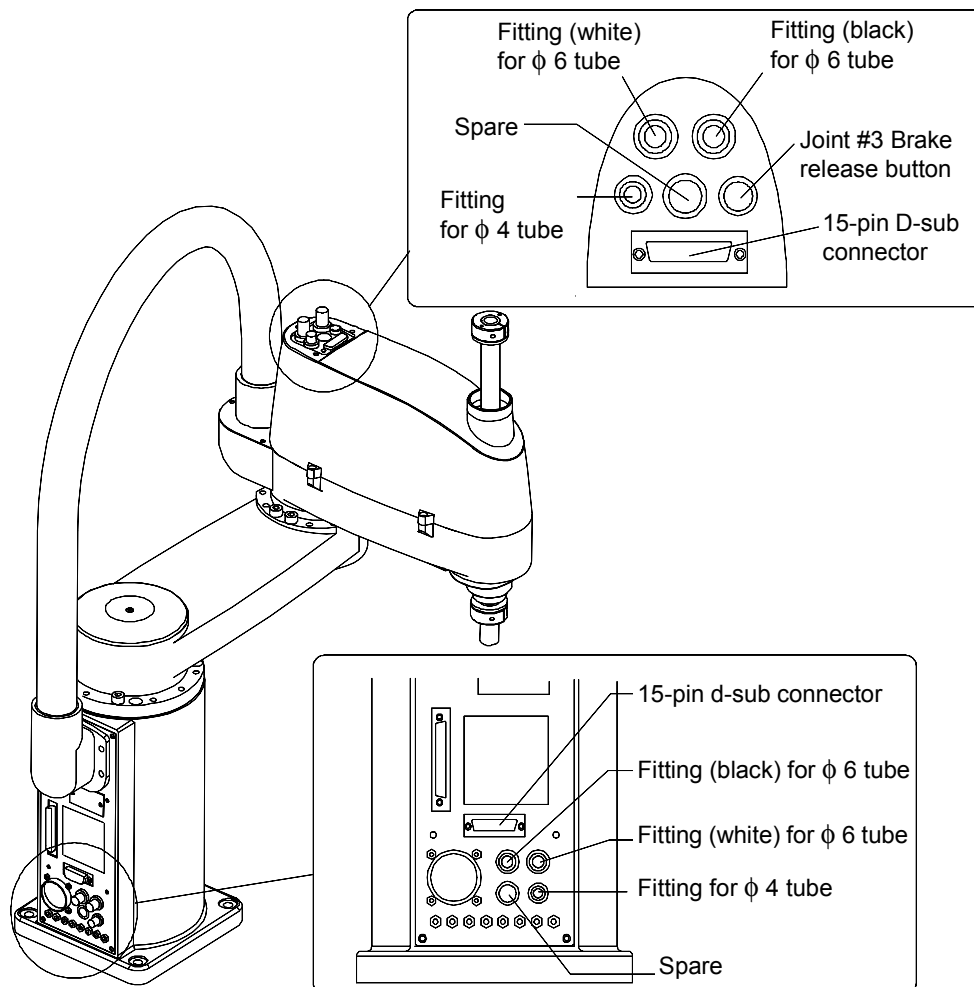
* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.

* If the manipulator is a Protected model, refer to chapter *12. Protected Model*.

Figure 9.   User wires and tubes

5. End Effectors

5.1 Attaching an end effector

Users are responsible for making their own end effector(s). Here, we point out some precautions to adhere to when attaching an end effector.

Install an end effector to the lower end of the shaft. Figure 10 shows the dimensions around the shaft. See to Figure 20 in *7. External Dimensions* for overall dimensions.

When you operate the manipulator with an end effector attached, the end effector could touch the main body of the manipulator depending on the outer diameter of the end effector, the size of the work piece or the position of the arms. When you are laying out the system, pay close attention to the interference area of the end effector.

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.
* If the manipulator is a Protected model, refer to chapter *12. Protected Model*.

	ES**1S	ES**3S	EL**3S
a	170	320	320
b	119	−31*	−10*
c	385	535	535

* The shaft of E***3S will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

2-M4 Depth 10   φ 44 Bellows diameter

φ 14 Through hole diameter

φ 39.5
Lower-limit mechanical stop diameter

1 mm Flat cut

φ 4, 90° Conical hole

φ 40
φ 39.5
φ 20h7
φ 14 through-hole

View A detail
(Calibration point position of Joint #3 & #4)

φ 14
φ 20h7 shaft diameter

φ 39.5
Upper-limit mechanical stop diameter

▼ The bottom of the manipulator base

(*) indicates the stroke margin by the mechanical stop.
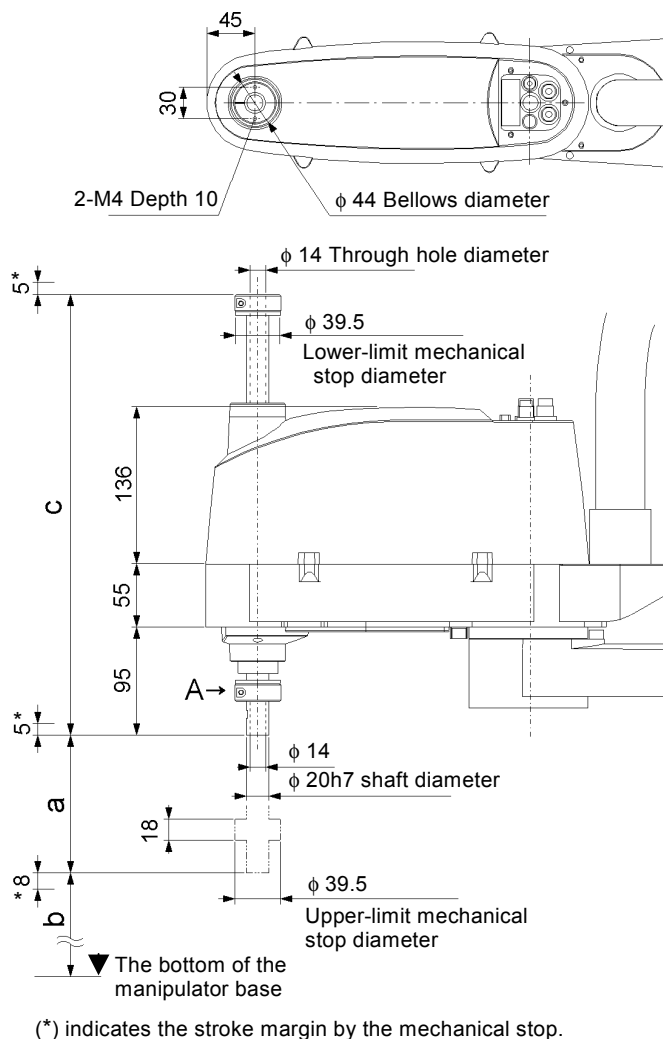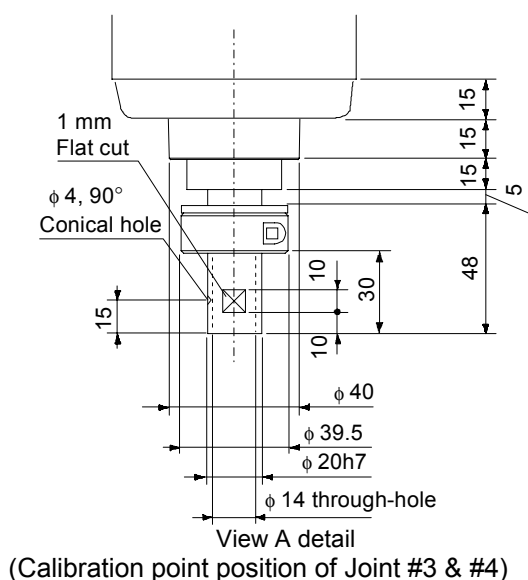
Figure 10. Dimensions around the shaft of Standard model [Unit :mm]

NOTE

👉

Do not move the upper-limit mechanical stop which is on the lower side of the shaft.

◆ Use a split muff coupling with an M4 bolt or larger to attach an end effector to the shaft.

◆ You can use the flat cut and conical hole on the end of the shaft to orient Joint #4 by tightening a setscrew.

◆ The electromagnetic brake is applied to Joint #3 when the power is off. Joint #3 cannot be raised or lowered by hand when the brake is engaged. This prevents Joint #3 from descending under the weight of the end effector and striking any peripheral equipment and the like when the power is cut during robot operation or when the power is on but in the MOTOR OFF condition.

If you want to raise and lower Joint #3 when you are attaching an end effector, turn ON the controller and keep on the Joint #3 brake release button pushing. This button is a momentary type which releases the brake only while it is pushed.

NOTE

👉

Joint #3 descends under it own weight while you are pushing the Joint #3 brake release button.

Joint #3 brake release button

Joint #3 may descend due to the weight of the end effector.
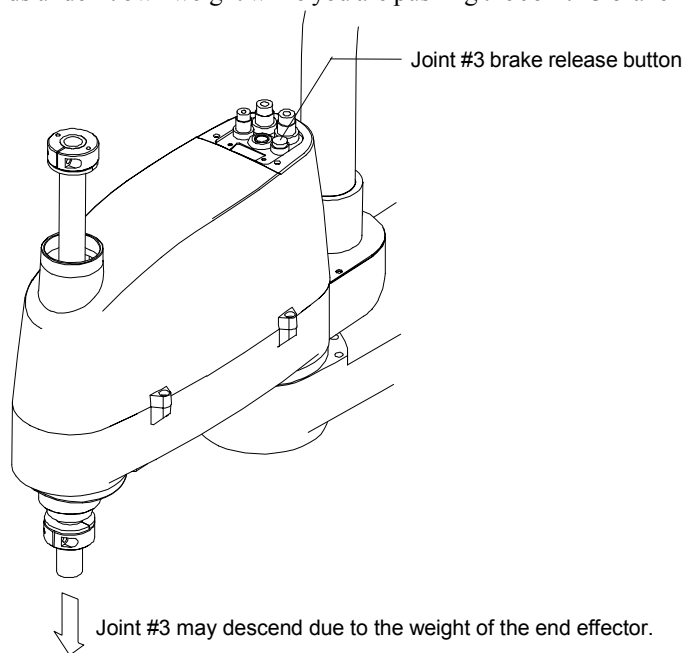
Figure 11. Joint #3 brake release button

Wire and tube layout

The Joint #3 shaft has a through-hole to the end effector for supplying air and electricity. The diameter of the through-hole is ϕ 14 mm. The lower limit mechanical stop of Joint #3 has two threaded holes (depth 10 mm) for M4 bolts for tooling. (See Figure 10.)

⚠ WARNING	■ If you use an end effector equipped with a gripper or chuck, set up electrical signals and / or pneumatics in such a way that the gripper does not release its object when the robot is turned OFF. All I/O's are set at the factory so that they automatically shut entirely OFF (0) when the robot is turned OFF, when the emergency stop switch is pressed, or when any of the robot's safety features are activated.

5.2 The end effector and acceleration / deceleration

To ensure optimum robot performance, it is important to make certain that the load (weight of the end effector and transported object) and moment of inertia of the load are within the maximum rating for the robot and that Joint #4 does not become eccentric. If the load or moment of inertia exceeds the rating or if the load becomes eccentric, adjust operating acceleration/deceleration speed in accordance with the explanations below.

Setting WEIGHT parameters

The rated weight capacity is 2kg, and the maximum weight capacity is 5kg. When a load is heavier than the rated weight, you must change the WEIGHT setting.

Weigh both the end effector and the work piece that the end effector will transport.

RC+

Enter their combined total weight into the [Weight:] text box on the WEIGHT tab of the Project | Robot Parameters dialog. (Refer to the chapter EPSON RC+ GUI in the EPSON RC+ User's Guide.) You may also execute the WEIGHT command from the EPSON RC+ Monitor Window.

SPEL 95

Enter their combined total weight into the [Weight:] text box in the [WEIGHT] panel of the Setup Robot Parameters dialog. (Refer to the section *Setting up the Robot Parameters* in chapter 11 of the User's Guide.)

300

Enter their combined total weight as the Hand Weight parameter in the WEIGHT command. (Refer to the Reference manual for details of WEIGHT command.)

Executing this command sets the maximum possible speed and operating acceleration/deceleration speed of the robot automatically in accordance with WEIGHT parameters.

NOTE
☞

The ES / EL series manipulators are not designed to work with loads exceeding 5kg. The total weight of the end effector and payload must not exceed 5kg. Always set the WEIGHT parameters according to the load, otherwise, the robot cannot fully operate as intended. Setting a value that is smaller than the actual load may cause errors or an excessive vibration. It will also shorten the life of parts and mechanisms.

RC+

SPEL 95
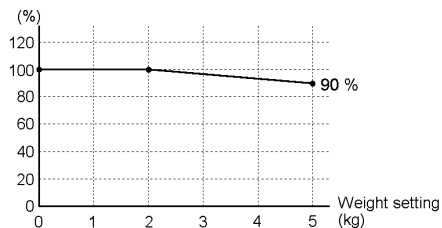
ES45
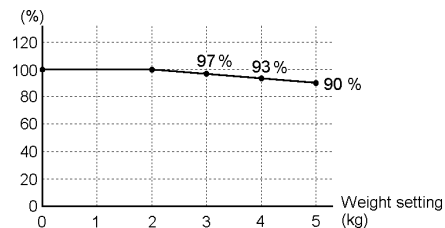
ES55
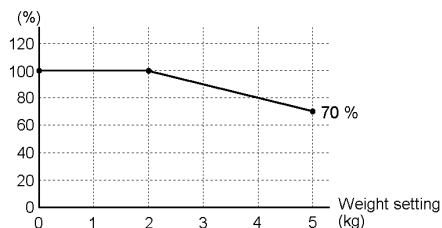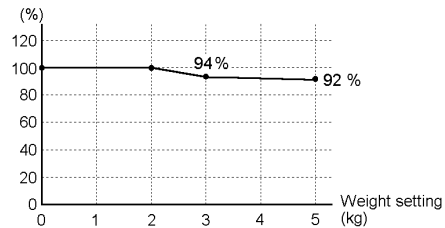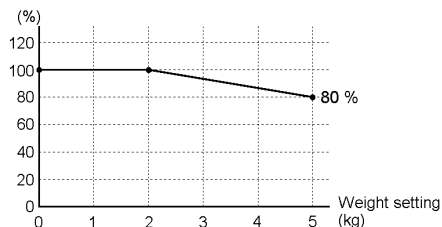
ES65

EL65

EL85

* The percentage in the graph is based on the speed at rated weight (2kg) as 100%.

300
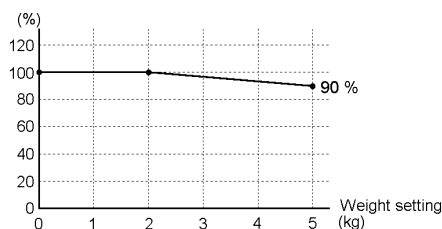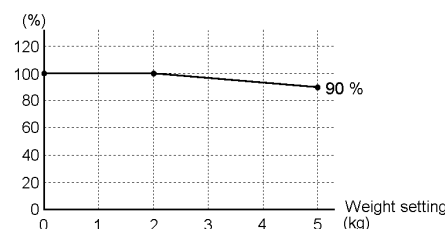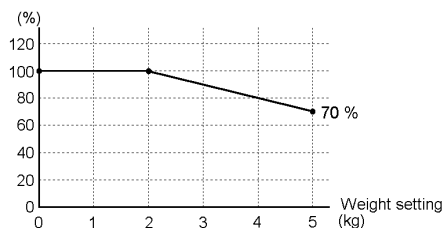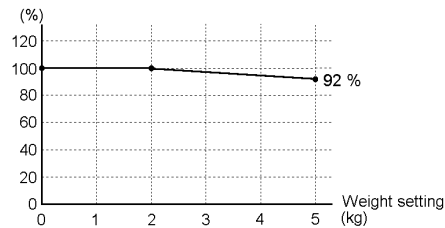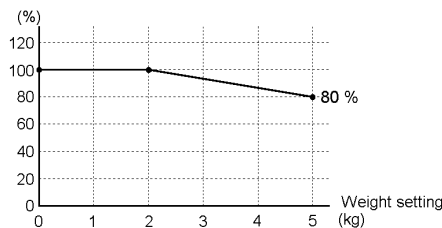
ES45

ES55

ES65

EL65

EL85

* The percentage in the graph is based on the speed at rated weight (2kg) as 100%.

Figure 12-1. Automatic speed setting by WEIGHT

RC+

SPEL 95
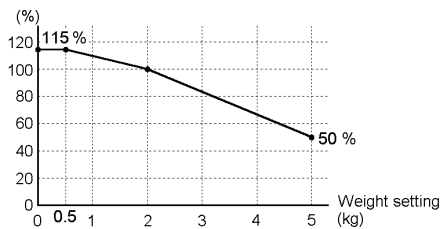
ES45
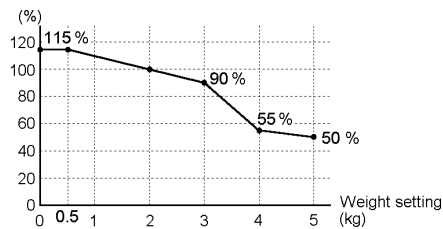
ES55
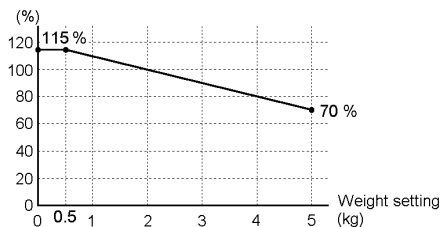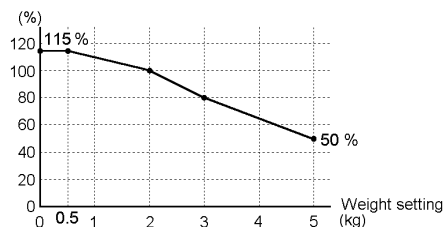
ES65

EL65

EL85

* The percentage in the graph is based on the speed at rated weight (2kg) as 100%.

300
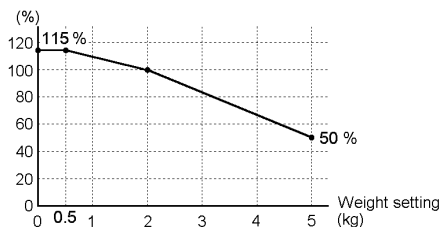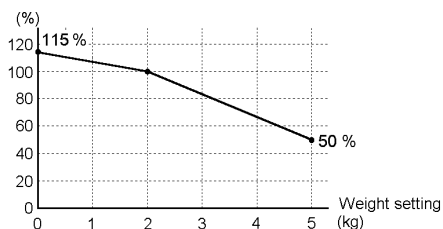
ES45
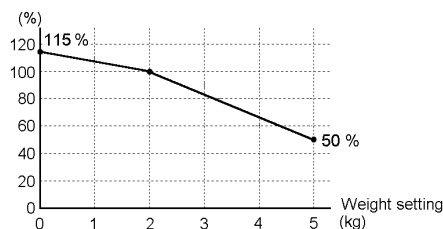
ES55

ES65

EL65
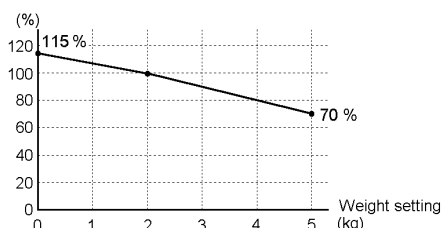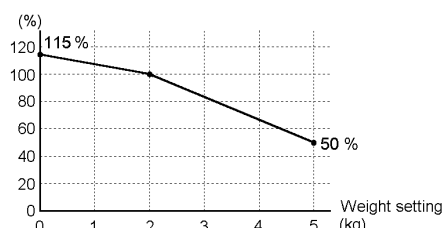
EL85

* The percentage in the graph is based on the speed at rated weight (2kg) as 100%.
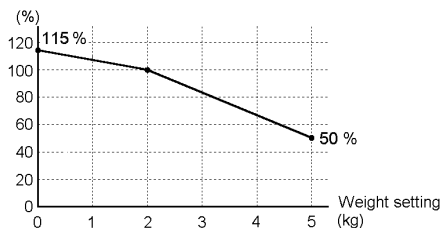
Figure 12-2. Automatic acceleration/deceleration setting by WEIGHT

Precautions for auto acceleration / deceleration

◆ When you move the manipulator horizontally with Joint #3 (Z) at a high position, the motion time will be faster. When Joint #3 gets below a certain point (-60mm in figure 13 below), then auto acceleration/deceleration is used to reduce acceleration/deceleration. When the manipulator moves with Joint #3 at a higher position, the motion acceleration/deceleration is faster, but it takes more time to move Joint #3 up and down. Adjust the position of Joint #3 for the robot motion after considering the relations between the current position and the destination position. The upper limit of Joint #3 during horizontal motion is set by the LimZ command.

ES45

ES55

ES65

EL65

RC+

SPEL 95

EL85

300

EL85
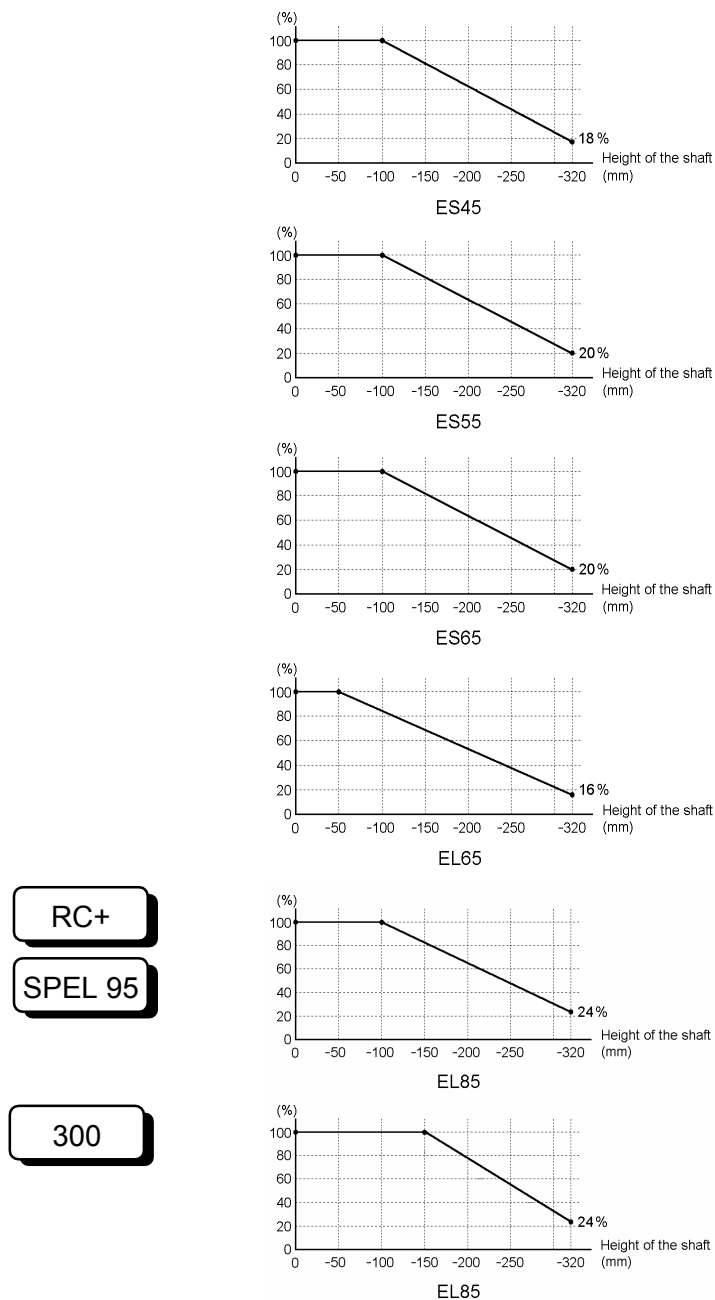
* The percentage in the graph is based on the acceleration/deceleration at the upper-limited position of Joint #3 as 100%

Figure 13. Automatic acceleration/deceleration vs. Joint #3 position

25

◆ If you move the manipulator horizontally when the position of Joint #3 is low, it may cause over shoot at the time of final positioning. We recommend that the height of the Joint #3 be as high as possible when you move the manipulator horizontally.

Moment of inertia and the ACCEL setting

When dealing with rotating shafts, you must account for the moment of inertia of a load. There are also ratings and maximum values for allowable moments of inertia. They differ depending on the Weight setting described above. The ratings and maximum moments of inertia are as follows:

W : Weight setting (kg)

I : Allowable moment of inertia (kg·m^2)
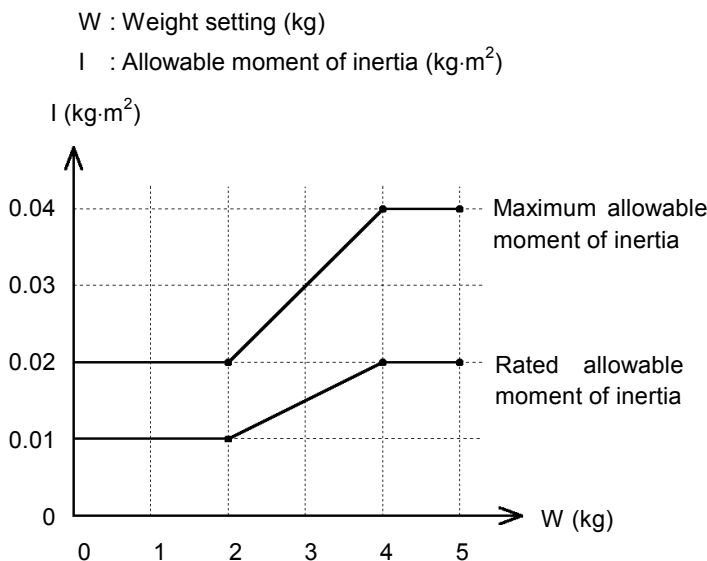
Figure 14. Allowable moment of inertia

When the moment of inertia of the end effector is equal to or less than the rated allowable moment of inertia, you may operate the robot at the maximum acceleration/deceleration speed setting (ACCEL 100, 100).

When the rated allowable moment of inertia is exceeded, lower the acceleration/ deceleration speed using the ACCEL command. Using the results of the following formula as a guideline, input the suitable value for the given conditions.

$A = I_0 / I \times 100$ (%)

  A : ACCEL value in accordance with the moment of inertia
  I_0 : Rated allowable moment of inertia
  I : Moment of inertia of the end effector

<Example> For the end effector weighting 3kg and with a moment of inertia of 0.02kg·m^2

```
WEIGHT 3
A = 0.015 / 0.02 × 100 = 75%
        ↓
ACCEL 75,75
```

Calculating the moment of inertia

The moment of inertia is defined as "the ratio of the torque applied to a rigid body free to rotate about a given joint to the angular acceleration thus produced about that joint". This value is typically referred to as "the moment of inertia", "inertia", or "GD^2". The following is an example of how to calculate the moment of inertia.

<Example>   Consider an end effector and work piece such as those shown in the diagram below. The moment of inertia of the entire load is found using the sum of each of the parts (a) to (c).

$$\begin{matrix} \text{Moment of inertia} \\ \text{of the whole} \end{matrix} = \begin{matrix} \text{Moment of inertia} \\ \text{of end effector (a)} \end{matrix} + \begin{matrix} \text{Moment of inertia} \\ \text{of work piece (b)} \end{matrix} + \begin{matrix} \text{Moment of inertia} \\ \text{of work piece (c)} \end{matrix}$$
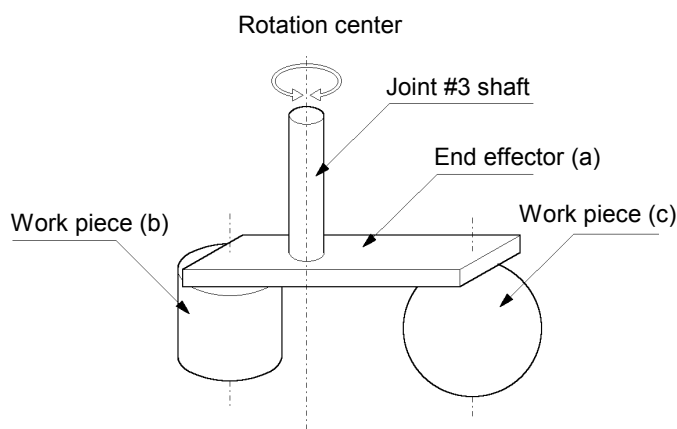
Figure 15. Example of load (end effector carrying work pieces)

The method of calculating the respective moments of inertia for (a), (b) and (c) is shown below. Using these basic formulas for moment of inertia as a reference, find the moment of inertia for the load as a whole.

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(a) Moment of inertia of a rectangular parallelepiped = $m\dfrac{b^2+h^2}{12}+m\times L^2$

Rotation center

Rectangular parallelepiped's
center of gravity

Mass m

L

h

b
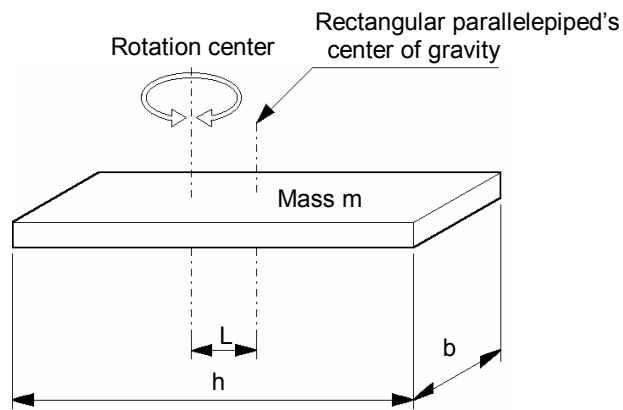
Figure 16 (a). Rectangular parallelepiped

(b) Moment of inertia of cylinder = $m\ \dfrac{r^2}{2}+m\times L^2$

Cylinder's center
of gravity

Rotation center

r

Mass m

L
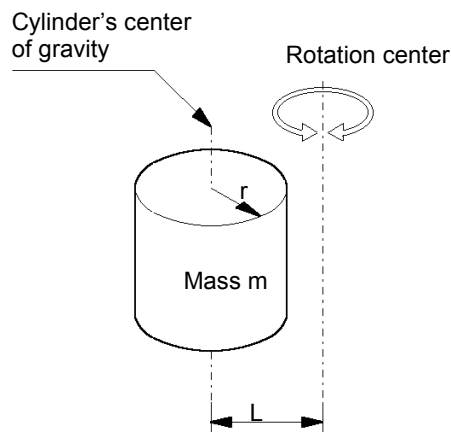
Figure 16 (b). Cylinder

(c) Moment of inertia of a sphere = $m\ \dfrac{2}{5}r^2+m\times L^2$

Sphere's center
of gravity

Rotation center

r

Mass m

L
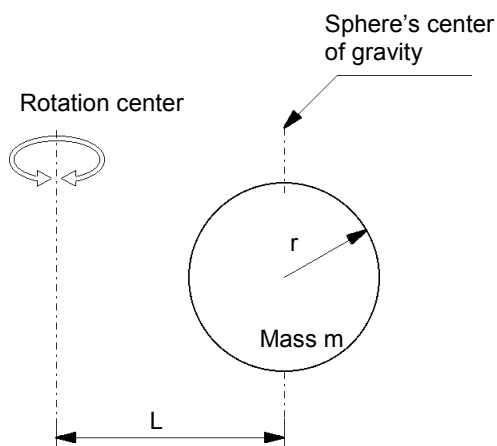
Figure 16 (c). Sphere

Eccentricity of Joint #4

The eccentricity of Joint #4 (rotation center) and the position of a load's center of gravity should not be more than 50 mm.
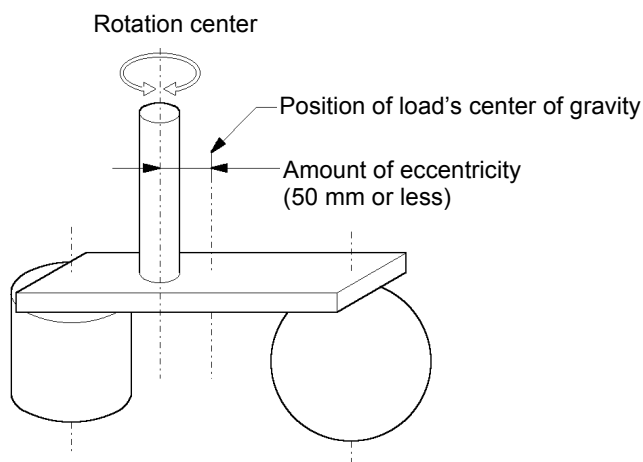
Figure 17. Amount of eccentricity

When the load and joint are eccentric, lower the acceleration/deceleration speed using the ACCEL command. Using the results of the following table and formula as a guideline, use a suitable value for the given conditions.

$A = A_i \times A_h /100$ (%)

    A :ACCEL setting value
    A_i :ACCEL setting value according to moment of inertia
    A_h :ACCEL % according to amount of eccentricity
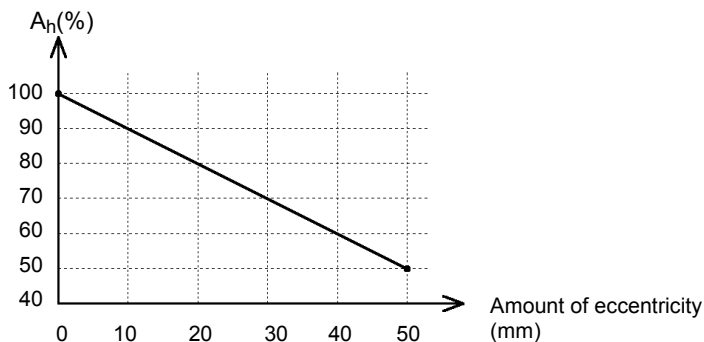
Figure 18. Eccentricity and ACCEL %

<Example>   For a 3kg end effector (and work piece) with a moment of inertia of 0.02kg·m^2 and eccentricity of 40 mm:

WEIGHT 3
A_i = 0.015/0.02×100=75 (%)
A_h = 60 (%)
A = 75×60/100=45 (%)
        ↓
ACCEL 45,45

6. Attaching a Camera, Valve, and Other Devices

Arm #2 has eight threaded holes.   Use these holes for attaching cameras, valves, and other equipment.   See Figure 10 in *7. External Dimensions* for information on dimensions.
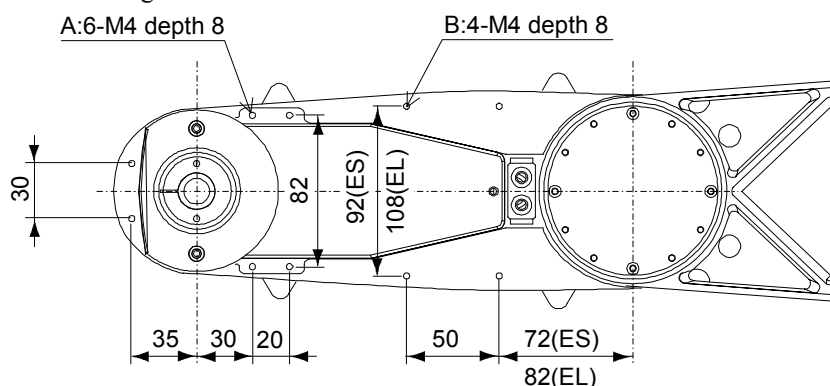
Height from the base-installed surface

	A	B
ES***S	378	383
ES***C/P	379	384
EC***S	399	404
EC***C/P	400	405

Figure 19.   Position of threaded holes in Arm #2 (bottom side) [unit: mm]

When you attach a load to the arm, you must consider WEIGHT parameters as explained in the section 5.2.   When you attach a camera or other devices to the shaft, enter the total weight of the end effector, work piece and the attached device to the parameter.   When you attach a camera or other device to the arm, calculate the weight as equivalent weight of Joint #3, add this to the load weight.

Refer to section *5.2 The end effector and acceleration / deceleration* for details on WEIGHT parameters.

Equivalent weight is found using the formula below.

When you attach the equipment near Joint #2   : $W_M = M (L_1)^2 / (L_1+L_2)^2$
When you attach the equipment to the end of Arm #2   : $W_M = M (L_M)^2 / (L_2)^2$

W_M : equivalent weight
M : weight of camera, etc.
L_1 : length of Arm #1
L_2 : length of Arm #2
L_M : distance form rotation center of Joint #2 to center of gravity of camera, etc.

<Example> A 1kg camera was attached to the end of the arm (340 mm from the rotation center of Joint #2) of an ES with a load weight of W = 2kg.

$M = 1$, $L_2 = 235$, $L_M = 340$

$W_M = 1 \times 340^2 / 235^2 = 2.09 \rightarrow 2.1$ (rounded up)

$W + W_M = 2 + 2.1 = 4.1$

Enter 4.1 as WEIGHT parameter.   Refer to section 5.2 for the method of setting WEIGHT parameter.

7. External Dimensions

ES series

* If the manipulator is a Clean model, refer to chapter *11. Clean Model*.

* If the manipulator is a Protected model, refer to chapter *12. Protected Model*.

φ44

4-φ10
Through holes

φ160

Signal cable connector

65

12

50

Power cable connector

φ39.5

max.900

φ105

(*) indicates the stroke margin
by the mechanical stop

180   230 or more
Space for cables

1mm
Flat cut

φ4, 90°
Conical hole

φ48
φ39.5
φ20h7
φ14 through hole
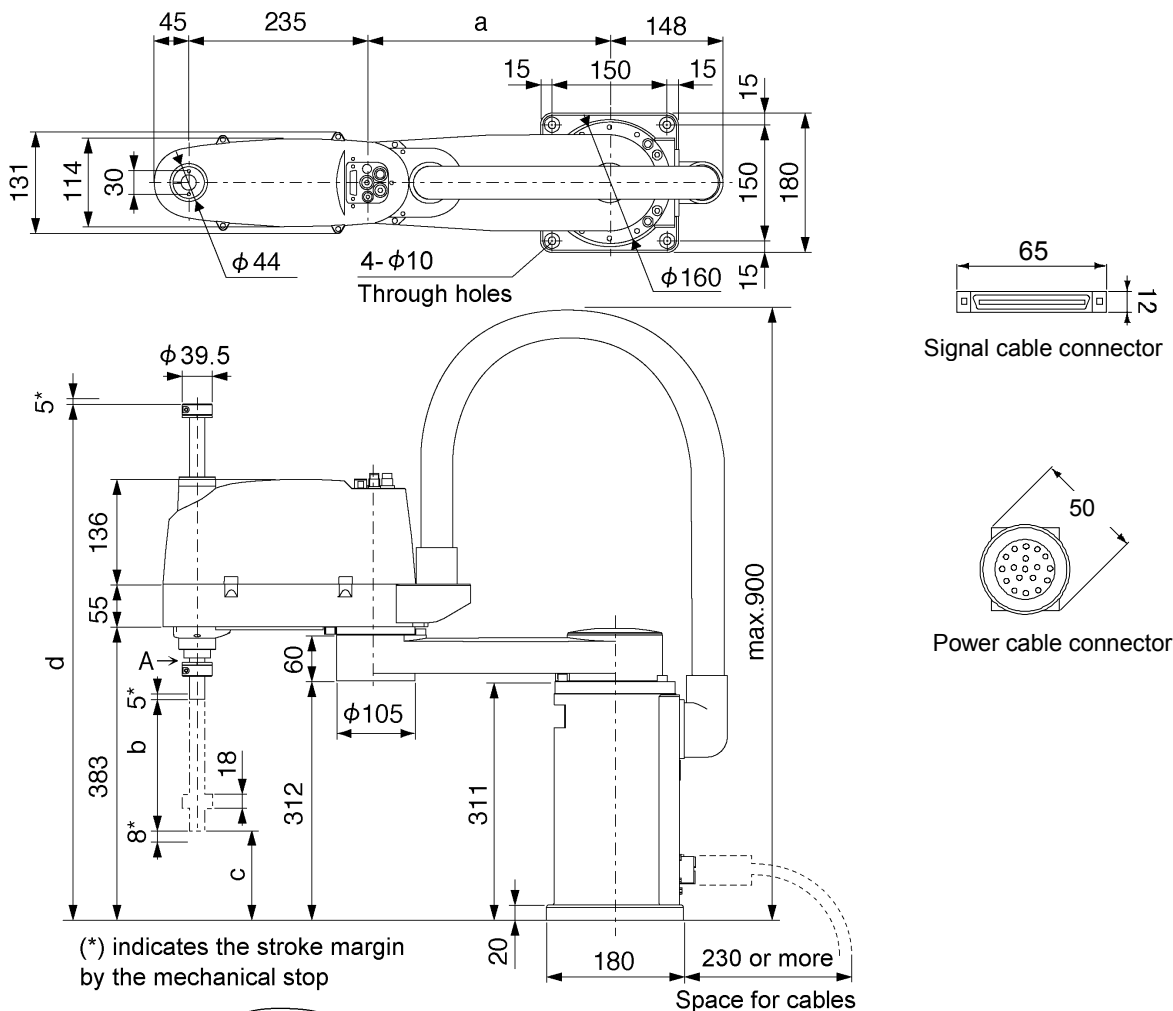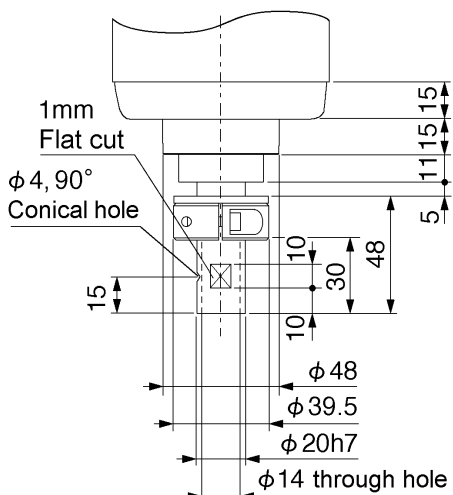
View A detail
(Calibration point position of Joint #3 & #4)

	ES45*S	ES55*S	ES65*S
a	215	315	415

	ES**1S	ES**3S
b	170	+320
c	119	−31*
d	674	824

* The shaft of ES**3S will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

Figure 20-1.   External dimensions of ES [unit : mm]

EL series

* If the manipulator is a Clean model, refer to chapter *11. Clean Model.*

* If the manipulator is a Protected model, refer to chapter *12. Protected Model.*

Signal cable connector

Power cable connector

(*) indicates the stroke margin
by the mechanical stop

Duct support
(for EL853S only)

Space for
cables

View A detail
(Calibration point position of Joint #3 & #4)
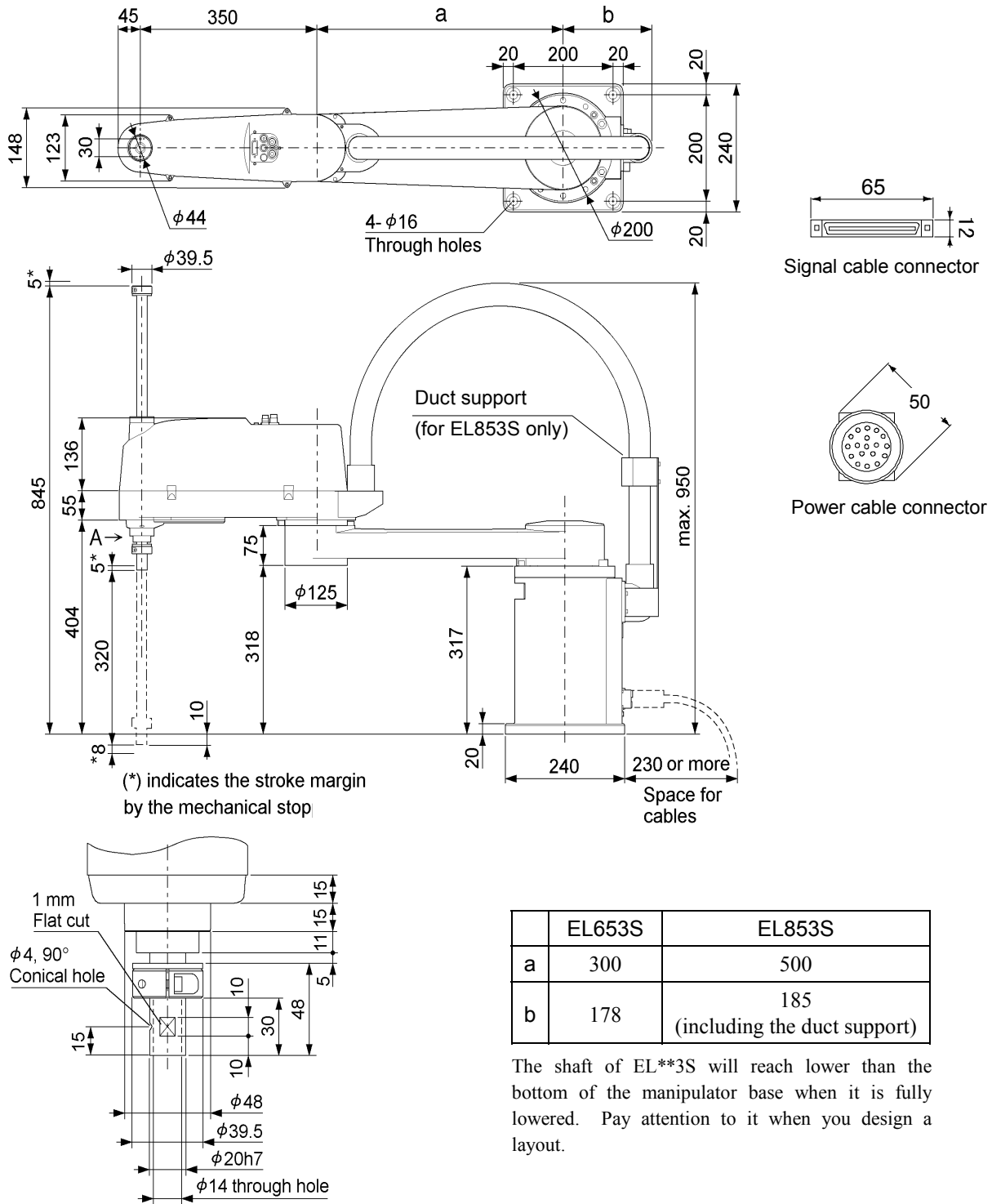
	EL653S	EL853S
a	300	500
b	178	185 (including the duct support)

The shaft of EL**3S will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

Figure 20-2.   External dimensions of EL [unit : mm]

8. Motion Range and Robot Coordinates

8.1 Standard motion range

The motion range and the robot coordinate of the ES / EL series is described below.

The following motion range shows the standard (maximum) specification.   When each axis motor is engaged, the center of Joint #3's lowest point moves in the area shown below.

"Area limited by mechanical stops" is the area where the center of Joint #3's lowest point can be moved when each axis motor is not engaged.   The center of Joint #3 cannot move beyond this area mechanically.

"Maximum space" is the area that contains the farthest reach of the arms.   If the maximum radius of the end effector is over 60 mm, then it will extend beyond the maximum space.   If this is the case, then the end effector itself dictates the maximum space.

The physical relationship of the manipulator's anchor holes and point P varies from one manipulator to another, but the maximum variance is ±2° referenced to the center of the manipulator base.   Take this into account when you lay out your system equipment if you use the outermost circumference of the motion range.
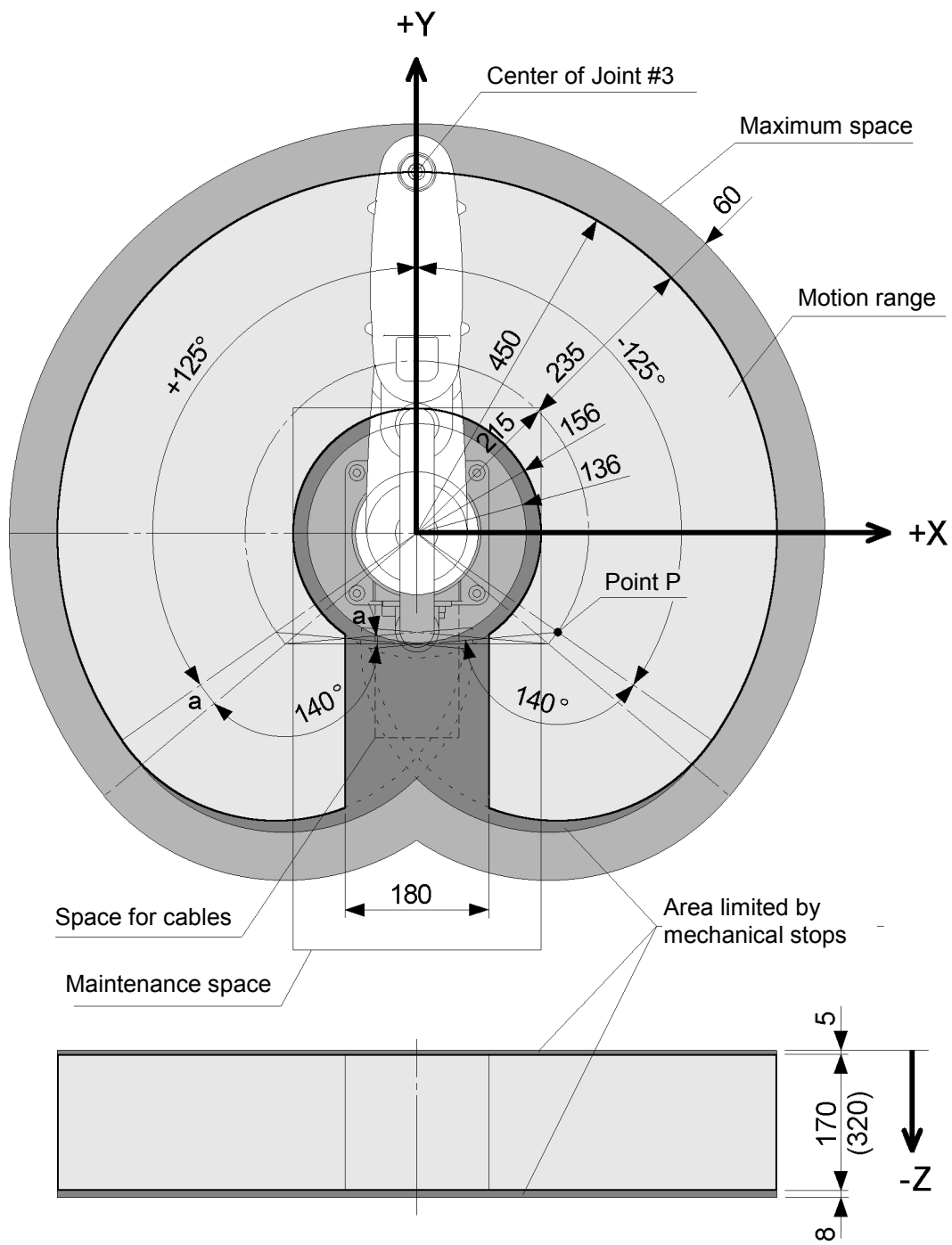
	ES45*S	ES45*C	ES45*P
a	5°	5°	3°

Value of dimensions in ( ) of Z stroke is option.

Figure 21-1.   Motion range of ES45** [unit : mm]
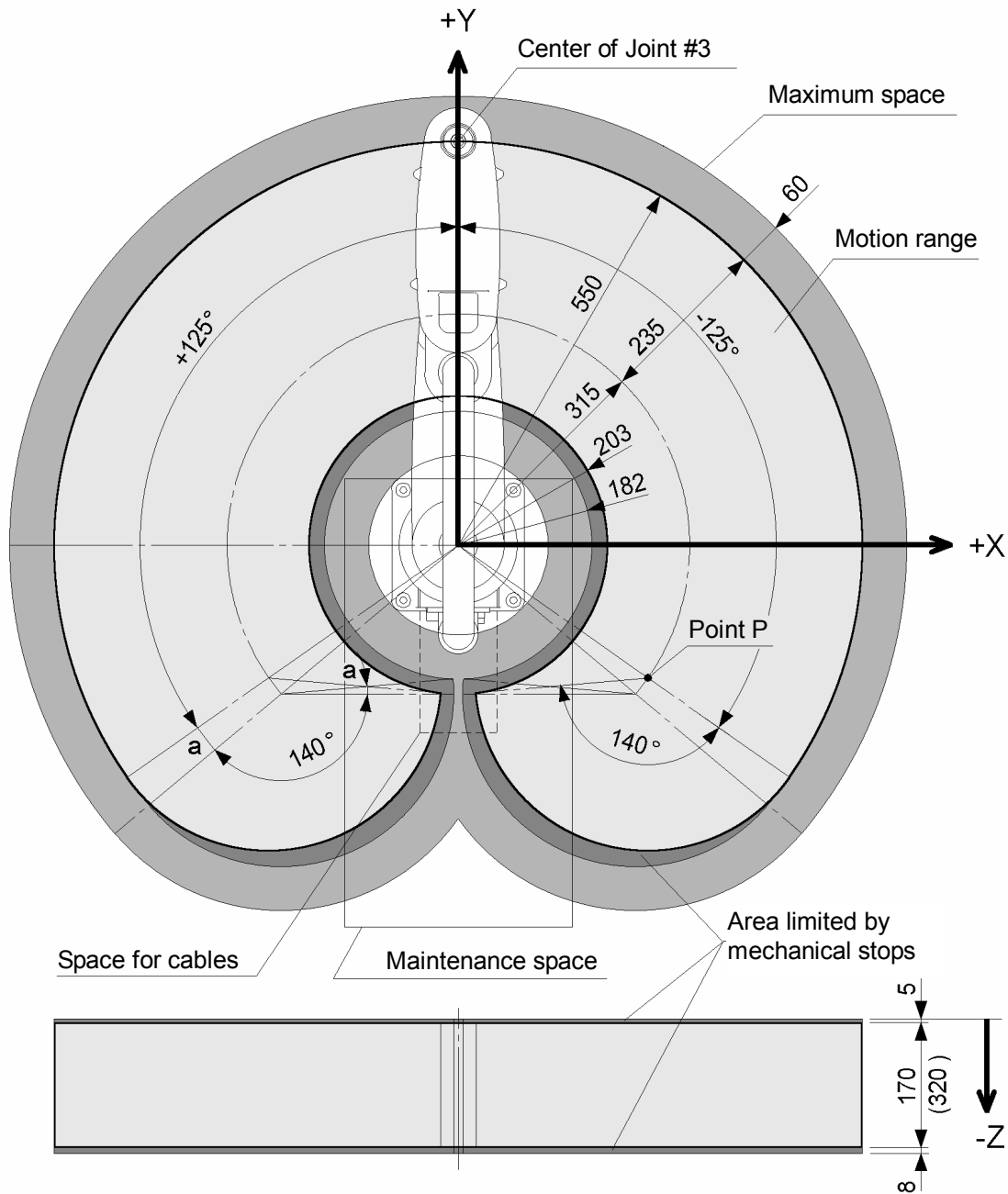
	ES55*S	ES55*C	ES55*P
a	5°	5°	3°

Value of dimensions in ( ) of Z stroke is option.

Figure 21-2.   Motion range of ES55** [unit : mm]
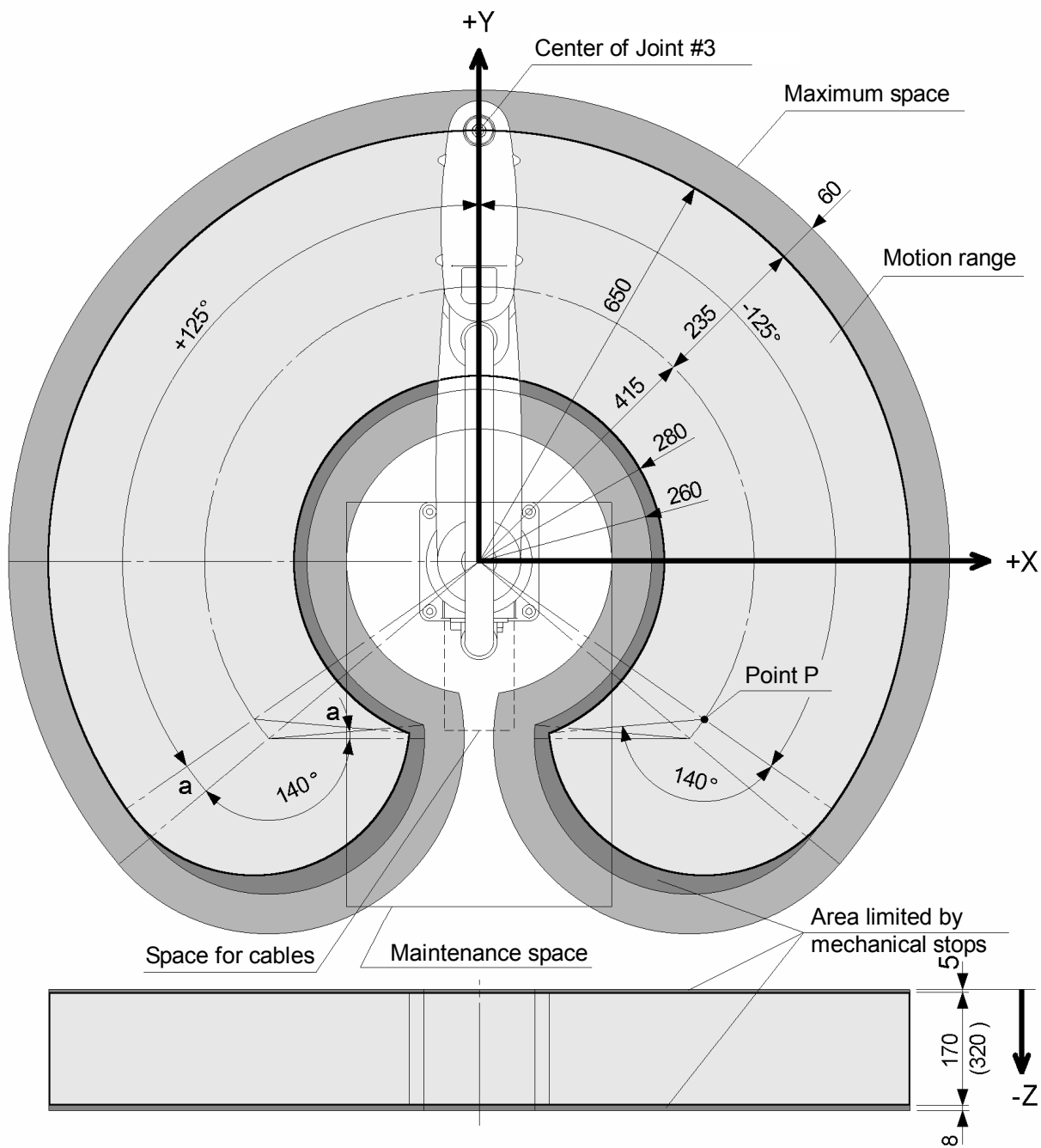
	ES65*S	ES65*C	ES65*P
a	5°	5°	3°

Value of dimensions in ( ) of Z stroke is option.

Figure 21-3.   Motion range of ES65** [unit : mm]
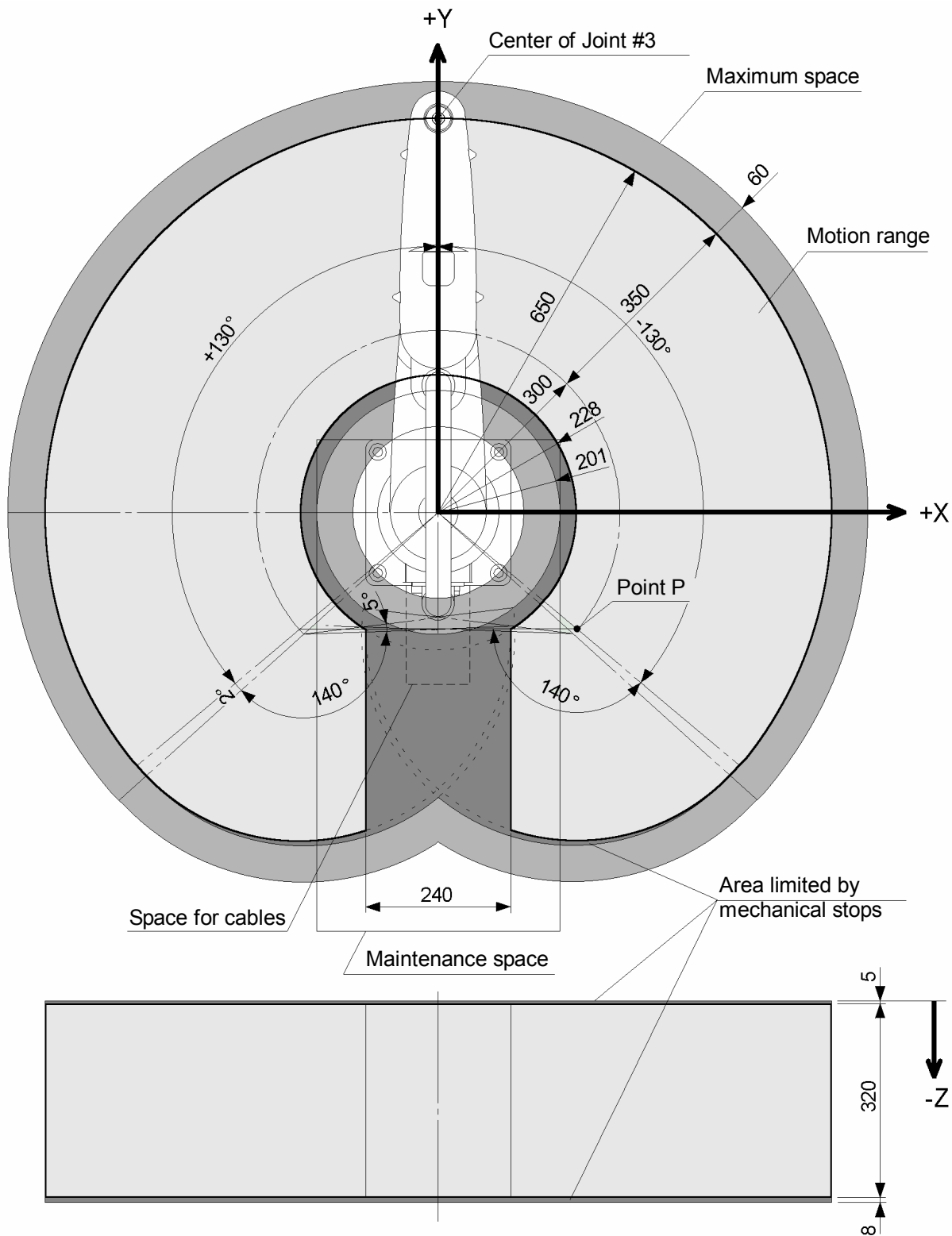
Figure 22-1.   Motion range of EL65** [unit : mm]
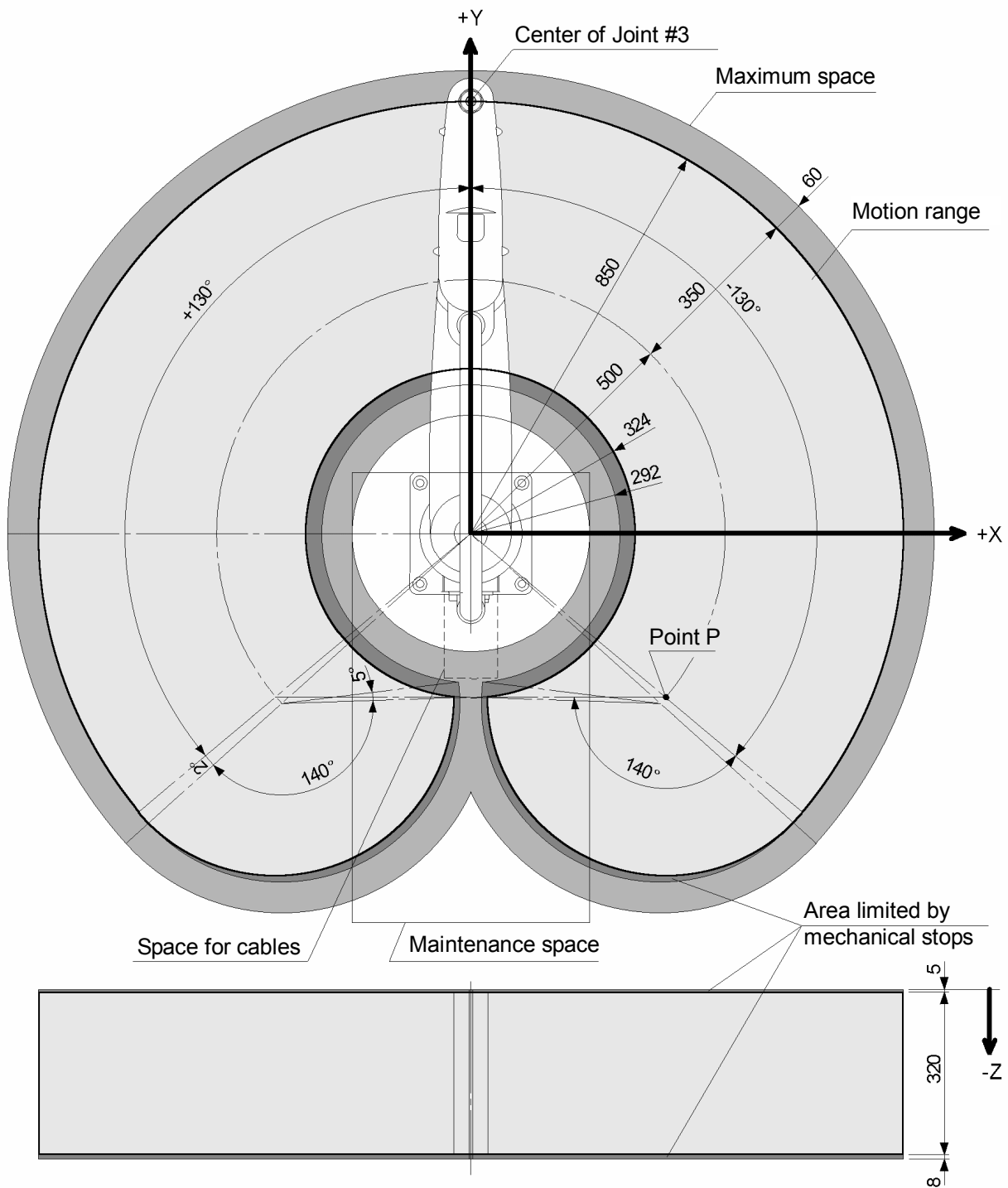
Figure 22-2. Motion range of EL85** [unit : mm]

8.2 Pulse range

The manipulator's motion range is controlled by the pulse lower limit and upper limit of each joint.   Pulse values are read from the servo motor's encoder output.   Here, we show the pulse range of each joint.

The 0 (zero) pulse position of Joint #1 is the position at which Joint #1 faces in the positive direction of the X-coordinate axis.   The pulse value is positive (+) in the counterclockwise direction from the 0 pulse position and negative (−) in the clockwise direction.
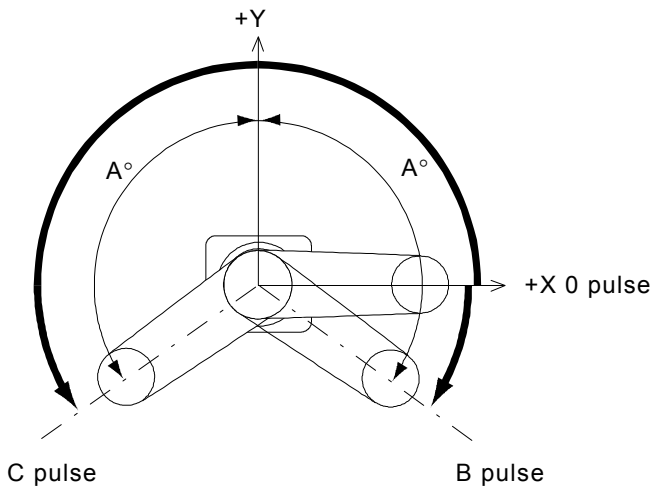
	ES series	EL series
A°	125°	130°
B pulse	−31858	−45512
C pulse	+195698	+250312

Figure 23.   Pulse range of Joint #1

The 0 pulse position of Joint #2 is the position at which Joint #2 is parallel to Joint #1.

A positive (+) pulse value is taken in the counterclockwise direction from the 0 pulse position, and a negative (-) pulse value is taken in the clockwise direction.
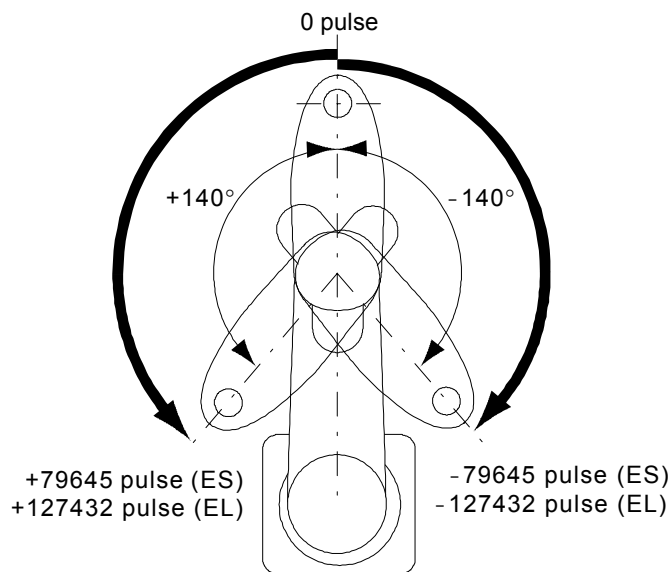
Figure 24.   Pulse range of Joint #2

The 0 pulse position of Joint #3 is the upper limit of Joint #3.   Joint #3 descends from the 0 pulse position and the pulse is negative (-).
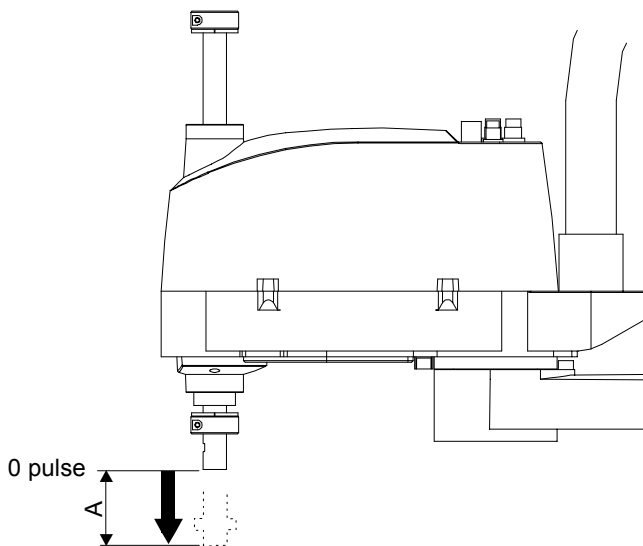
Manipulator	ES**1S	E***3S	ES**1C/P	E***3C/P
A: Joint #3 stroke (mm)	170	320	150	300
Pulse range (pulse)	0 ~ -52224	0 ~ -98304	0 ~ -46080	0 ~ -92160

Figure 25.   Pulse range of Joint #3

The 0 pulse position of Joint #4 is the position at which the flat cut surface of the Joint #4 shaft faces the positive direction of the X-coordinate axis when Joint #1 and #2 are parallel to the X-coordinate axis.   The pulse value is positive (+) in the counterclockwise direction from the 0 pulse position and negative (-) in the clockwise direction.
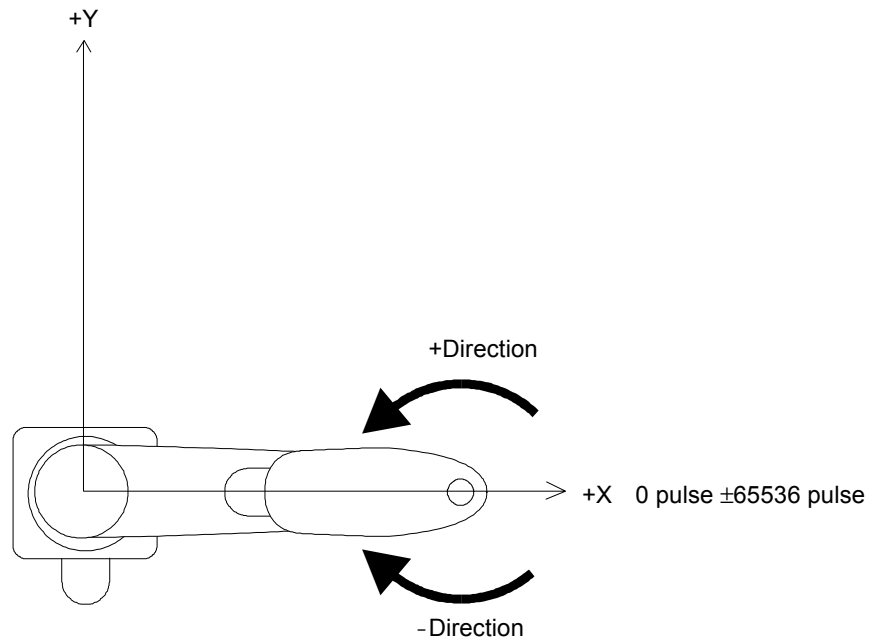
Figure 26.   Pulse range of Joint #4

8.3 Changing the Motion Range

> ⚠ **WARNING**
>
> ■ Both the mechanical stop and the software settings must always be set at the same time when a motion range is being set up.
>
> * The motion ranges of Joint #3 of Clean model manipulator and all joints of Protected model manipulator cannot be changed with mechanical stops.

The motion range is preset at the factory as explained in *8.1 Standard motion range* in this chapter.   This is the manipulator's maximum motion range.

It is possible to change the motion range for reasons of layout efficiency or safety.   Make any changes in the motion range in accordance with the following instructions.

Methods of setting the motion range

You can set the motion range by doing any of the following:

(1)   Set the pulse range (for all joints).

(2)   Set the mechanical stops (for Joint #1 to #3 of Standard model, Joint #1 and #2 of Clean model).

(3)   Set the Cartesian (rectangular) range in the X, Y coordinate system of the robot (for Joint #1 and #2).
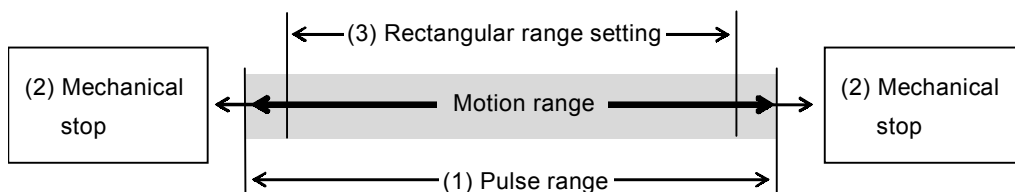
Figure 27.   Setting the motion range

(1) Changing motion range using pulse range

Pulses are the basic unit of robot arm operation.   Setting the upper and lower limits (pulse range) of these pulse values is the most fundamental setting in terms of robot control.

RC+

You can set the pulse range by using the RANGE tab in the Project | Robot Parameters dialog.   (Refer to the chapter *EPSON RC+ GUI* in the EPSON RC+ User's Guide.) You may also execute the RANGE command from the EPSON RC+ Monitor Window.

SPEL 95

You can set the pulse range by using the [RANGE] panel.   (Refer to *Setting the Robot Parameters* in chapter 11 of the User's Guide.)

300

You can set the pulse range by using either the RANGE command or the JRANGE command.   Each command has special features, as explained below.   Use the command that best fits your application.   Refer to the reference manual for details about each command.

RANGE	Sets the pulse ranges for all joints at once.
JRANGE	Sets the pulse ranges for one joint.

The maximum pulse range is shown in "8.2 Pulse range" in this chapter.   Always set pulse ranges to the inside of the mechanical stops.

When the robot receives a move command, it first checks whether or not the destination specified by the command is within the pulse range.   The robot does not move if the destination is outside the set pulse range.   Instead, an error occurs.

(2) Changing motion range using mechanical stops

Mechanical stops physically limit the absolute area that the manipulator can move. You can change the angle of the stops to the angles shown in the following table to limit motion range for Joints #1 to #3 of Standard model and Joints #1 and #2 of the Clean model.

Joint	Manipulator	Possible area setting using the mechanical stops									
#1	ES***S/C	+125°	+95°	+65°	+35°	+5°	−5°	−35°	−65°	−95°	−125°
	EL***S/C	+130°	+100°	+70°	+40°	+10°	−10°	−40°	−70°	−100°	−130°
#2	E****S/C	+140°	+120°	+95°	/	/	/	/	−95°	−120°	−140°
#3	E****S	less than the maximum stroke*									

When you change the position of the mechanical stops, you must also input the corresponding pulse range.

The methods of changing area settings using the mechanical stops are shown below.

Changing the mechanical stop positions for Joint #1 and #2

Both Joint #1 and Joint #2 has threaded holes in positions corresponding to the angles for stop settings. You can change the positions of the mechanical stops by setting bolts in the appropriate holes. The positions of the mechanical stops are shown below.

Mechanical stop of Joint #2

Mechanical stop of Joint #1
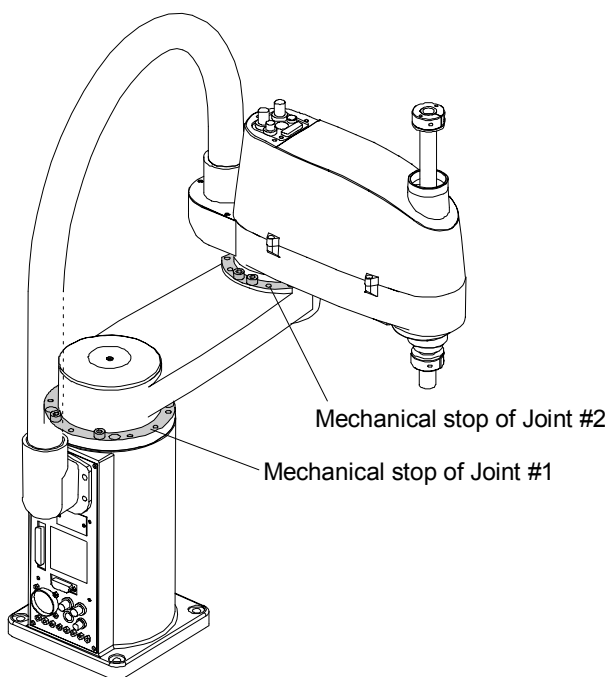
Figure 28.　Locations of the mechanical stops

RC+

(1)   Exit EPSON RC+, shut down the SPEL Runtime Drivers, and turn OFF the Drive Unit.

SPEL 95

(1)   Exit SPEL 95, and turn OFF the Drive Unit.

300

(1)   Turn OFF the controller.

(2)   Screw a hexagon socket head cap bolt into each of the holes corresponding to the angle setting.

Joint	Series	Hexagon socket head cap bolt (fully threaded)	Number of bolts	Recommended tightening torque
#1	ES	M8×10		3720N·cm (380kgf·cm)
	EL	M12×20	1/side	12740N·cm (1300kgf·cm)
#2	ES/EL	M8×10		3720N·cm (380kgf·cm)

Threaded hole locations corresponding to the angle setting are shown below.
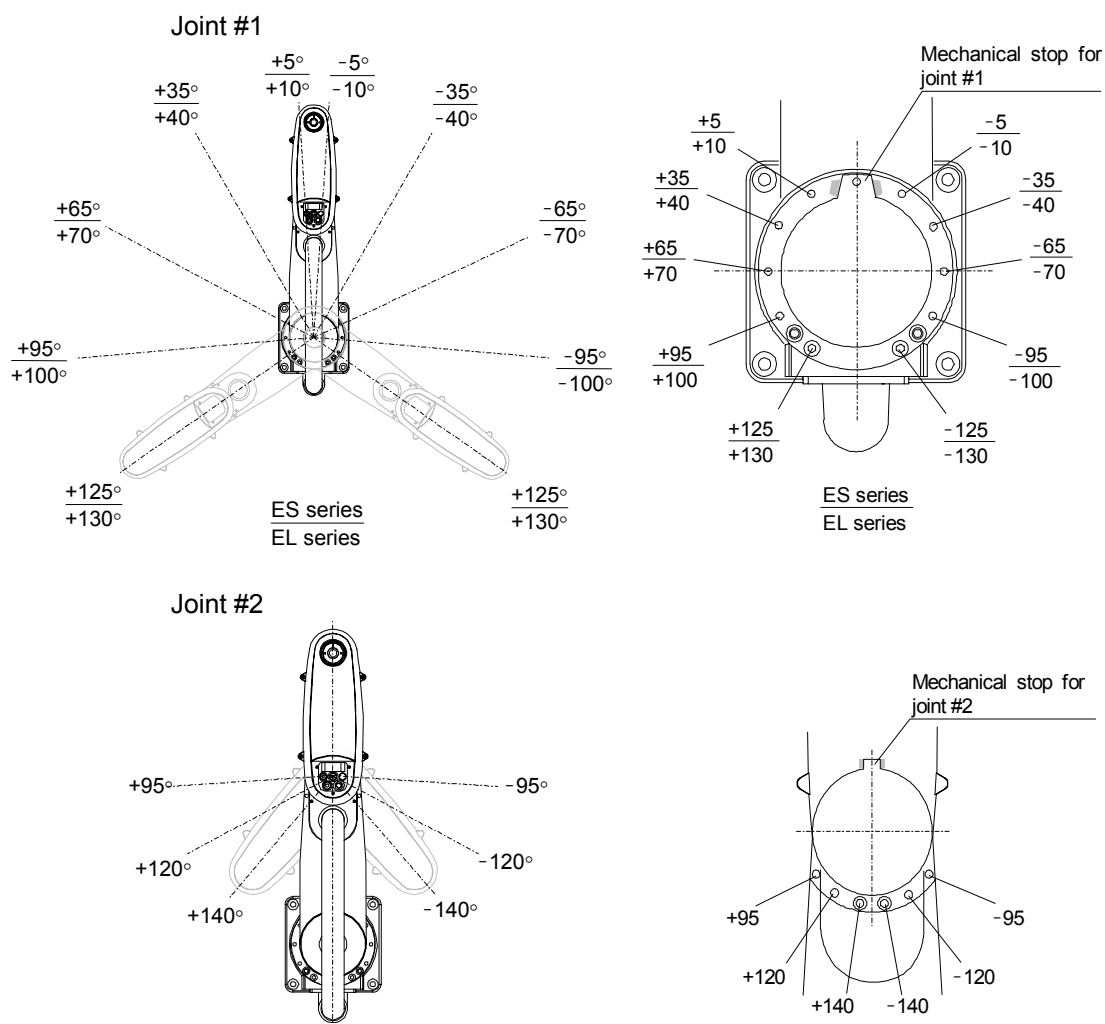
Figure 29.   Threaded holes for changing the position of mechanical stops

47

RC+

(3)   Turn ON the Drive Unit, and start EPSON RC+.

SPEL 95

(3)   Turn ON the Drive Unit, and start SPEL 95.

300

(3)   Turn ON the controller.

RC+

(4)   Set the pulse range corresponding to the new positions of the mechanical stops using the RANGE tab in the Project | Robot Parameters dialog. (Refer to the chapter *EPSON RC+ GUI* in the EPSON RC+ User's Guide.) You may also execute the RANGE or JRANGE from the EPSON RC+ Monitor Window.

SPEL 95

(4)   Set the pulse range corresponding to the new positions of the mechanical stops using the [RANGE] panel. (Refer to *Setting the Robot Parameters* in chapter 11 of the User's Guide.

300

(4)   Set the pulse range corresponding to the new positions of the mechanical stops using either the RANGE or JRANGE command.

The pulse value corresponding to the angle setting in Figure 29 is described in the tables below.

NOTE

☞   Always set the pulse range to the inside of the position of the mechanical stops.

ES series Angle setting and Pulse value

Joint #1				Joint #2			
angle setting	pulse value	angle setting	pulse value	angle setting	pulse value	angle setting	pulse value
+5°	86472	−5°	77369	+95°	54045	−95°	−54045
+35°	113778	−35°	50063	+120°	68267	−120°	−68267
+65°	141085	−65°	22756	+140°	79645	−140°	−79645
+95°	168392	−95°	−4552				
+125°	195698	−125°	−31858				

EL series Angle setting and Pulse value

Joint #1				Joint #2			
angle setting	pulse value	angle setting	pulse value	angle setting	pulse value	angle setting	pulse value
+10°	113778	−10°	91022	+95°	86472	−95°	−86472
+40°	147912	−40°	56888	+120°	109227	−120°	−109227
+70°	182045	−70°	22755	+140°	127432	−140°	−127432
+100°	216178	−100°	−11378				
+130°	250312	−130°	−45512				

<Example> Joint #1 of the ES series manipulator is set from -65° to +95°and Joint #2 is set from -120° to +95°.

RC+

```
>JRANGE 1,22756,168392          ' Sets the pulse range of Joint #1
>JRANGE 2,-68267,54045          ' Sets the pulse range of Joint #2
>RANGE                          ' Displays RANGE values
  22756, 168392, -68267, 54045, -52224, 0, -65536, 65536
```

SPEL 95

Select the [RANGE] panel and set the minimum value for Joint #1 to 22756 and the maximum value at 168392. Additionally, set the minimum value for Joint #2 at -68267 and the maximum value at 54045.

300

```
>JRANGE 1,22756,168392          ' Sets the pulse range of Joint #1
>JRANGE 2,-68267,54045          ' Sets the pulse range of Joint #2
>RANGE                          ' Displays RANGE values
  22756      168392
 -68267       54045
 -52224           0
 -65536       65536
```

(5) Check the following:

◆ Move the arm by hand until it touches the mechanical stop. The arm should not hit any obstructions, such as peripheral equipment.

◆ Using the PULSE/GO PULSE command, operate the joint at slow speed until it reaches the position of the smallest and largest pulse range settings. The arm should not hit the mechanical stops.

<Example in (4)>
Joint #1 is set from -85° to +115°and Joint #2 is set from -132° to +132°.

RC+   300

```
MOTOR ON
SPEED 5                         ' Sets at slow speed.
PULSE 22756,0,0,0               ' Moves to the smallest pulse position
                                  of Joint #1.
PULSE 168392,0,0,0             ' Moves to the largest pulse position of
                                  Joint #1.
PULSE 81920,-68267,0,0         ' Moves to the smallest pulse position
                                  of Joint #2.
PULSE 81920,54045,0,0          ' Moves to the largest pulse position of
                                  Joint #2.
```

SPEL 95

Click the <DEBUG> button and enter the commands shown below in the [Command Execution] Window. (Refer to Chapter 3 of the Introduction manual for details on using the [Command Execution] Window.)

```
MOTOR ON
SPEED 5                          ' Sets at slow speed.
GO PULSE(22756,0,0,0)           ' Moves to the smallest pulse position
                                   of Joint #1.
GO PULSE(168392,0,0,0)          ' Moves to the largest pulse position of
                                   Joint #1.
GO PULSE(81920,-68267,0,0)      ' Moves to the smallest pulse position
                                   of Joint #2.
GO PULSE(81920,54045,0,0)       ' Moves to the largest pulse position of
                                   Joint #2.
```

The PULSE / GO PULSE command moves all joints to the specified positions at the same time. Please specify safe positions after considering motion of not only the joints whose   pulse range have been changed, but also other joints. In this example, when you check Joint #2, Joint #1 is moved to the center of its motion range (pulse value: 81920).

If the arm is touching a mechanical stop or if it has hit a stop and an error has occurred, either reset the pulse range to a narrower setting or extend the position of the mechanical stop within limits.

RC+

(6)   Turn ON the Drive Unit, and start EPSON RC+.

SPEL 95

(6)   Turn ON the Drive Unit, and start SPEL 95.

300

(6)   Turn ON the controller.

(2) Changing the position of the mechanical stop for Joint #3

RC+

SPEL 95

* This method applies only to Standard model.

(1)   With the Drive Unit ON and the motors OFF (using the MOTOR OFF command), push the joint #3 brake release button.

300

(1)   With the controller ON and the motors OFF (using the MOTOR OFF command), push the joint #3 brake release button.

NOTE
☞

When you push the brake release button, Joint #3 may descend under the weight of the end effector, so be sure to support the shaft when you push the button.

Joint #3 can be moved up and down while you are holding down the brake release button. Push the shaft all the way up to the upper limit.
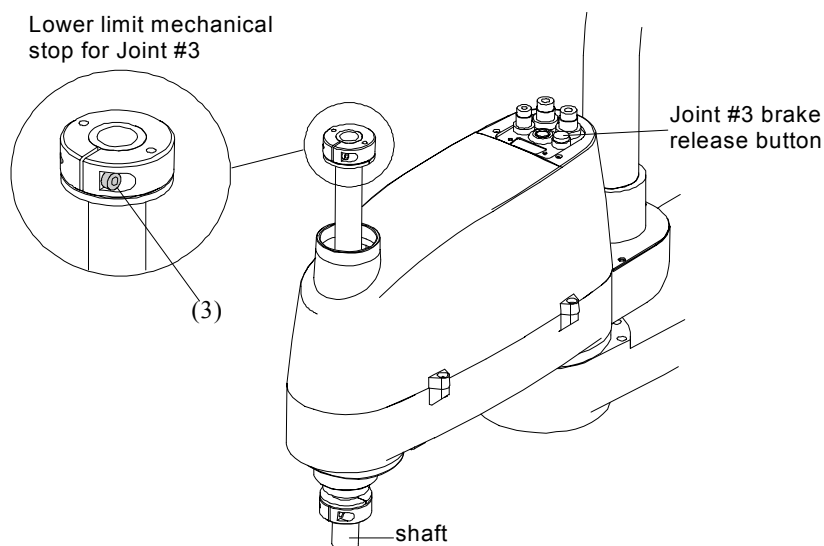
Figure 30.   Mechanical stop for Joint #3

RC+

(2)   Exit EPSON RC+, shut down the SPEL Runtime Drivers, and turn OFF the Drive Unit.

SPEL 95

(2)   Exit SPEL 95, and turn OFF the Drive Unit.

300

(2)   Turn OFF the controller.

(3)   The lower-limit mechanical stop is a split muff coupling fastened to the top of the shaft. Loosen the coupling's M4×15 bolt.   (See Figure 30.)

NOTE
☞

Joint #3 has mechanical stops above and below, but only the lower-limit stop position can be changed.   Do not move the upper-limit mechanical stop, as it also functions as part of the calibration point detector.

(4)   The upper end of the shaft defines the maximum stroke.   So, when you want to limit
      the stroke, lower the lower-limit mechanical stop by the length you want to limit the
      stroke.   As an example, let's say that the lower-limit mechanical stop is set at the
      standard 170 mm, making the lower-limit Z coordinate ‑170 mm.   If you want to
      make the lower-limit Z coordinate ‑100 mm, you must lower the lower-limit
      mechanical stop 70 mm.   Use calipers to measure the distance when you lower the
      stop.
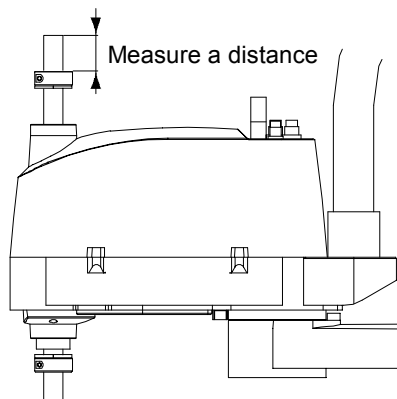
Figure 31.   Changing the position of the mechanical stop for Joint #3

(5)   Firmly tighten the bolt of the split muff coupling once it is in the appropriate position.
      Recommended tightening torque is 490N·cm (50kgf·cm).

RC+

(6)   Turn ON the Drive Unit, and start EPSON RC+.

SPEL 95

(6)   Turn ON the Drive Unit, and start SPEL 95.

300

(6)   Turn ON the controller.

(7)   Move the shaft to the lowest position by hand while pushing the brake release button.
      Make sure that the shaft is not too high for the operation points.

(8)   Calculate the lower-limit pulse of the pulse range using the following formula.   (The
      lower limit Z coordinate is negative, so always make certain that the result of
      calculations is negative.)

$$\text{Lower limit of pulse} = \text{lower limit Z axis value} / 20 \times 4096 \times 1.5$$

<Example>
The stroke is 170 mm.   You lower the mechanical stop 70 mm and change the lower
limit Z coordinate to ‑100 mm.
$$(\text{‑}100) / 20 \times 4096 \times 1.5 = \text{‑}30720$$

(9)   Set the pulse range.   The upper-limit pulse is 0.
      <Example in (8)>
      > JRANGE 3,-30720,0

(10) Move Joint #3 slowly using the PULSE command to the position of the lower-limit value of the pulse range.   If the mechanical stop is being hit, or if it is hit and an error occurs, either narrow the pulse range just enough to eliminate interface, or widen the position of the mechanical stop.   The typical clearance for the mechanical stop at the lower-limit pulse position is approximately 5 mm.

<Example in (8)>
   Execute the following commands from the Monitor Window.

   MOTOR ON   ' Turn the motor on
   SPEED 5   ' Sets on slow speed
   PULSE 0,0,-30720,0   ' Moves to lower limit-pulse position of Joint #3.
                                 In the example, all pulses other than that of Joint
                                 #3 are 0.   You should substitute these zeroes
                                 with a pulse for a position in which there is no
                                 interference even when you lower Joint #3.

(11) If you need a clear view, remove four mounting bolts (See Figure 32) from the arm cover, open the cover, and look from the side.
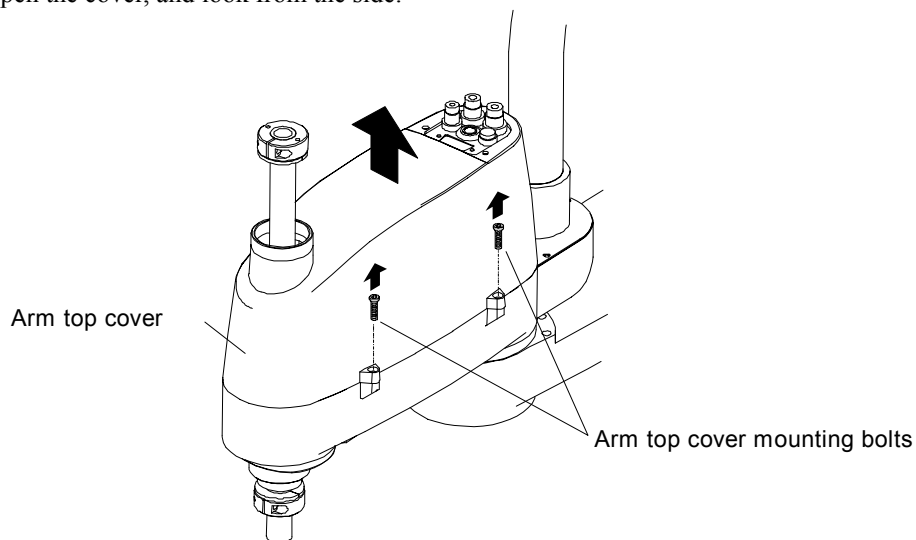
Figure 32.   Arm top cover

(3) Changing motion range using X, Y limits

Use this method to set the upper and lower limits of the X and Y coordinates.

⚠ **WARNING**
■ This setting applies only to the software, so it does not change the physical range.   The maximum physical range is based on the positions of the mechanical stops.

NOTE
☞
If you need to change this setting for ES45**/EL65**, you must be careful because the end effector may hit the rear side of the manipulator depending on the motion.

RC+
Set the X Y range by using the XYLIM tab in the Project | Robot Parameters dialog. (Refer to the chapter EPSON RC+ GUI in the EPSON RC+ User's Guide.)   You may also execute the XYLIM command from the EPSON RC+ Monitor Window.

For only ES45**, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-90	90	Figure 21-1 in this chapter
Y	-450	0	

For only EL65**, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-120	120	Figure 22-1 in this chapter
Y	-650	0	

For example:
```
>XYLIM -90,90,-450,0
```

SPEL 95
Set the X Y range by using the [XYLIM] panel.   For details on the [XYLIM] panel, Refer to Chapter 11, section *Setting the Robot Parameters* in the User's Guide.
For only ES45**, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-90	90	Figure 21-1 in this chapter
Y	-450	0	

For only EL65**, at the factory shipping, it is set as follows:

coordinate	lower limits [mm]	upper limits [mm]	Refer to
X	-120	120	Figure 22-1 in this chapter
Y	-650	0	

For example:
```
>XYLIM -90,90,-450,0
```

300

Refer to the User's manual for SRC-300/320 *11. Set up, Set the robot parameters* in Function volume.

For ES45**, at the factory shipping, it is set as follows:
XYLIM -90,90,-450,0
(Refer to Figure 21-1 in this chapter.)

For EL65**, at the factory shipping, it is set as follows:
XYLIM -120,120,-650,0
(Refer to Figure 21-1 in this chapter.)

9. Emergency Stop

If the manipulator moves abnormally during operation, immediately press the emergency stop switch.

By pressing the emergency stop switch, the motor power is cut and the dynamic brake activates and stops the rotation of motor as inertia.

However, you should not press the emergency stop switch during normal operation unnecessarily. The braking distance depends on timing to activate the emergency stop switch and motion speed, but robot arm may overrun the stop position under servo-control and may collide with peripheral equipment.

We recommend pressing the emergency stop switch when the arm is not moving, when you want to prevent the robot from being operated.

(Refer to the Controller manual for more details of the emergency stop switch.)

10. Specifications

The tables on the following pages show the standard specifications for the ES and EL series manipulators.

If the manipulator is a Clean model, refer to the section *11.5 Additional Specifications* in chapter *11. Clean Model*.

If the manipulator is a Protected model, refer to the section *12.6 Additional Specifications* in chapter *12. Protected Model*.

10.1 ES series Standard model specifications

Model		ES45**	ES55**	ES65**
Arm length	Arm #1 + #2	215 + 235 mm	315 + 235 mm	415 + 235 mm
Weight		20kg		
Driving method	All joints	AC servo motor		
Max. operation speed *1	Joint #1 + #2 Joint #3 Joint #4	4733 mm/s 1000 mm/s 1687 °/s	5290 mm/s 1000 mm/s 1687 °/s	5277 mm/s 1000 mm/s 1687 °/s
Repeatability	Joint #1 + #2 Joint #3 Joint #4	±0.02 mm ±0.01 mm ±0.03 °		
Max. motion range *2 Value in ( ) is option	Joint #1 Joint #2 Joint #3 Joint #4	±125 ° ±140 ° 170 mm (320 mm) ±360 °		
Max. pulse range Value in ( ) is option	Joint #1 Joint #2 Joint #3 Joint #4	–31858 to +195698 ±79645 –52224 (–98304) to 0 ±65536		
Resolution	Joint #1 Joint #2 Joint #3 Joint #4	0.0010986 °/pulse 0.0017578 °/pulse 0.0032552 mm/pulse 0.005493 °/ pulse		
Motor power consumption	Joint #1 Joint #2 Joint #3 Joint #4	200 W 100 W 100 W 100 W		
Payload	rated / max.	2kg /5kg		
Joint #4 allowable moment of inertia *3	rated / max.	With rated payload (2kg) : 0.01kg·m^2 / 0.02kg·m^2 With max. payload (5kg) : 0.02kg·m^2/ 0.04kg·m^2		
Diameter of the shaft/through hole		φ 20 (h7) mm / φ 14 mm		
Joint #3 down force		100 N (10.2kgf)		
Installed wire for customer use		15 wires (15 -pin D-sub connector)		
Installed pneumatic tube for customer use		φ 6 mm 2 pneumatic tubes φ 4 mm 1 pneumatic tube Allowable pressure: 0.59MPa (6kgf/cm^2)		
Environmental requirements		Temperature: 5 to 40 °C (No drastic change is allowed.) Humidity: 10 to 80 % (No condensation is allowed.)		
Equivalent continuous A-weighted sound pressure level *4		L_{Aeq} = 66 dB (A)		
Applicable controller		EPSON RC+, SRC5**, SRC-3**		
Default values	SPEED ACCEL SPEEDS ACCELS FINE WEIGHT	5 10, 10 50 200 10, 10, 10, 10 2, 235		

10.2 EL series Standard model specifications

Model		EL65**	EL85**
Arm length	Joint #1 + #2	300 mm + 350 mm	500 mm + 350 mm
Weight		31kg	
Driving method	All joints	AC servo motor	
Max. operation speed *1	Joint #1 + #2 Joint #3 Joint #4	4970 mm/s 1000 mm/s 1687 °/s	5860 mm/s 1000 mm/s 1687 °/s
Repeatability	Joint #1 + #2 Joint #3 Joint #4	±0.025 mm ±0.01 mm ±0.03 °	
Max. motion range *2	Joint #1 Joint #2 Joint #3 Joint #4	±130 ° ±140 ° 320 mm ±360 °	
Max. pulse range	Joint #1 Joint #2 Joint #3 Joint #4	-45512 to +250312 ±127432 -98304 to 0 ±65536	
Resolution	Joint #1 Joint #2 Joint #3 Joint #4	0.0008789 °/pulse 0.0010986 °/pulse 0.0032552 mm/pulse 0.005493 °/pulse	
Motor power consumption	Joint #1 Joint #2 Joint #3 Joint #4	400 W 200 W 100 W 100 W	
Payload	rated / max.	2kg /5kg	
Joint #4 allowable moment of inertia *3	rated / max.	With rated payload (2kg) : 0.01kg·m^2 / 0.02kg·m^2 With max. payload (5kg) : 0.02kg·m^2 / 0.04kg·m^2	
Diameter of the shaft/through hole		ϕ 20 (h7) mm / ϕ 14 mm	
Joint #3 down force		100 N (10.2kgf)	
Installed wire for customer use		15 wires (15 -pin D-sub connector)	
Installed pneumatic tube for customer use		ϕ 6 mm 2 pneumatic tubes ϕ 4 mm 1 pneumatic tube Allowable pressure: 0.59MPa (6kgf/cm^2)	
Environmental requirements		Temperature: 5 to 40 °C (No drastic change is allowed.) Humidity: 10 to 80 % (No condensation is allowed.)	
Equivalent continuous A-weighted sound pressure level *4		L_{Aeq} = 70 dB (A) or under	
Applicable controller		EPSON RC+, SRC5**, SRC-3**	
Default values	SPEED ACCEL SPEEDS ACCELS FINE WEIGHT	5 10, 10 50 200 10, 10, 10, 10 2, 350	

*1 : In case of PTP control.   In case of CP control, maximum operation speed on horizontal plane is 1120 m/s.

*2 : Base backside is excluded from the maximum working area in ES65**.

*3 : When the center of gravity is at the center of the Joint #4.   If the center of gravity is not at the center of Joint #4, speed and acceleration must be reduced.

*4 : Operation conditions of manipulator during measurement:

Under the rated load, 4-joints simultaneous motion, maximum speed, maximum acceleration, duty 50%.

Measurement point:

At the front of manipulator, 100 mm apart from the motion range, 50 mm above the base-installed surface.

10.3 Model settings

RC+

To set the manipulator model using the EPSON RC+ system, use the Setup | System Configuration | Robots tab.   Refer to the chapter "Robot Configuration" in the EPSON RC+ User's Guide.

SPEL 95

When setting the manipulator model using the SRC5** controller, select the model with the [Basic Settings] panel that is displayed when [Setup] - [Robot Manipulator Settings] is executed.   Refer to Chapter 11 in the User's Guide for the section *Setting the Robot Paramters.*

300

Manipulator models used with the controller SRC-3** are pre-set by DIP switch SD1 on the MPU board in the controller.   Be sure not to change the DIP switch settings.   Also, if an MT label is attached, the manipulator has custom specifications, and settings may differ from those described above.   When making an inquiry, please note the custom specifications number on the MT label.

Model name		DIP switch SD1 (model select switch) setting					
		bit 3	bit 4	bit 5	bit 6	bit 7	bit 8
ES***S	ES451S	-	ON	-	-	-	-
	ES551S	-	-	ON	-	-	-
	ES651S	-	ON	ON	-	-	-
	ES453S	-	ON	-	ON	-	-
	ES553S	-	-	ON	ON	-	-
	ES653S	-	ON	ON	ON	-	-
EL***S	EL653S	-	ON	-	-	ON	-
	EL853S	-	-	ON	-	ON	-
ES***C/P	ES451C/ES451P	ON	ON	-	-	-	-
	ES551C/ES551P	ON	-	ON	-	-	-
	ES651C/ES651P	ON	ON	ON	-	-	-
	ES453C/ES453P	ON	ON	-	ON	-	-
	ES553C/ES553P	ON	-	ON	ON	-	-
	ES653C/ES653P	ON	ON	ON	ON	-	-
EL***C/P	EL653C/EL653P	ON	ON	-	-	ON	-
	EL853C/EL853P	ON	-	ON	-	ON	-

11. Clean Model

The Clean models for the ES / EL series include extra features that reduce dust emitted by the manipulator to enable use in clean room environments (See NOTE). This chapter describes the differences between the Standard and Clean models for the ES / EL series.

The parentheses ( ) next to each title shows the relevant section for the ES / EL series Standard model that should be referred to.

NOTE
☞
Clean model requirements specify a maximum of 10 particles (0.13 μm or more in diameter) in 28317 cm^3 (1cft) sample-air around the center of the motion range.

11.1 Manipulator part names

For basic information on manipulator part names, refer to *1. Manipulator Part Names*.

Model names that end with a "C" indicate models that meet Clean model requirements.

ES 55 1 C

Option	Clean model
Joint #3 stroke	1: 150 mm, 3: 300 mm
Arm length	45: 450 mm, 55: 550 mm, 65: 650 mm, 85: 850 mm
Series name	ES, EL

Some parts of the following diagram differ from the standard manipulator's external view.

Upper bellows

Lower bellows

Exhaust port
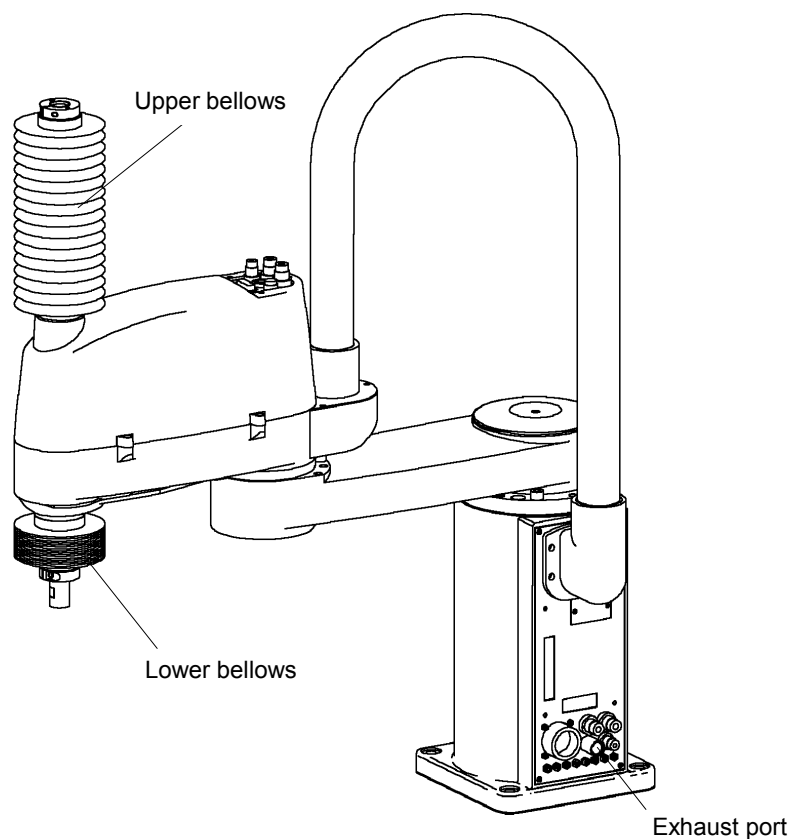
11.2 Installation method

Chapter *3. Installation* contains instructions and safety precautions for unpacking and installing the manipulator.

(1) After unpacking the manipulator outside of the clean room, use bolts to fasten it down so that it will not tip over.

(2) Before installing the manipulator in the clean room, make sure it has been cleaned. It's preferable to wipe off the dust with a little alcohol or distilled water on a lint-free cloth.

(3) Transport the manipulator to the clean room and install it.

(4) Connect the exhaust tube to the exhaust port. (Refer to the next section.)

11.3 Exhaust System

The Clean model requires the following type of exhaust system to prevent emission of dust particles from the manipulator.

Exhaust port size	Inner diameter ϕ 12 mm Outer diameter ϕ 16 mm
Exhaust tube	Outer diameter ϕ 12 mm (Inner diameter ϕ 8 mm) or the polyethylene tube with inner diameter ϕ 16 mm or over
Recommended exhaust flow rate	Approximately 1000cm^3/s (Normal)

NOTE
☞

The gap between the exhaust port and the exhaust tube must be sealed with vinyl tape so that the junction is airtight.

If the exhaust flow is not sufficient, dust particle emission may exceed the specified maximum level.

NOTE
☞

The exhaust system draws air from this Clean model manipulator's base interior and arm cover interior. A crack or other opening in the base unit can cause loss of negative air pressure in the outer part of the arm, which can cause increased dust emission. Therefore, do not remove the maintenance cover on the front of the base, the acrylic cover on the back of the base, or the sealing tape on the connector.

11.4 External dimensions

ES series Clean model [unit : mm]
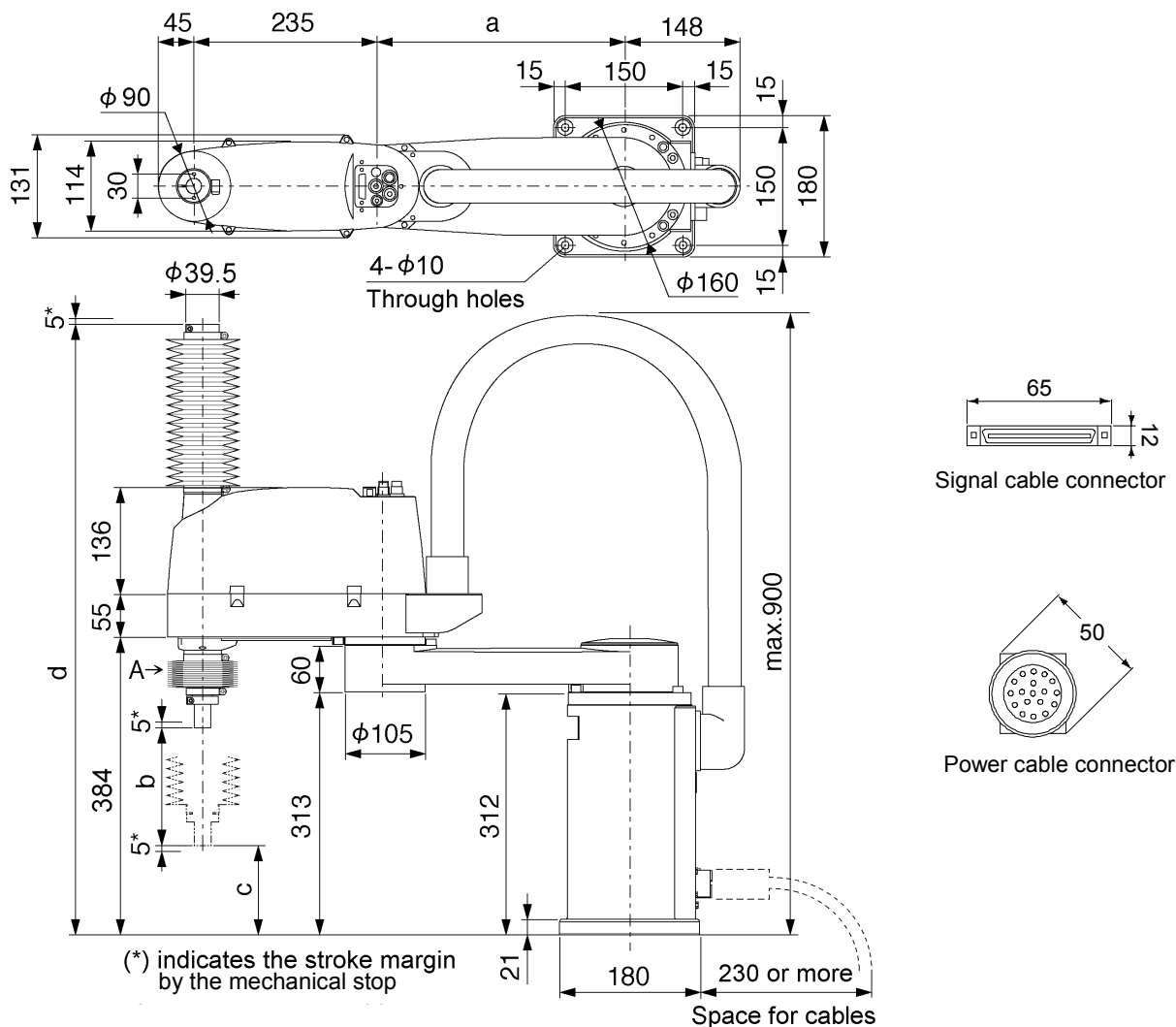
(*) indicates the stroke margin
by the mechanical stop

Space for cables

Signal cable connector

Power cable connector
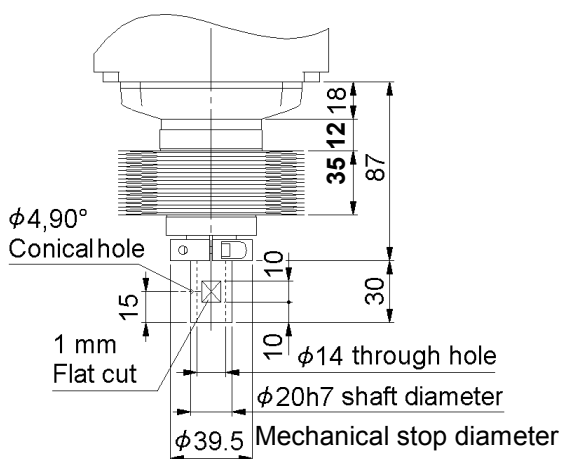
	ES45*C	ES55*C	ES65*C
a	215	315	415

	ES**1C	ES**3C
b	150	300
c	117	-33*
d	785	935

* The shaft of ES**3C will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

φ4,90°
Conical hole

1 mm
Flat cut

φ14 through hole

φ20h7 shaft diameter

φ39.5 Mechanical stop diameter

View A detail
(Calibration point position of the Joint #3 & #4)

EL series Clean model [unit : mm]

φ90

φ39.5

4- φ16
Through holes

φ200

Duct support
(for EL853C only)

(*) indicates the stroke margin
by mechanical stop

φ125

max. 950

230 or more
Space for
cables

240

View A detail
(Calibration point position of the Joint #3 & #4)

φ4,90°
Conical hole

1 mm
Flat cut

φ14 through hole

φ20h7 shaft diameter
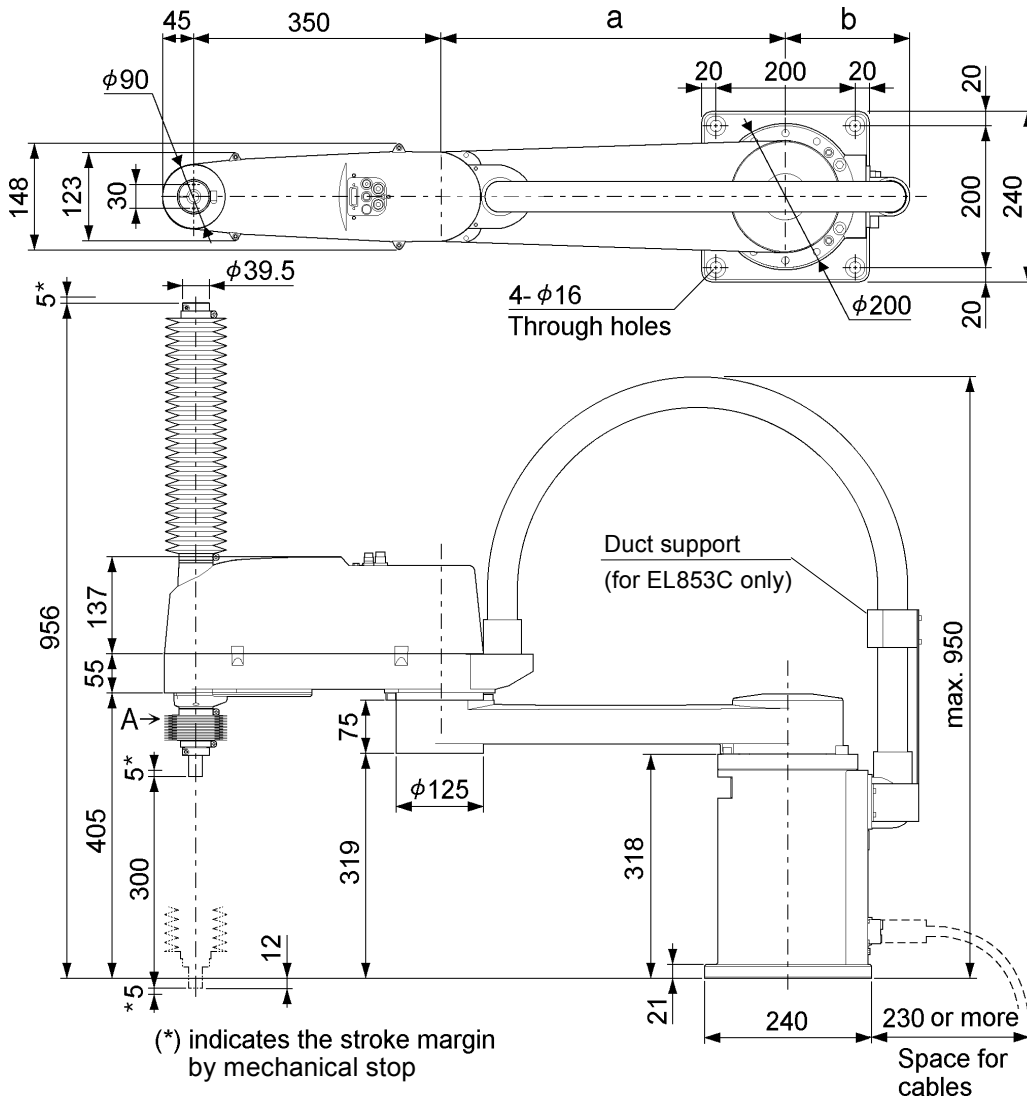
φ39.5 | Mechanical stop
diameter
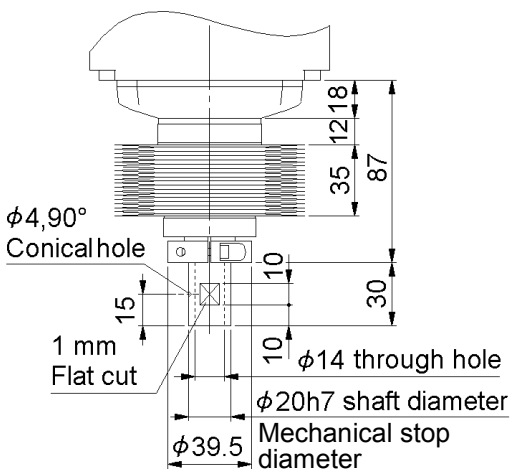
	EL653C	EL853C
a	300	500
b	178	185 (including the duct support)

The shaft of EL**3C will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

65

12

Signal cable connector

50
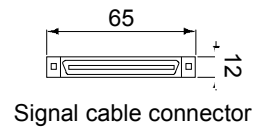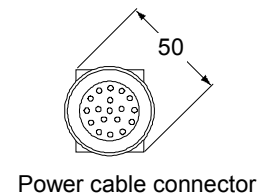
Power cable connector

11.5 Additional specifications

For standard specifications, refer to chapter *10. Specifications* in Part 1.

Model	ES***C	EL***C
Max. motion range of Joint #3 Value in ( ) is option	150mm (300mm)	300mm
Cleanliness level	Maximum of 10 particles (0.13 µm or more in diameter) in 28317 cm^3 (1cft) sample-air located near the center of the work area.	
Exhaust tube	Outer diameter ϕ 12 mm (inner diameter ϕ 8 mm) or the polyethylene tube with inner diameter ϕ16 mm or over	
Recommended exhaust flow rate	Approximately 1000cm^3/s (Normal)	

12. Protected Model

The protected models for the ES / EL series include shielding on the manipulator specifically for use in a dusty, wet or oily environment. The degree of the protective shielding is equivalent to IP65.*

*   The specified grade of protection shielding: IP65 (IEC 144).

IP 6 5

This digit ("5") stands for the degree of protection from water. The "5" indicates that it would not be gravely affected when directly hit by a jet stream of water from any direction. However, this may not apply if the jet stream is a substance other than water. For example, if the manipulator is hit by oil or detergent, the degree of protection may deteriorate. Please note that this degree of protection is tested using the specified testing procedure. Depending on the pressure of an actual jet stream, the protection may be more or less effective than defined.

This digit ("6") stands for the degree of protection for human body or solid matter. The "6" indicates that it would not allow entrance of dust inside.

This chapter describes the differences between standard and protected models for the ES / EL Series. The parentheses ( ) after each title show the relevant section for the ES / EL Series standard model that should be referred to.

12.1 Manipulator part names

For information on standard manipulator parts, refer to *1. Manipulator Part Names*.

Model names that end with a "P" indicate Protected models.

<u>ES</u> <u>55</u> <u>1</u> <u>P</u>

              Option .... Protected model

           Joint #3 stroke ... 1: 150 mm, 3: 300 mm

        Arm length .... 45: 450 mm, 55: 550 mm, 65: 650 mm, 85: 850 mm

     Series name .... ES, EL
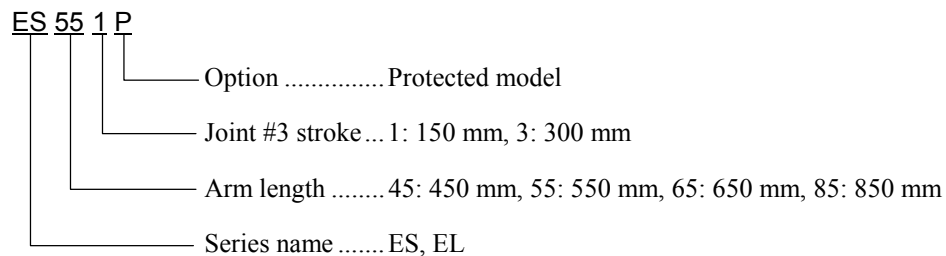
Some parts of the following diagram differ from the standard manipulator's external view.
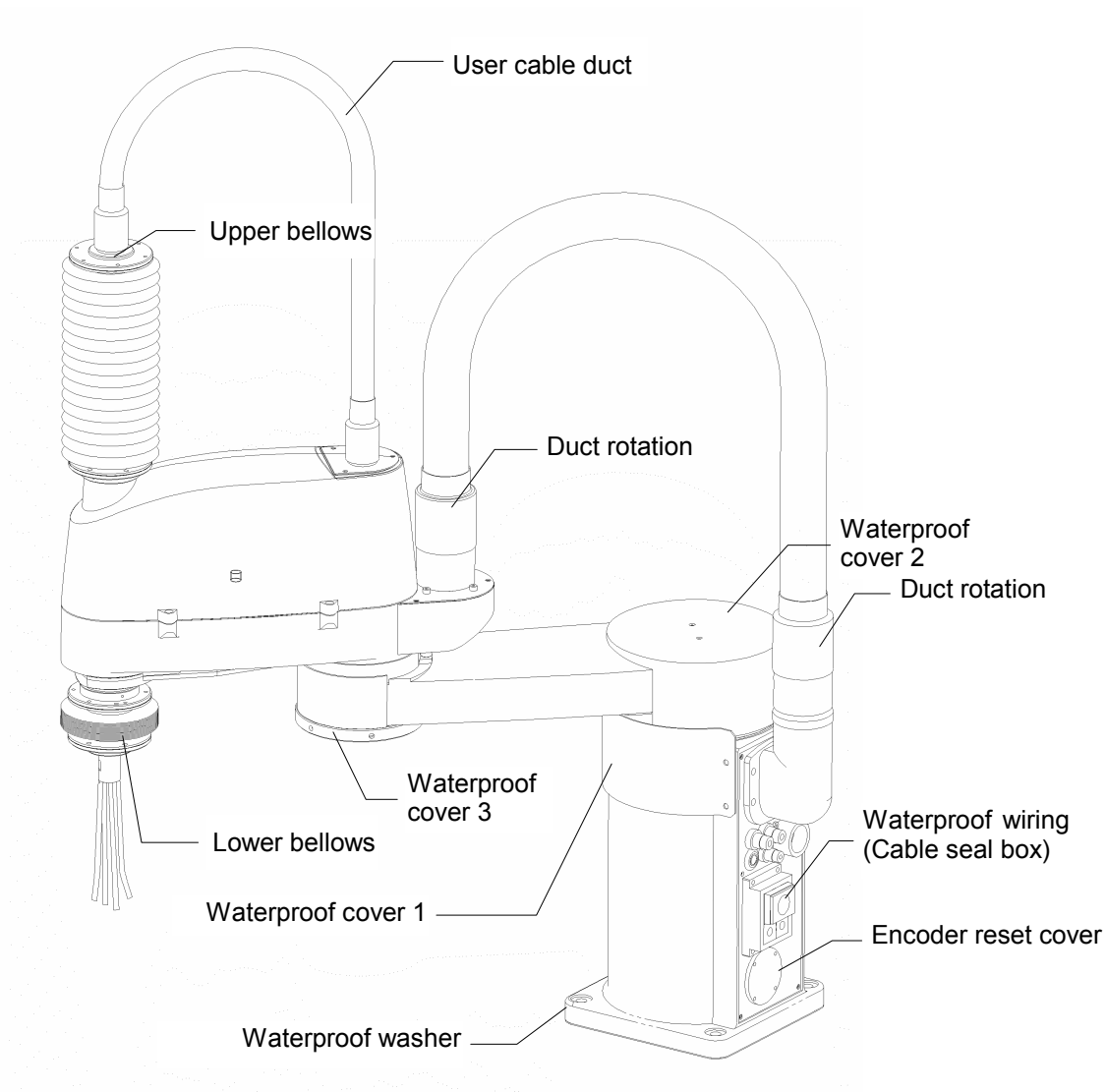
12.2 Environmental conditions

General environmental conditions

For basic environmental information, refer to *2.1 Environmental conditions*.

A suitable environment is necessary for the manipulator to function properly and safely.

Please install the robot in a location that meets the following requirements:

Ambient temperature	5 to 40°C (with minimum temperature variation)
Ambient relative humidity	10 to 80 % (no condensation)
First transient burst noise	2kV max.
Electrostatic noise	6kV max.
Environment	◆ Install indoors. ◆ Keep away from direct sunlight. ◆ Keep away from flammable or corrosive solvents and gases. ◆ Keep away from shocks or vibrations. ◆ Keep away from sources of electric noise.

Manipulators with this standard specification are not suitable for operation in a harsh environment such as painting, etc. Contact the service center or the suppliers for details.

⚠ **WARNING**

RC+

SPEL 95

■ To avoid electric shock and circuit breakdown caused by an unexpected water leak, use an earth leakage breaker on the AC power cable of the Drive Unit. For the selection of the breaker, refer to *Power Requirements*, in the User's Guide for the controller you are using. (SRC3** Controllers have the earth leakage breakers built in.)

Special environmental conditions

The protected model comes with protective shielding from dusty or wet environments where splashes are possible. In order to ensure the model will perform all of its designed functions, please make sure that the equipment is used according to the following conditions:

◆ As an IP65 equivalent certified product, the manipulator should withstand water splashes from a hose. However, immersing in water should be avoided even if it is just part of the manipulator.

◆ The manipulator's surface is finished to tolerate oil at large. However, if your requirements specify that the manipulator must withstand certain kinds of oil, please consult with your local sales dealer.

◆ Measurements for dew formation on the manipulator have not been preformed. Therefore, use normal temperature water when using water around the manipulator.

◆ If your requirements specify that the manipulator handles food, please consult with your local sales dealer to test the equipment prior to use. Ensure that no damage to food occurs due to the manipulator's handling.

◆ The manipulator cannot be used in corrosive environments where strong acid or alkaline is used. In a salty environment where the rust is likely to gather, the manipulator is susceptible to rust.

◆ If the manipulator must be placed near machine tools, please make sure that the bellows are not touched by the tools.

◆ The controller unit* supplied with the protected model will not withstand the same dusty, wet, or oily environments as the manipulator. Therefore, the controller unit must be stored in either a separate room or a protective box to comply with its own environment specifications.

◆ To store the controller unit* in a protective box, it is imperative to use a heat exchanger to keep the calorific value generated from the controller under 300W.

    * The controller unit:
      RC+   : EPSON RC+   (PC Control unit / Drive Unit)
      SPEL 95/SRC5**   : Control Unit / Drive Unit
      SRC-3**   : Controller

12.3 Connecting the cables

For basic information about cabling, refer to section *3.3 Connecting the cables.*

<table>
<tr>
<td>⚠️ WARNING</td>
<td>■ Do not expose the manipulator or connectors to water or dust when connecting or disconnecting cables.

■ Do not place a manipulator without a power cable connector in an environment where it is exposed to water or dust.

■ Invasion of water or dust may cause electric shock or malfunction.</td>
</tr>
</table>

(1) Power cable

The manipulator's power cable connector (X100) is designed to be water proof when connected.   Please make sure that no moisture or dust is left on the pins on both ends when connected.

The controller's power cable connector (X2) is not designed water proof.   Therefore, the controller unit's power cable must be connected in the same environment as the controller unit itself is set up.

(2) Signal cable

The manipulator's signal cable connector is connected to the relay board on the base connector plate.   The relay board area is shielded from the dust or moisture.

The controller's signal cable connector is not designed to be water proof.   Therefore, the controller unit's signal cable must be connected in the same environment as the controller unit itself.

12.4 User wires and pneumatic tubes

For basic information about user wiring and pneumatics, refer to chapter *4. User Wires and Pneumatic tubes*.

Electrical wires and air tubes have been incorporated into the cable unit for your use.

⚠ CAUTION	■ Since the outlets for the user wires and the air tubes lead to the inside of the arm, they need to be sealed completely after the wiring to the end effector is completed. The outlet must be sealed completely with vinyl tape or equivalent.

Electrical wires

Rated voltage	AC/DC 30V
Allowable current	1A
Number of cables	15
Nominal sectional area	0.211 mm^2
Outer diameter	φ 8.3±0.3 mm
Note	Shielded

The manipulator's user cable connector is connected to the relay board on the back of the base body. The relay board area is shielded from dust or moisture.

The cable is 0.8 m long with its end simply cut off. The user wire connector on the end effector's side is connected inside the Arm Cover to go through the user cable duct and the spline shaft until it comes out from the end effector's side. The cable on this end is 1 m long and left simply cut off. There are 16 wires on each end. Except for the brown/(green) cable that does not connect to anything, the other 15 wires should have a matching wire of the same color.

Pneumatic tubes

Max. usable pneumatic pressure	Number of pneumatic tubes	Outer diameter × inner diameter
0.59Mpa (6kgf/cm^2)	3	φ 4 mm × φ 2.5 mm

The base side of the air tubes are equipped with joints for connecting air tubes with an outer diameter of φ 6 mm and φ 4 mm. The cable on the end effector is 0.8 m long and left simply cut off.

0.8 m

Fitting (black) for ϕ 6 mm pneumatic tube
Connect to ϕ 4 mm (black) pneumatic tube
on the end effector

Fitting (white) for ϕ 6 mm pneumatic tube
Connect to ϕ 4 mm (blue) pneumatic tube
on the end effector

Fitting for ϕ 4 mm pneumatic tube
Connect to ϕ 4 mm (yellow) pneumatic
tube on the end effector

Spare

Signal cable

User wire (10 m)

Encoder reset cover
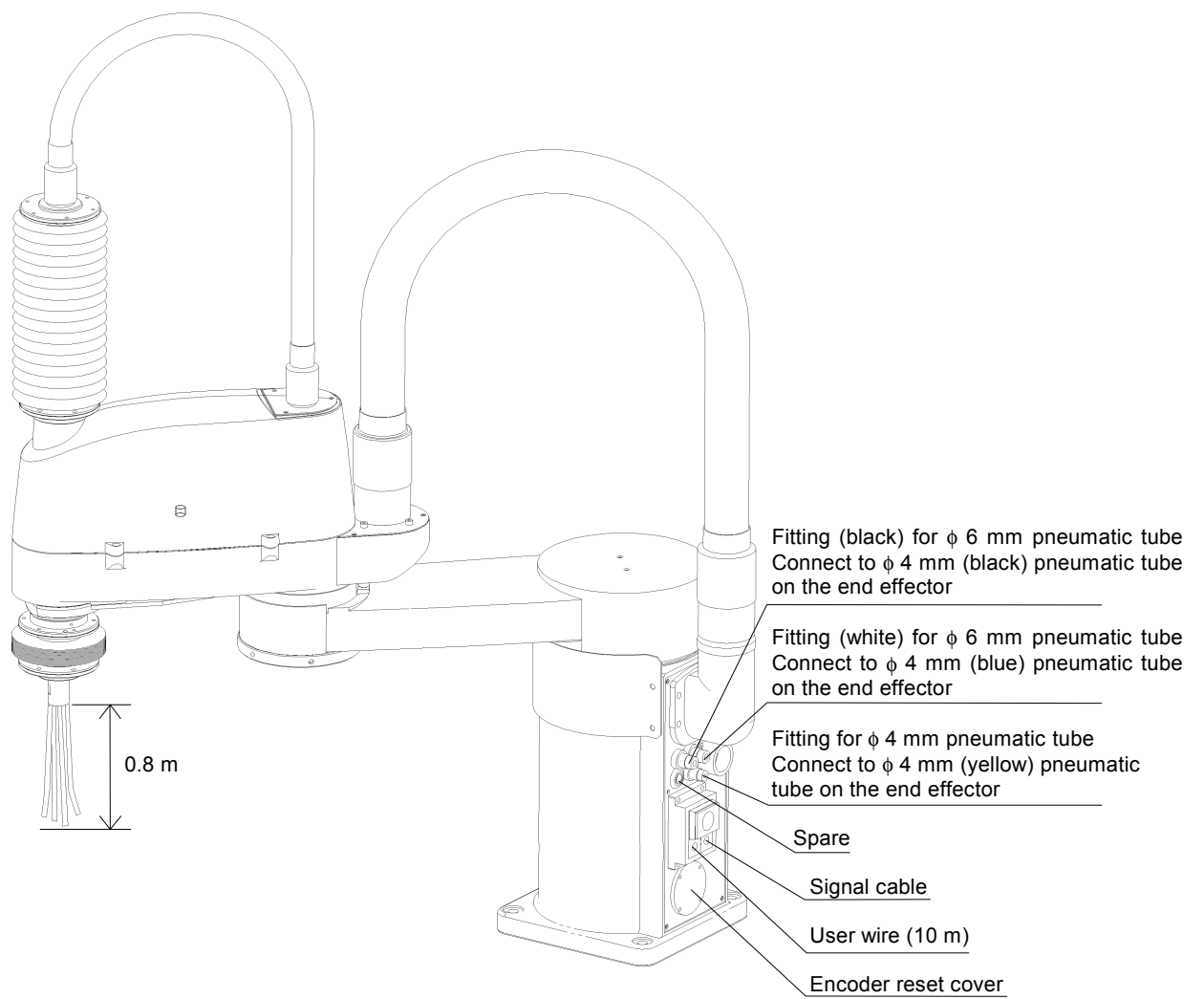
12.5 External dimensions

ES series Protected model [unit : mm]

(*) indicates the stroke margin by mechanical stop.

View A detail
(Calibration point position of Joint #3 & #4)
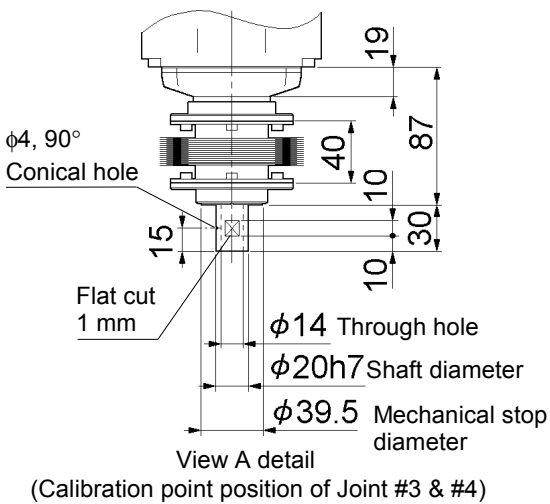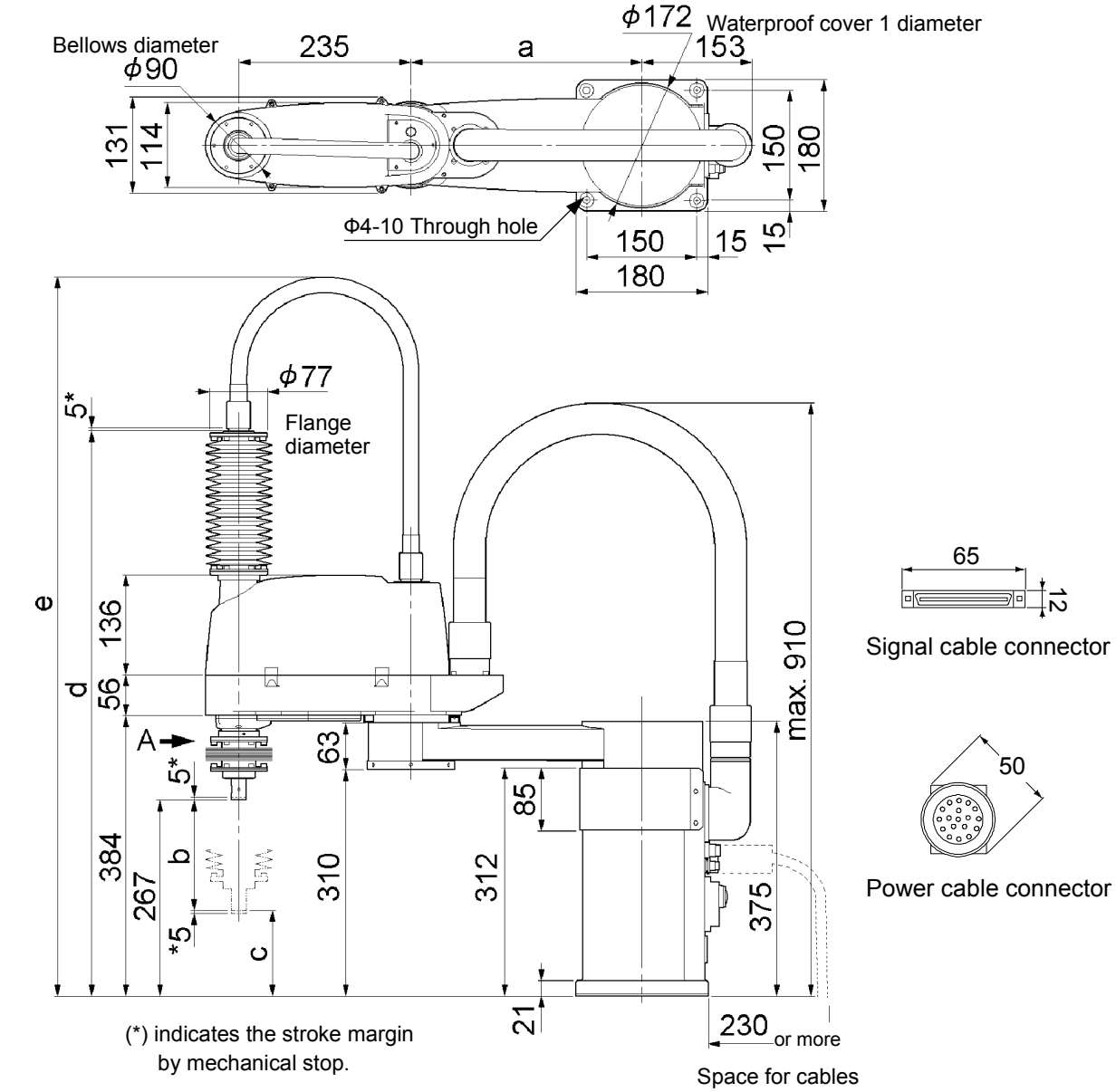
	ES45*P	ES55*P	ES65*P
a	215	315	415

	ES**1P	ES**3P
b	150	300
c	117	-33*
d	789	939
e	980	1130

* The shaft of ES**3P will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

EL series Protected model [unit : mm]

Bellows diameter

φ90

350   a   φ214 Waterproof cover 1 diameter   b

148 123

Φ4-16
Through hole

200 240

200   20   20

240

φ77
Flange diameter

5*

max. 1160   995   137

55

A

5*

405   288   300

12   *5

Duct support
(for EL853P only)

max. 950

78

316

318

85

21

396

230   or more

Space for cable

65

12

Signal cable connector

50

Power cable connector

(*) Indicates the stroke margin
by mechanical stop.

φ4, 90°
Conical hole

19

87

40

10

15

30

10

Flat cut
1 mm

φ14 Through hole

φ20h7 Shaft diameter

φ39.5 Mechanical stop diameter

View A detail
(Calibration point position of Joint #3 & #4)

	EL653P	EL853P
a	300	500
b	178	185 (including the duct support)

The shaft of EL**3P will reach lower than the bottom of the manipulator base when it is fully lowered. Pay attention to it when you design a layout.

12.6 Additional specifications

For standard specifications, refer to section *10. Specifications*.

The table below contains additional information about protected models.

Model	ES∗∗∗P	EL∗∗∗P
Max. motion range of Joint #3 Value in parentheses is optional	150 mm (300 mm)	300 mm
The specified grade of protection shielding	IP65	

Part 2
Maintenance

Part 2 contains maintenance information for the ES and EL Series Manipulators, including instructions for:

- Maintenance schedules
- Connection diagrams
- How to replace parts
- Calibration
- Parts list

Maintenance Safety Precautions

Please read this manual and other relevant manuals carefully before performing any routine maintenance.   Keep this manual in a handy location for easy access at all times.

*If the manipulator is a Protected model, refer to chapter *13. Protected Model Maintenance*.

⚠ WARNING

- Only trained personnel should be allowed to operate, test, and maintain this robot and the robot system.   Trained personnel are those who are certified trainees of company sponsored training courses (held on a regular basis) or those who have carefully read the manuals and have equivalent knowledge and skill.

- When you perform maintenance work or inspection of the robot, be sure to use the specified locking procedure for each robot system before starting work.

- When connecting or disconnecting the cables between the manipulator and the controller, make sure the power is turned off and pull out the power plug from the power source.   Failure to turn off the power can result in electric shock or malfunction.

- After replacing parts, do not test the manipulator within the safeguarded area.

- Before operation, make sure that emergency stop switches and safeguard switch function properly.

⚠ CAUTION

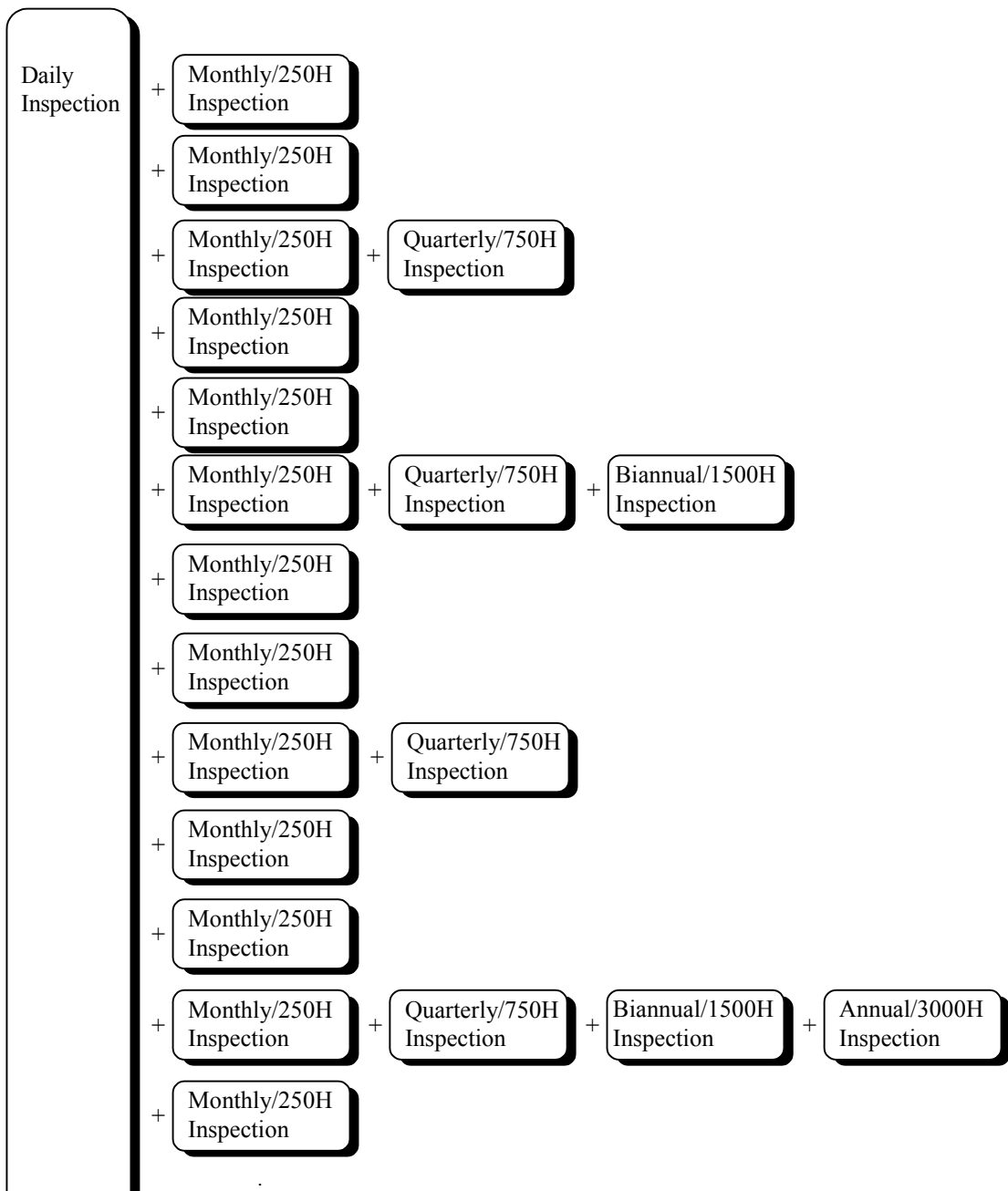- Please make sure the cables are connected properly.   Also, avoid putting heavy objects on the cables, bending the cables at extreme angles, or otherwise damaging the cables.   If the cables are damaged, the robot may function abnormally in a dangerous manner.

- Do not remove any parts or units that have no removal procedures in this manual.   Do not perform maintenance that is not specified in this manual.

---

1. General Maintenance

Proper inspection steps are essential to preventing trouble and maintaining safety.   This section describes maintenance inspection schedule and procedures. Be sure to perform inspection and maintenance as described in this chapter.

1.1 Maintenance Inspection Schedule

Inspection procedures are divided into five stages: daily, monthly, quarterly, biannually and annually.   However, if the robot is operated for 250 hours or longer per month, the inspection schedule is different.   In this case, each step of inspection should be added every 250 hours, 750 hours, 1500 hours, and 3000 hours operation.

Daily Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection + Quarterly/750H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection + Quarterly/750H Inspection + Biannual/1500H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection + Quarterly/750H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection

+ Monthly/250H Inspection + Quarterly/750H Inspection + Biannual/1500H Inspection + Annual/3000H Inspection

+ Monthly/250H Inspection

1.2 Inspections

Inspection while the power is OFF (Be sure to turn off the power)

Inspection item	Point of inspection	Daily	Monthly	Quarterly	Biannual	Annual
Grease condition	Refer to the next page					
Check looseness of bolts/screws and tighten them if necessary. (Follow the torque values in the table on the next page to tighten them.)	End effector installing bolts	O	O	O	O	O
	Manipulator installing bolts	O	O	O	O	O
	Each arm locking bolts	O	O	O	O	O
	Bolts and screws around shaft					O
	Bolts and screws which secure motors, reduction gears etc.					O
Check looseness of connectors. If looseness is found, plug it in securely, or tighten.	External connectors on manipulator (on the base connector plate)	O	O	O	O	O
	Manipulator cable unit		O	O	O	O
Visually check for external defect. Clean if necessary.	External appearance of manipulator	O	O	O	O	O
	External cables		O	O	O	O
Check a bend or improper position. Repair or place it properly.	Safeguard etc.	O	O	O	O	O
Check tension of timing belts. Tighten it if necessary.	Inside Arm #2				O	O

Inspection while the power is ON, or while manipulator is moving

Inspection item	Point of inspection	Daily	Monthly	Quarterly	Biannual	Annual
Check motion range	Motion range of each joint					○
Check disconnection by swinging cables.	External cables (including cable unit)				○	○
Check backlash by pushing arms during MOTOR ON condition.	Each arm					○
Check if any malfunctions occur or not; such as strange sound and vibration during robot operation.	Whole	○	○	○	○	○
Measure repeatability by gauge.	Repeatability					○

1.3 Lubrication

For this manipulator, reduction gears and ball screw spline shaft are used.

These parts require lubrication or replacing grease periodically. If lubrication is not done properly, and the manipulator is operated with insufficient grease, sliding parts will be damaged and the efficiency of the manipulator will be reduced. Once these parts are damaged, a lot of time and money will be required for repairs.

Only use the grease types specified in the following table.

Position	Joint #3	Joint #1 and #2
Greasing part	Ball screw spline shaft	Reduction gear unit
Greasing interval	First time: after 50 km operation 2nd or more: after 100 km operation	When replacing the motor[*]
Grease type	AFB grease (THK)	SK-1A (Harmonic Drive Systems)
Refer to:	The section *Greasing the Ball Screw Spline Unit* in *9. Replacing the Ball Screw Spline Unit*. If the manipulator is a Clean model, refer to chapter *11. Clean Model*. If the manipulator is a Protected model, refer to chapter *13. Protected Model*.	*6. Replacing the Reduction Gear Unit*.

[*] It is not necessary to change grease of the reduction gear periodically under normal condition, if the grease has been changed when replacing motor. However, in a case of severe working condition (such as high duty, high speed, large loading, etc.), change grease every 10,000 hours.

1.4 Tightening Torque of Bolts

Hexagon socket head cap bolts are used where mechanical strength is required in the manipulator. At the time of construction, these bolts are fastened at the tightening torques shown in the following table.

When additional tightening is necessary after inspection and when parts replacement is necessary, tighten the bolts with a torque wrench.

Bolts	Tightening torque	
M3	245 N·cm	(25 kgf·cm)
M4	490 N·cm	(50 kgf·cm)
M5	980 N·cm	(100 kgf·cm)
M6	1760 N·cm	(180 kgf·cm)
M8	3720 N·cm	(380 kgf·cm)
M10	7350 N·cm	(750 kgf·cm)
M12	12740 N·cm	(1300 kgf·m)

1.5 Matching mechanical and electrical origins

After replacing motors or reduction gears, the mechanical origin position does not match the electrical origin position.   Calibration is required to match these origin positions.   Refer to *11. Calibration*.

You need to record pulse values for a specific position for calibration.

Before replacing parts, move the manipulator to the point which you can check precision easily, then execute the PULSE/WHERE command and record the pulse values displayed.

RC+

```
>PULSE
```

```
PULSE  [J1 value] pls   [J2 value] pls   [J3 value] pls   [J4 value] pls
```

SPEL 95

Click the <DEBUG> button and input them to the [Command Execution] window as follows.   (Refer to the User's Guide for details of [Command Execution] window.)

```
>WHERE
pulse 1:[Joint #1 pulse value] 2:[Joint #2 pulse value] 3:[Joint #3 pulse value]
```

4:[Joint #4 pulse value]

300

```
>PULSE
```

      [Joint #1 pulse value]   [Joint #2 pulse value]

      [Joint #3 pulse value]   [Joint #4 pulse value]

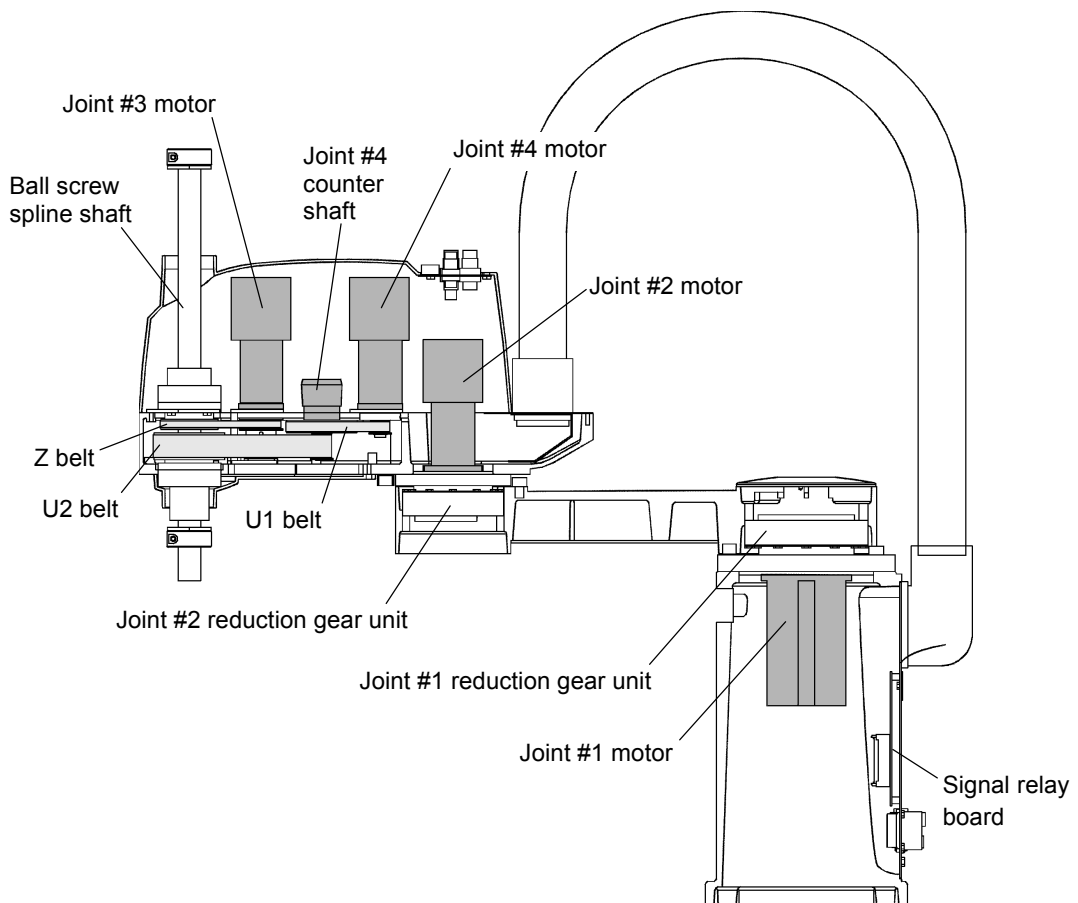## 1.6 Differences between ES and EL Series

Though the size of reduction gears and motors, and length of the arms for the ES series and EL series are different, the methods for maintenance are almost the same.

This chapter explains procedures using figures for the ES551S manipulator and describes the differences between the ES / EL series when needed.

1.7 Internal Layout

* If the manipulator is a Protected model, refer to chapter *13. Protected Model*.

The outline and name of internal configuration are shown below.

Joint #3 motor

Ball screw
spline shaft

Joint #4
counter
shaft

Joint #4 motor

Joint #2 motor

Z belt

U2 belt

U1 belt

Joint #2 reduction gear unit

Joint #1 reduction gear unit

Joint #1 motor

Signal relay
board

2. Opening the Covers

The methods for removing the various covers that are related to the maintenance of each part are explained here.

⚠ WARNING	■ Do not expose the manipulator to water or dust when you open the covers for maintenance. Invasion of water or dust may cause electric shock or malfunction.

* The covers for the Protected model are sealed with the main body of the manipulator to prevent moisture and dust. The seals will be torn when you remove the covers. Be sure to reseal the covers after you finish maintenance operations. For details on sealing the covers, refer to *13.2 Sealing the Manipulator* in *13. Protected Model*.

2.1 Arm Top Cover

The arm top cover can be opened by pulling upward after four bolts (ES: M4×8, EL: M4×12) are removed. It can not be removed completely, because user's wiring and piping are connected, but normal maintenance is possible.

ES:M4×8
EL:M4×12

Arm top cover
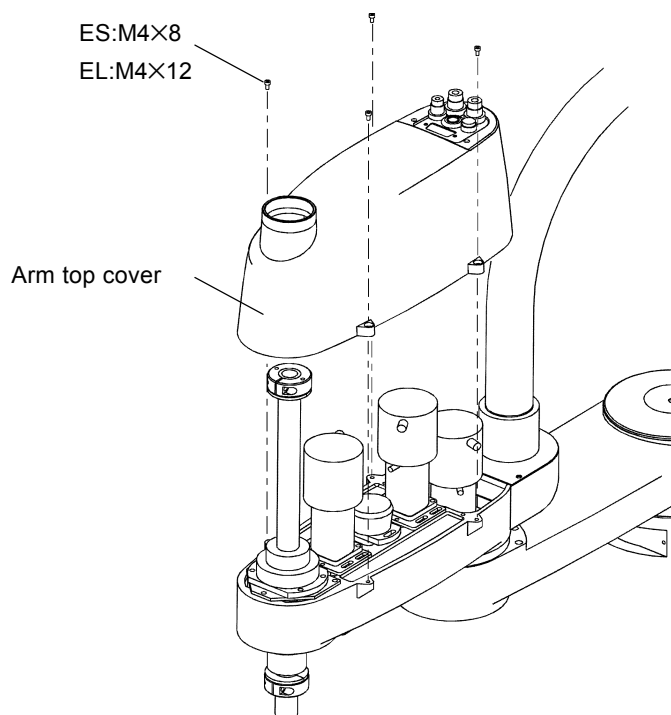
Be careful not to pinch cables when installing the cover. Do not bend these cables forcibly or push them into the cover. This can cause disconnection. Observe the cable locations during cover removal and wire the cables in their original locations during reassembly.

2.2 Arm Bottom Cover

The arm bottom cover is fastened to the lower position of Arm #2 with three bolts (M4×8). Remove these bolts, then pull the arm bottom cover downward. The cover may be unable to be removed when an end effector is installed. If there is no problem (e, g, inspection of timing belt), lower Joint #3 to the position shown in the figure below, in advance. Then loosen the bolts and remove the cover.

Arm bottom cover

M4×8
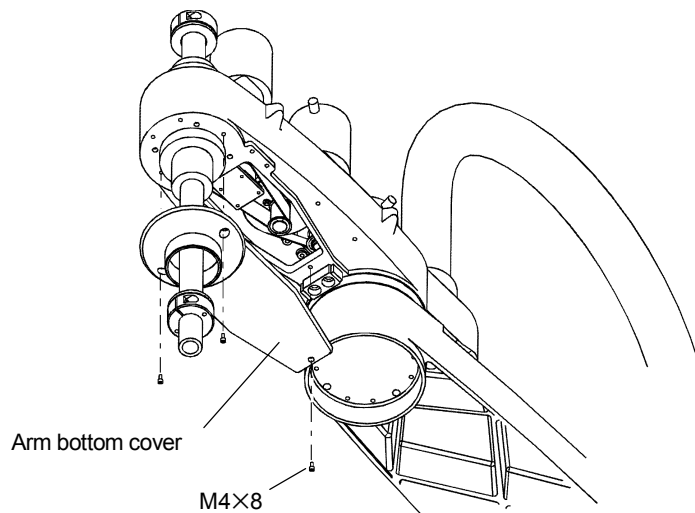
2.3 Joint #1 Cover

* If the manipulator is a Protected model, the waterproof cover 2 must be removed before removing Joint #1 cover. Refer to *Sealing* in chapter *13. Protected Model*.

The Joint #1 cover can be removed when the cover mounting bolt (M4×8) is removed.

M4×8

Joint #1 cover
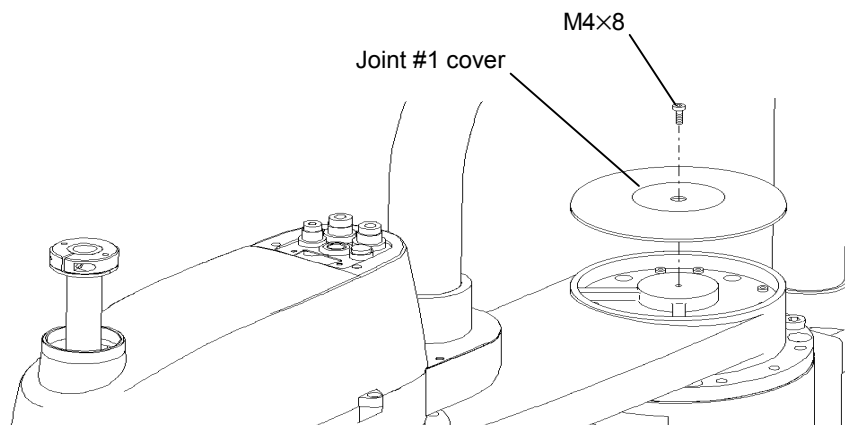
2.4 Base Connector Plate

The base connector plate is fastened to the rear panel of the manipulator with four M4×8 bolts (with six bolts for Protected model).

The base connector plate is separated from the base when these bolts are removed. However, the base connector plate is internally connected to connectors and ground wires. Be careful not to pull the base connector plate forcibly.
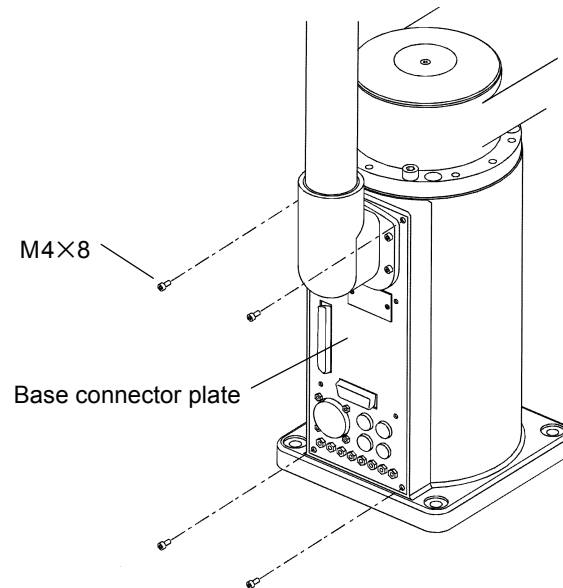
M4×8

Base connector plate

3. Replacing the Cable Unit

⚠ **WARNING**

- When connecting or disconnecting the cables, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in a robot may malfunction.

- When replacing the cable unit, remove the cable (the power cable, signal cable, and user wiring and piping) connected to the manipulator before replacing the cable unit.

NOTE
☞

As a preparation before turning OFF power, keep the manipulator ON for more than 30 minutes. This is necessary to charge the super-capacitor of each motor for retaining position data.

The charged motor can retain position data for about 2 hours when its cable is disconnected. (Motors whose serial number start with "0" can retain the data for about 2 days.)

Since the power is supplied to each motor from the lithium battery on the signal relay board via signal connector, the position data of the motor will be retained after the main power is turned OFF. However, when the signal connector is removed, the position data will only be retained by the super-capacitor.

The position data cannot be retained beyond the time duration mentioned above after which it will be lost. If this happens, errors will occur when the power is turned ON.

   RC+   : Error 5016

   SRC5**/SPEL 95   : Error 5016

   SRC-3**   : Error 195

In this case, calibration is necessary.

When exchanging the cable unit, it is necessary to reconnect the connectors inside the arm top cover and base. In doing so, refer to the wiring schematics in this chapter so that the connectors will be properly reconnected. Also, when reinstalling the new cables into the cover, carefully locate the cables, remembering how they were inside the cover before replacement, so that they will not be bent forcibly or pinched. If the cables are bent forcibly or pinched when reinstalling the cover, it may cause cable disconnection or such failures.

NOTE
☞

For the details of each connector and its connection, refer to chapter *4. Connector Pin Assignments*.

3.1 Cable Unit Replacement Procedure

*   * If the manipulator is a Protected model, refer to section *13.4 Replacing the Cable Unit* in the chapter *13. Protected Model Maintenance*.

Removal

(1) Turn OFF the PC Control Unit / Control Unit / Controller power.

(2) Disconnect all the connectors and tubes from the base connector plate located at the rear of the manipulator.

(3) Remove the four mounting bolts (M6×12) from the main cable elbow fitting.
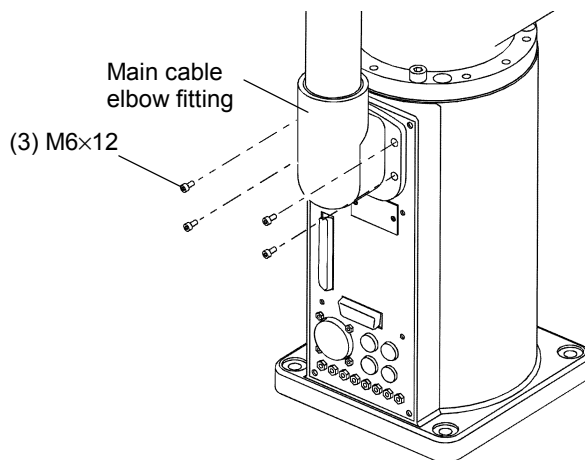
(4) Remove the mounting bolts from the base connector plate. Pull the cover forward (refer to chapter *2. Opening the Covers*). Be careful not to pull the base connector plate forcibly since the strain on the cables may cause wire disconnection. Also, remember the approximate cable arrangement so that the cables can be reconnected similarly during replacement.

(5) Cut off the wire tie inside the main cable elbow fitting.
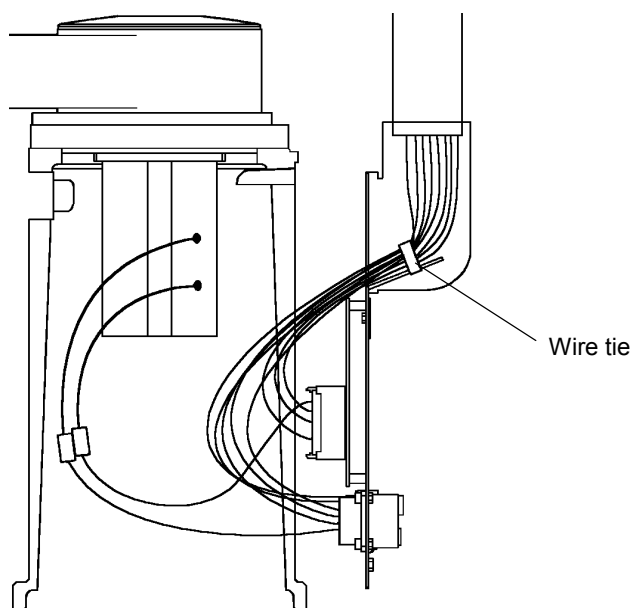
(6) Remove the four bolts (M3×8) from the receptacle and remove the receptacle from the base connector plate.
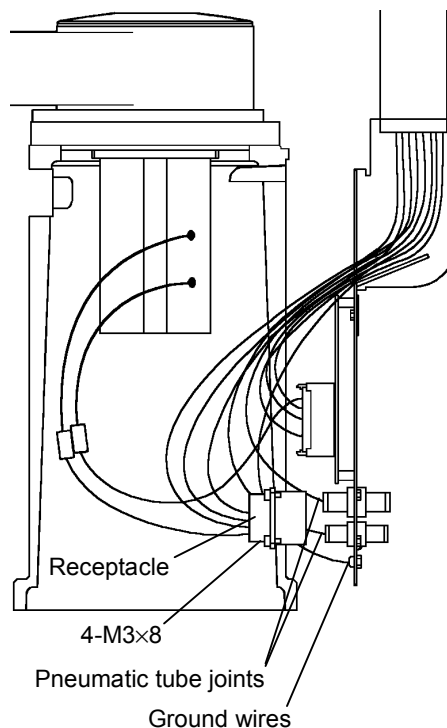
Receptacle

4-M3×8

Pneumatic tube joints

Ground wires

(7) Disconnect the ground wires and pneumatic tubes from the base connector plate. Each pneumatic tube can be pulled out by first pushing the fitting release ring. The ground wire terminals are fastened with bolts (M4×8).

(8) Open the arm top cover (refer to chapter *2. Opening the Covers*). Be careful not to pull the arm top cover off forcibly since the strain on the connected cables may cause wire disconnection. Also, pay attention to and remember the approximate cable arrangement so that the cables can be reconnected similarly after the unit replacement.

(9) Using either a spanner (double side 51mm wide) or pair of pliers, loosen the duct joint.
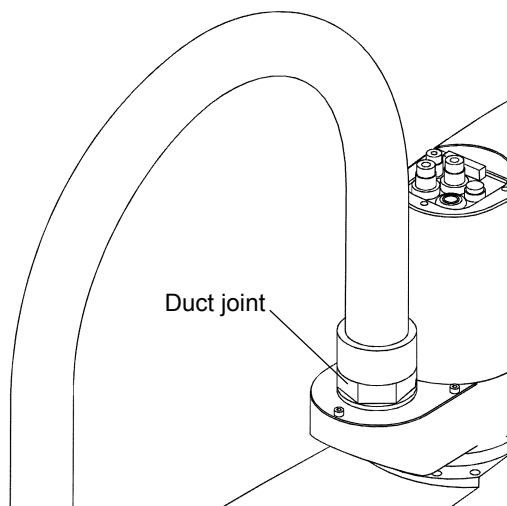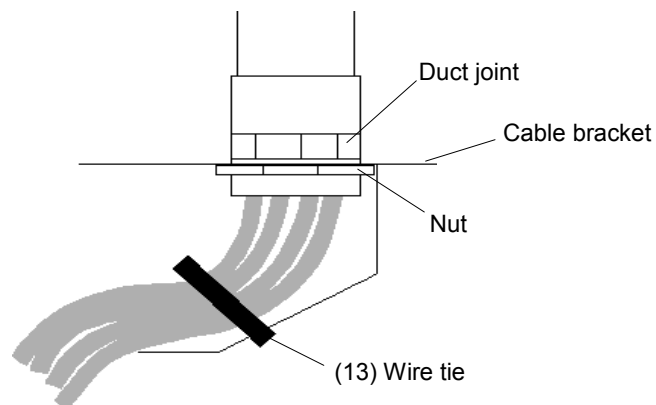
Duct joint

(10) Referring to the *Wiring Schematic 1* in this chapter, disconnect the ground wires and pneumatic tubes from the arm.   To disconnect each pneumatic tube, pull it out by first pushing the fitting release ring.   The ground wire terminals are secured by bolts (M4×8).

(11) Referring to the wiring schematics in this chapter, disconnect the connectors from the base and arm.   To disconnect the power connector, pull it out while pushing the presser tongue next to the connector number on the motor side.

NOTE

☞   For manipulators whose serial number start with "1," their motors must be connected to the signal relay board of the new cable unit within 2 hours.   Otherwise, the motor will lose the position data and it is necessary to calibrate again.

(12) Remove the cable bracket from the arm (3-M4×8 bolts).
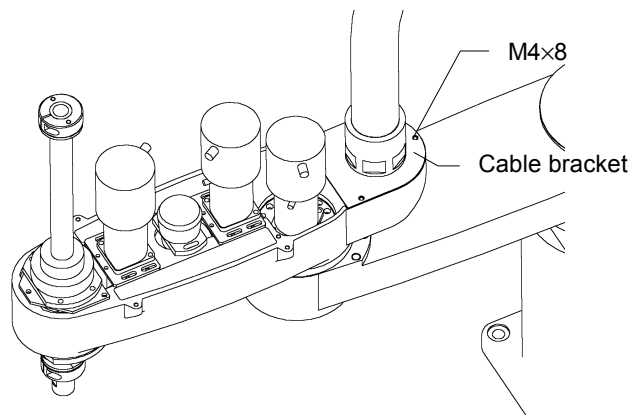
(13) Cut off the wire tie binding cables to the cable bracket.

(14) Remove the joint from the nut.   Pull the cables out of the cable bracket and nut.   The nut is hitting the back of the cable bracket at the corner, preventing it self from rotating.

(15) If there are any wire ties binding the cables, cut them off.   Remove the cable unit.

Installation

(1) Pass the cables of the new cable unit through the cable bracket and nut. Fasten the duct joint to the cable bracket.

(2) Pass the cables through the base connector plate and fasten the main cable elbow fitting using four bolts (M6×12).

(3) Referring to the wiring schematics in the following pages, connect the connectors properly.
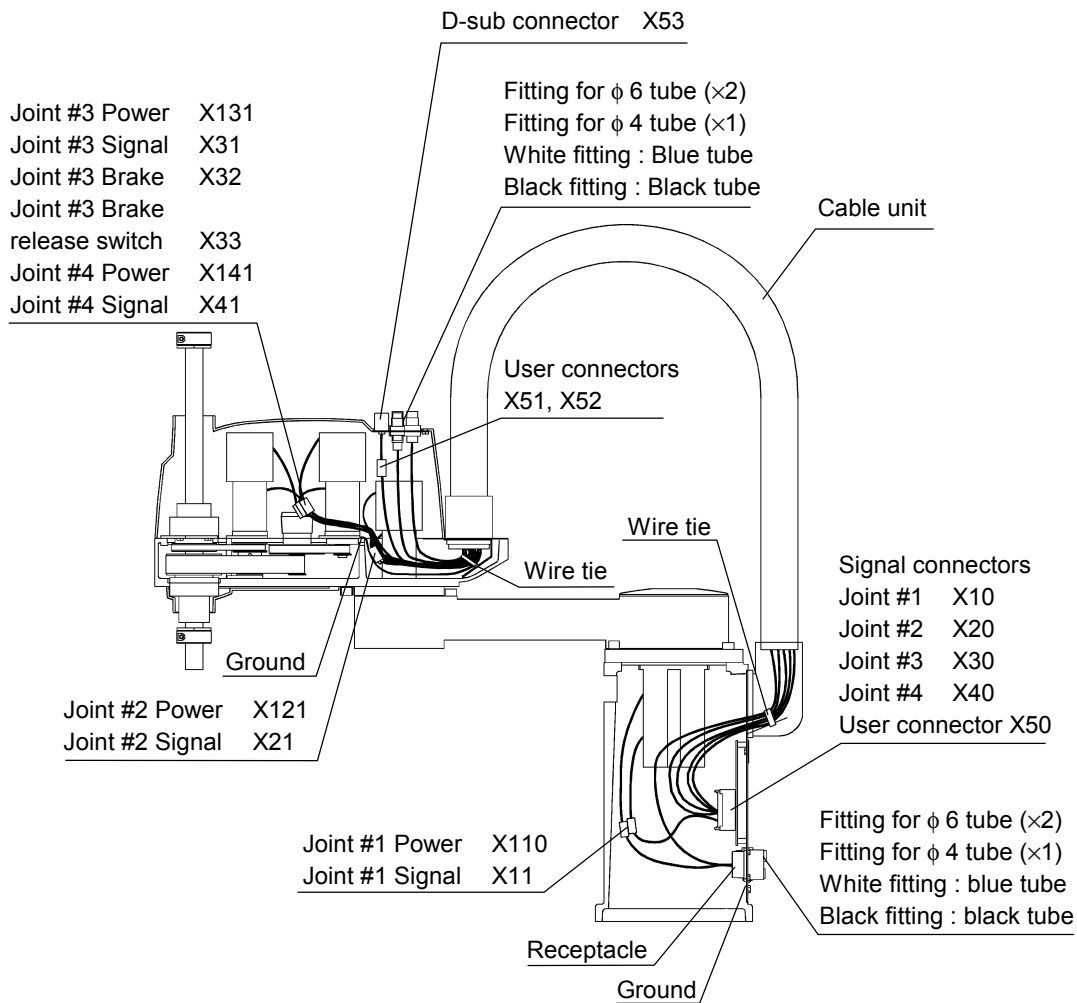
⚠ CAUTION	■ Connect the signal cable securely. Do not put anything heavy on the signal cable or bend it too much. This may damage the signal cable. If abnormality occurs in the signal cable, the robot may malfunction.

(4) Referring to the *Wiring Schematic 1* in the next page, connect the ground wires and pneumatic tubes properly.

(5) Mount the receptacle on the base connector plate using four bolts (M3×8).

(6) Bind the cables with wire ties as they were before the unit replacement. The following must be paid attention to when binding the cables with a wire tie:
   ◆ The cables must not touch the pulley, timing belt or other movable parts or areas.
   ◆ Do not pinch the cables when closing the cover.
   ◆ Do not allow unnecessary strain on the cables. The cables must be arranged as such so that they will not be forcibly bent. Unnecessary strain on the cables may cause wire disconnection inside.
   ◆ The cables inside the duct must be long enough so that the cables will not be pulled.

(7) Attach the cable bracket to the arm using three bolts (M4×8).

(8) Fasten the duct joint using a spanner (double side 51mm wide) or a pair of pliers.

(9) Place the base connector plate back to where it was and fasten it.

(10) Reinstall the arm top cover to complete the reassembly.

3.2 Wiring Schematic 1

To remove the cable unit, remove the connectors in the arm top cover and base. These connectors are connected as shown in the figure below. For more information, refer to the next page and the wiring list in *4. Connector Pin Assignments*.

* If the manipulator is a Protected model, refer to chapter *13. Protected Model Maintenance*.

D-sub connector   X53

Fitting for ϕ 6 tube (×2)
Fitting for ϕ 4 tube (×1)
White fitting : Blue tube
Black fitting : Black tube

Cable unit

Joint #3 Power   X131
Joint #3 Signal   X31
Joint #3 Brake   X32
Joint #3 Brake
release switch   X33
Joint #4 Power   X141
Joint #4 Signal   X41

User connectors
X51, X52

Wire tie

Wire tie

Ground

Signal connectors
Joint #1   X10
Joint #2   X20
Joint #3   X30
Joint #4   X40
User connector X50

Joint #2 Power   X121
Joint #2 Signal   X21

Joint #1 Power   X110
Joint #1 Signal   X11

Fitting for ϕ 6 tube (×2)
Fitting for ϕ 4 tube (×1)
White fitting : blue tube
Black fitting : black tube

Receptacle

Ground

3.3 Wiring Schematic 2

* If the manipulator is a Protected model, refer to chapter *13. Protected Model*.
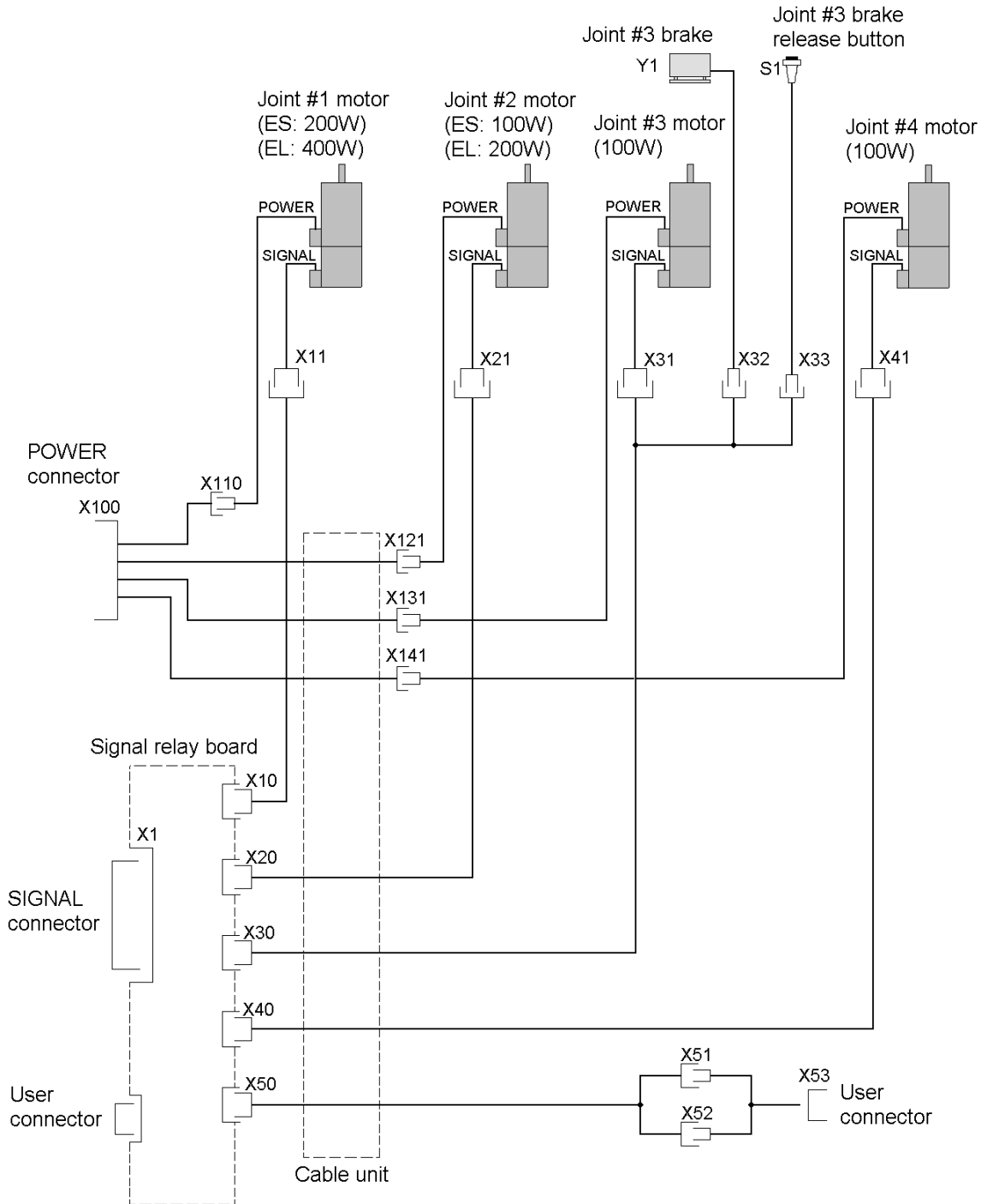
4. Connector Pin Assignments

X10 Signal connector

No.		Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	1A	BLU/(WHT)	X11-1
2B	$1\overline{A}$	WHT/(BLU)	X11-2
3A	1B	YLW/(WHT)	X11-3
3B	$1\overline{B}$	WHT/(YLW)	X11-4
4A	1Z	GRN/(WHT)	X11-5
4B	$1\overline{Z}$	WHT/(GRN)	X11-6
5A	1S *	RED/(WHT)	X11-7
5B	$1\overline{S}$ *	WHT/(RED)	X11-8
6A	ENC+5V	PPL/(WHT)	X11-12
6B	EGND	WHT/(PPL)	X11-13
7A	BAT+	BLU/(BRN)	X11-9
7B	BAT–	BRN/(BLU)	X11-10
8A	RES	YLW/(BRN)	X11-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X11 Motor signal connector

No.		Line color	Connect to
1	$1\overline{A}$	BLU/(WHT)	
2	1A	WHT/(BLU)	
3	$1\overline{B}$	YLW/(WHT)	
4	1B	WHT/(YLW)	
5	$1\overline{Z}$	GRN/(WHT)	
6	1Z	WHT/(GRN)	
7	$1\overline{S}$ *	RED/(WHT)	Joint #1
8	1S *	WHT/(RED)	motor
9	BAT+	BLU/(BRN)	encoder
10	BAT–	BRN/(BLU)	(SIGNAL)
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for the manipulators whose Serial
   number starts with "1" does not have
   S-channel signal.

X20 Signal connector

	No.	Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	2A	BLU/(WHT)	X21-1
2B	2$\overline{A}$	WHT/(BLU)	X21-2
3A	2B	YLW/(WHT)	X21-3
3B	2$\overline{B}$	WHT/(YLW)	X21-4
4A	2Z	GRN/(WHT)	X21-5
4B	2$\overline{Z}$	WHT/(GRN)	X21-6
5A	2S *	RED/(WHT)	X21-7
5B	2$\overline{S}$ *	WHT/(RED)	X21-8
6A	ENC+5V	PPL/(WHT)	X21-12
6B	EGND	WHT/(PPL)	X21-13
7A	BAT+	BLU/(BRN)	X21-9
7B	BAT-	BRN/(BLU)	X21-10
8A	RES	YLW/(BRN)	X21-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X21 Motor signal connector

	No.	Line color	Connect to
1	2A	BLU/(WHT)	
2	2$\overline{A}$	WHT/(BLU)	
3	2B	YLW/(WHT)	
4	2$\overline{B}$	WHT/(YLW)	
5	2Z	GRN/(WHT)	
6	2$\overline{Z}$	WHT/(GRN)	Joint #2
7	2S *	RED/(WHT)	motor
8	2$\overline{S}$ *	WHT/(RED)	encoder
9	BAT+	BLU/(BRN)	(SIGNAL)
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for the manipulators whose Serial
   number starts with "1" does not have
   S-channel signal.

X30 Signal connector

	No.	Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	3A	BLU/(WHT)	X31-1
2B	3$\overline{A}$	WHT/(BLU)	X31-2
3A	3B	YLW/(WHT)	X31-3
3B	3$\overline{B}$	WHT/(YLW)	X31-4
4A	3Z	GRN/(WHT)	X31-5
4B	3$\overline{Z}$	WHT/(GRN)	X31-6
5A	3S *	RED/(WHT)	X31-7
5B	3$\overline{S}$ *	WHT/(RED)	X31-8
6A	ENC+5V	PPL/(WHT)	X31-12
6B	EGND	WHT/(PPL)	X31-13
7A	BAT+	BLU/(BRN)	X31-9
7B	BAT -	BRN/(BLU)	X31-10
8A	RES	YLW/(BRN)	X31-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	BRK.SW	BRN/(YLW)	X33-2
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	$\overline{EMB2}$	GRN/(BRN)	X31-2
12B	+24V	BRN/(GRN)	X32-2
13A	N.C.		
13B	N.C.		

X31 Motor signal connector

	No.	Line color	Connect to
1	3A	BLU/(WHT)	
2	3$\overline{A}$	WHT/(BLU)	
3	3B	YLW/(WHT)	
4	3$\overline{B}$	WHT/(YLW)	
5	3Z	GRN/(WHT)	
6	3$\overline{Z}$	WHT/(GRN)	
7	3S *	RED/(WHT)	Joint #3
8	3$\overline{S}$ *	WHT/(RED)	motor
9	BAT+	BLU/(BRN)	encoder
10	BAT -	BRN/(BLU)	(SIGNAL)
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

X32 brake connector

	No.	Line color	Connect to
1	$\overline{EMB2}$	GRN/(BRN)	Joint #3
2	+24V	BRN/(GRN)	brake (Y1)

X33 brake SW connector

	No.	Line color	Connect to
1	$\overline{EMB2}$	GRN	Joint #3 brake
2	BRK.SW	BRN/(YLW)	release button (S1)

* Motor for the manipulators whose Serial number starts with "1" does not have S-channel signal.

X40 Signal connector

	No.	Line color	Connect to
1A	FGND	GRN	shield
1B	N.C.		
2A	4A	BLU/(WHT)	X41-1
2B	4$\overline{\text{A}}$	WHT/(BLU)	X41-2
3A	4B	YLW/(WHT)	X41-3
3B	4$\overline{\text{B}}$	WHT/(YLW)	X41-4
4A	4Z	GRN/(WHT)	X41-5
4B	4$\overline{\text{Z}}$	WHT/(GRN)	X41-6
5A	4S　　*	RED/(WHT)	X41-7
5B	4$\overline{\text{S}}$　　*	WHT/(RED)	X41-8
6A	ENC+5V	PPL/(WHT)	X41-12
6B	EGND	WHT/(PPL)	X41-13
7A	BAT+	BLU/(BRN)	X41-9
7B	BAT-	BRN/(BLU)	X41-10
8A	RES	YLW/(BRN)	X41-11
8B	N.C.		
9A	N.C.		
9B	N.C.		
10A	N.C.		
10B	N.C.		
11A	N.C.		
11B	N.C.		
12A	N.C.		
12B	N.C.		
13A	N.C.		
13B	N.C.		

X41 Motor signal connector

	No.	Line color	Connect to
1	4A	BLU/(WHT)	
2	4$\overline{\text{A}}$	WHT/(BLU)	
3	4B	YLW/(WHT)	
4	4$\overline{\text{B}}$	WHT/(YLW)	
5	4Z	GRN/(WHT)	
6	4$\overline{\text{Z}}$	WHT/(GRN)	Joint #4
7	4S　　*	RED/(WHT)	motor
8	4$\overline{\text{S}}$　　*	WHT/(RED)	encoder
9	BAT+	BLU/(BRN)	(SIGNAL)
10	BAT-	BRN/(BLU)	
11	RES	YLW/(BRN)	
12	ENC+5V	PPL/(WHT)	
13	EGND	WHT/(PPL)	
14	FGND	GRN	

* Motor for manipulators whose Serial
  number starts with "1" does not have
  S-channel signal.

X50 Signal connector

	No.	Line color	Connect to
1A		BLU/(WHT)	X51-1
1B		WHT/(BLU)	X51-2
2A		YLW/(WHT)	X51-3
2B		WHT/(YLW)	X51-4
3A		GRN/(WHT)	X51-5
3B		WHT/(GRN)	X51-6
4A		RED/(WHT)	X51-7
4B		WHT/(RED)	X51-8
5A		PPL/(WHT)	X51-9
5B		WHT/(PPL)	X51-10
6A		BLU/(BRN)	X52-1
6B		BRN/(BLU)	X52-2
7A		YLW/(BRN)	X52-3
7B		BRN/(YLW)	X52-4
8A		GRN/(BRN)	X52-5
8B		GRN	shield

X51 Signal connector

	No.	Line color	Connect to
1		BLU/(WHT)	X53-1
2		WHT/(BLU)	X53-2
3		YLW/(WHT)	X53-3
4		WHT/(YLW)	X53-4
5		GRN/(WHT)	X53-5
6		WHT/(GRN)	X53-6
7		RED/(WHT)	X53-7
8		WHT/(RED)	X53-8
9		PPL/(WHT)	X53-9
10		WHT/(PPL)	X53-10

X52 Signal connector

	No.	Line color	Connect to
1		BLU/(BRN)	X53-11
2		BRN/(BLU)	X53-12
3		YLW/(BRN)	X53-13
4		BRN/(YLW)	X53-14
5		GRN/(BRN)	X53-15
6		GRN	shield

X100 Receptacle

	No.	Line color	Connect to
1	1U	BLK	X110-1
3	1V	WHT	X110-2
6	1W	RED	X110-3
10	2U	BLK	X121-1
14	2V	WHT	X121-2
16	2W	RED	X121-3
15	3U	BLK	X131-1
13	3V	WHT	X131-2
9	3W	RED	X131-3
4	4U	BLK	X141-1
2	4V	WHT	X141-2
7	4W	RED	X141-3
5	FGND	GRN	
17	FGND	GRN/YLW	
8	N.C.		
12	N.C.		
11	N.C.		

X110 Motor power connector

	No.	Line color	Connect to
1	1U	BLK	Joint #1 motor (POWER)
2	1V	WHT	
3	1W	RED	
4	FGND	GRN/YLW	

X121 Motor power connector

	No.	Line color	Connect to
1	2U	BLK	Joint #2 motor (POWER)
2	2V	WHT	
3	2W	RED	
4	FGND	GRN/YLW	

X131 Motor power connector

	No.	Line color	Connect to
1	3U	BLK	Joint #3 motor (POWER)
2	3V	WHT	
3	3W	RED	
4	FGND	GRN/YLW	

X141 Motor power connector

	No.	Line color	Connect to
1	4U	BLK	Joint #4 motor (POWER)
2	4V	WHT	
3	4W	RED	
4	FGND	GRN/YLW	

5. Replacing the Motors

⚠ WARNING	■ Only trained personnel should be allowed to maintain this unit. ■ When replacing the motors, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock and malfunction.

⚠ CAUTION	■ Be careful not to apply an excessive shock to the motor shaft when replacing a motor. This may shorten the life of the motor and encoder. This also may destroy them. ■ Never disassemble the motor and encoder. If you do, a position shift will occur. The motor and encoder cannot be used again in this case.

> NOTE ☞ The mechanical origin position changes when the motor is replaced. As a result, the previous teach points change. After motor replacement, adjust the origin position as described in Chapter *11. Calibration*.

Motor Types

Specify the Z code when ordering a replacement motor.

Description	Series	Joint	Specification	Serial number	Old code	New code
AC servo motor	ES	#1	200W-ABS	0****	ZA000614	R13ZA00061400
				1****	ZA000625	R13ZA00062500
		#2, 3, 4	100W-ABS	0****	ZA000613	R13ZA00061300
				1****	ZA000624	R13ZA00062400
	EL	#1	400W-ABS	0****	ZA000615	R13ZA00061500
				1****	ZA000626	R13ZA00062600
		#2	200W-ABS	0****	ZA000614	R13ZA00061400
				1****	ZA000625	R13ZA00062500
		#3, 4	100W-ABS	0****	ZA000613	R13ZA00061300
				1****	ZA000624	R13ZA00062400

Motor Locations

Joint #4 countershaft

Joint #2 motor

Joint #3 motor

Joint #4 motor
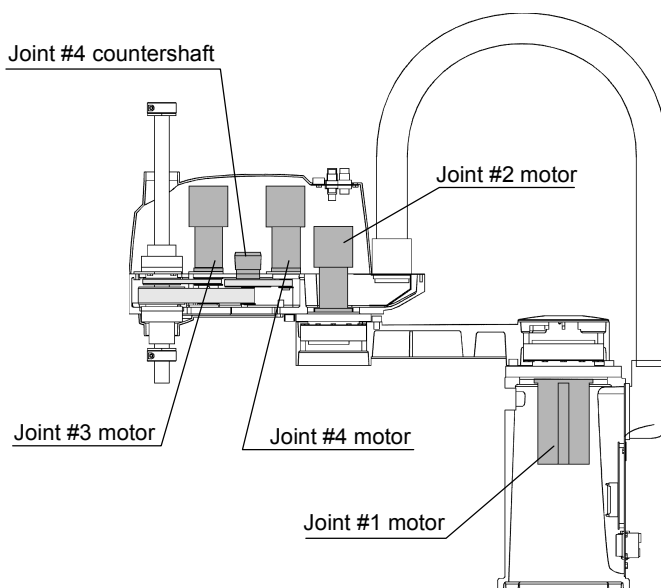
Joint #1 motor

5.1 Replacing the Joint #1 Motor

Removal : Joint #1

(1) Open the base connector plate. (Refer to *2. Opening the Covers*.)

(2) Remove the two bolts (2-M4×8) from the maintenance plate and remove the maintenance plate.

   ∗ If the manipulator is a Protected model, the waterproof cover 1 must be removed before removing the maintenance plate.   Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model*.

M4×8

Maintenance plate

Maintenance hole
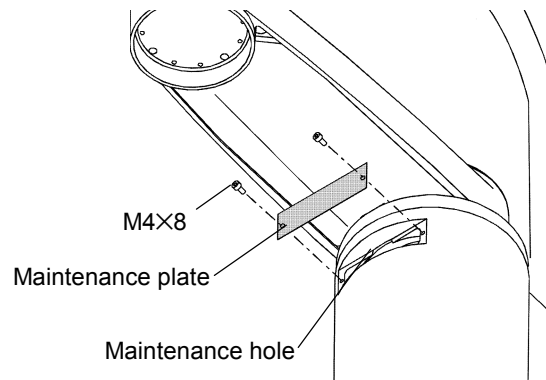
(3) Disconnect the connectors (X110 and X11).   To disconnect X110, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the four bolts (M4×15 for the ES series; M5×15 for the EL series) from the motor flange and pull the motor downward.   In this case, insert a hexagon head wrench from the maintenance hole and remove the two bolts at the maintenance hole side.   If it is difficult to extract the motor, extract it while moving Arm #1 slightly.
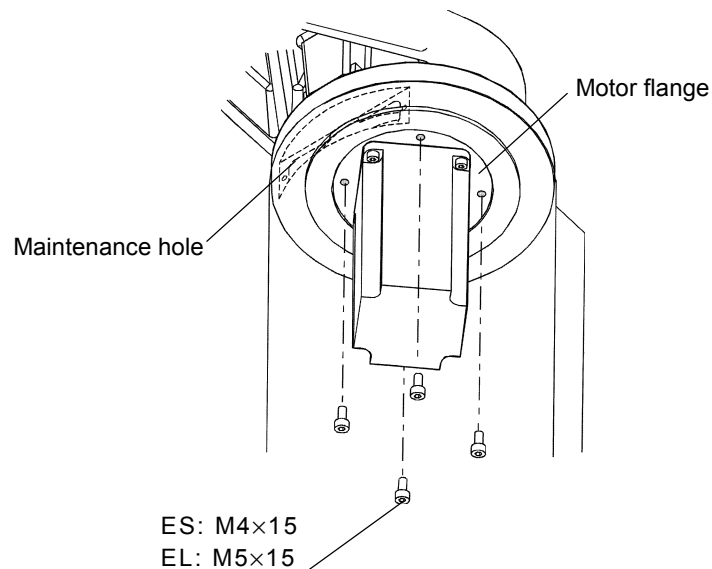
Motor flange

Maintenance hole

ES: M4×15
EL: M5×15

(5) Using a hexagon head wrench (2.5mm wide) in the screw holes of the waveform generator, remove the two flat point setscrews (M5×6). Remove the waveform generator from the motor. One of the setscrews has a brass bush inside which must not be lost.

Between the ES and EL series, the direction in which the waveform generator is attached is different.
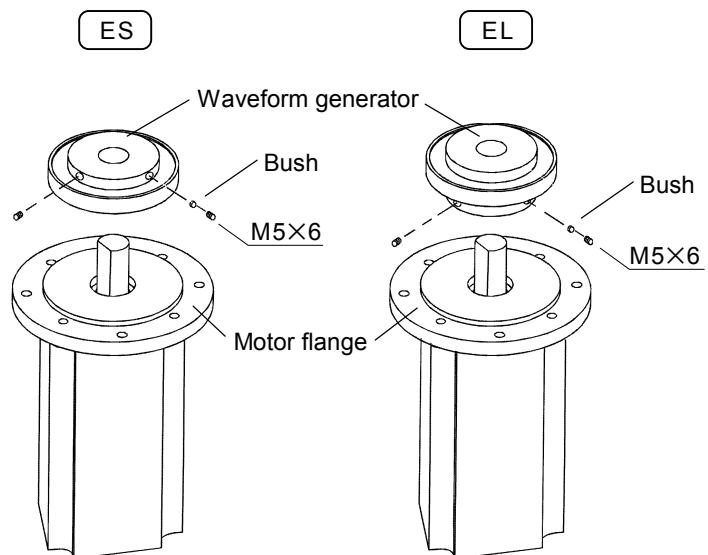
(6) Remove the four bolts (M5×12) from the motor and remove the motor flange.
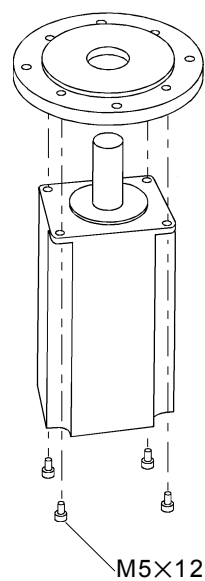
Installation : Joint #1

(1) Attach a new motor to the motor flange with four bolts (M5×12).

(2) Mount the waveform generator to the motor shaft with two flat point setscrews (M5×6). Match the end face of the waveform generator to the end face of the motor shaft. One of the setscrews should touch the flat side of the motor shaft perpendicularly. Insert a bush in the other setscrew hole and tighten the screw. Do not over tighten to avoid damage to the motor shaft.

NOTE
☞
For the ES and EL series manipulators, the direction in which the waveform generator is attached is different (See below). For ES, the setscrews should be located at the end of the motor shaft. For EL, the setscrews should be located at the mid-point of the motor shaft.

ES

Waveform generator

Bush

M5×6

Flat face

End face of motor shaft

Flat point setscrew

EL

Waveform generator

Bush

M5×6

Flat face

End face of motor shaft

Flat point setscrew
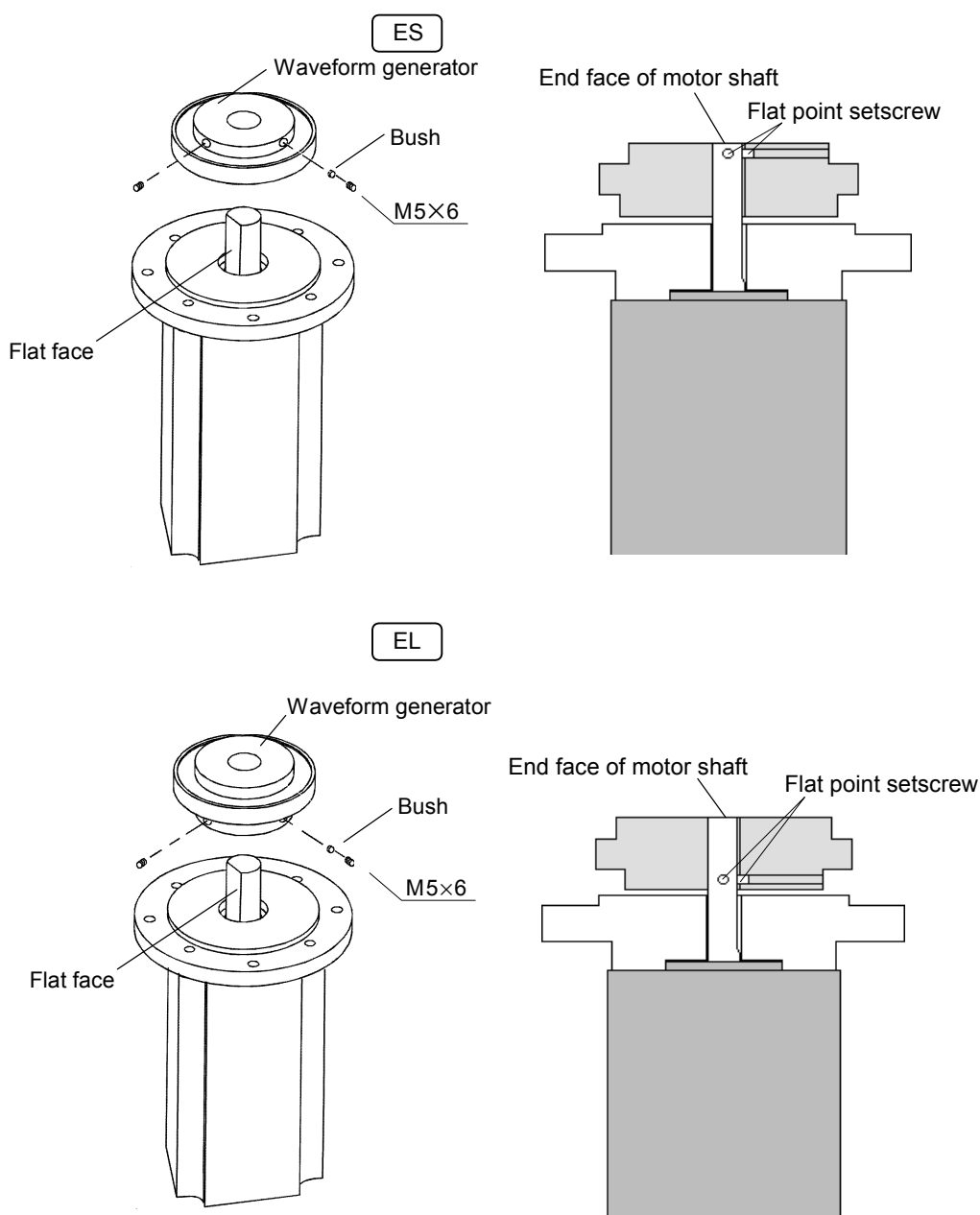
(3) Install the motor flange in the manipulator base with four bolts (M4×15 for the ES series; M5×15 for the EL series) so that the motor faces the main set by 45 degrees and the motor cable faces the base connector plate.   If the waveform generator does not fit into the arm easily, move Arm #1 slowly by hand while pushing the wave generator into place.   Insert a hexagon head wrench into the maintenance hole and tighten the two bolts at the maintenance hole side.
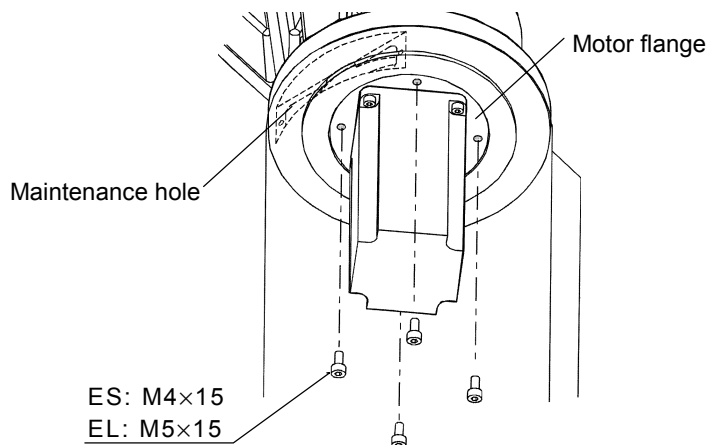
(4) Connect the connectors X110 and X11.
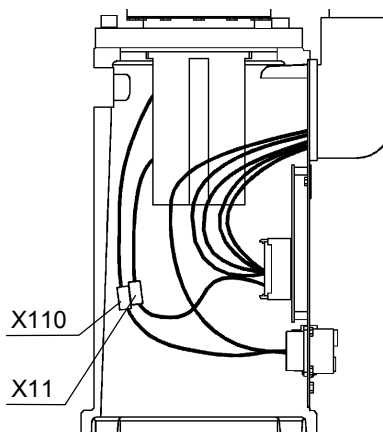
(5) Attach the maintenance plate with two bolts (M4×8).

   ∗ If the manipulator is a Protected model, the maintenance plate must be sealed and the waterproof cover 1 must be installed.   Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(6) Install the base connector plate.   (Refer to chapter *2. Opening the Covers*.)

   ∗ If the manipulator is a Protected model, seal the base connector plate.   Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(7) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #1.   (Refer to chapter *11. Calibration*.)

5.2 Replacing the Joint #2 Motor

Removal : Joint #2

(1) Remove the three bolts (M4×8) from the duct plate.
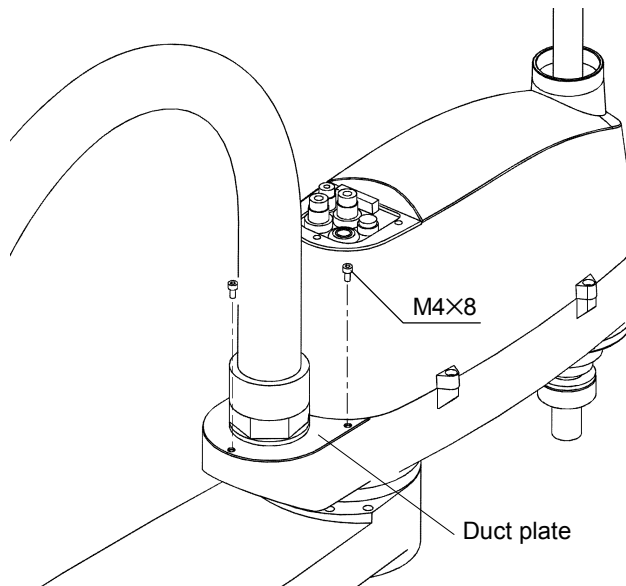
(2) Open the arm top cover.   (Refer to chapter *2. Opening the Covers*.)

(3) Cut off the wire ties which fasten the Joint #2 motor and cables.

(4) Disconnect the connectors, X121 and X21.   To disconnect X121, pull it out while pushing the presser tongue next to the connector number on the motor side.

(5) Remove the four bolts (M4×10 for the ES series; M4×15 for the EL series) from the motor flange and pull the motor unit upward.   If it is difficult to extract the motor, extract it while moving Arm #2 slightly.
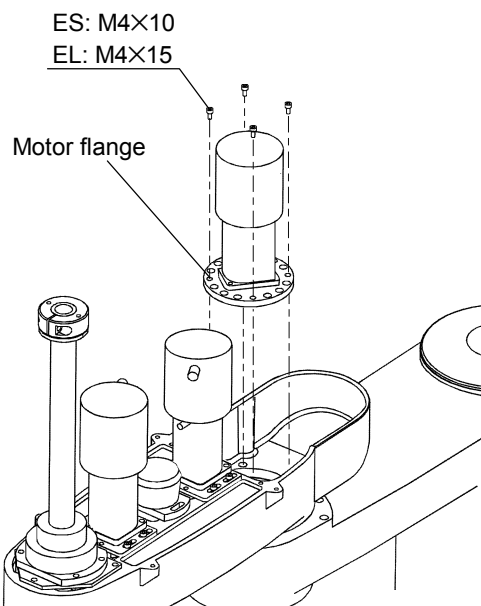
(6) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6 for the ES series; M5×6 for the EL series). Remove the waveform generator from the motor. One of the setscrew holes has a brass bush inside which must not be lost.
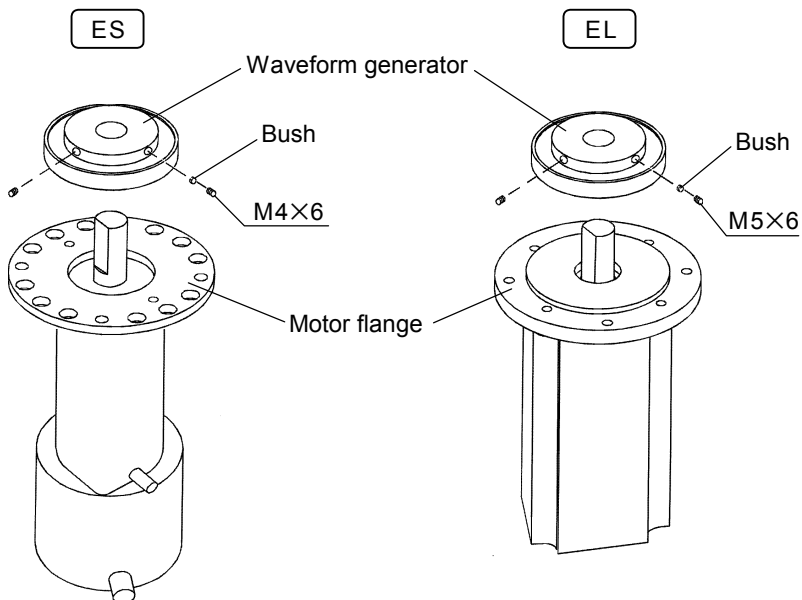
(7) Remove the bolts (2-M4×10 for the ES series; 4-M5×12 for the EL series) from the motor and remove the motor flange.
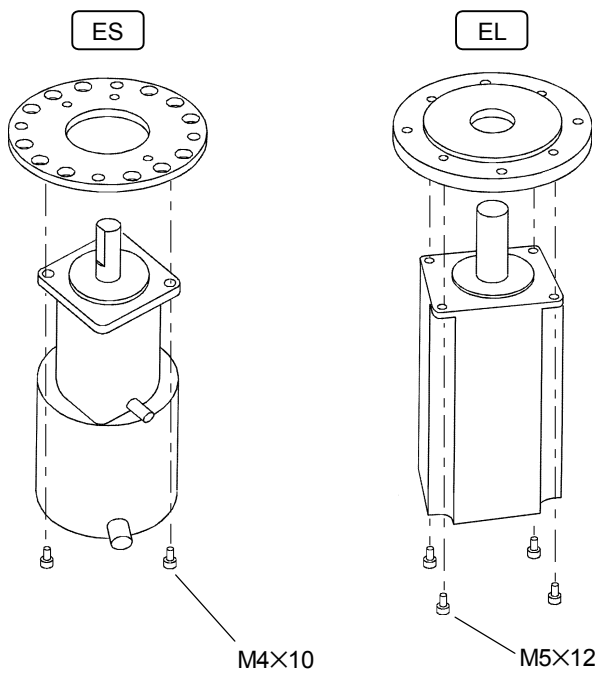
Installation : Joint #2

(1) Attach a new motor to the motor flange with bolts (2-M4×10 for the ES series; 4-M5×12 for the EL series).

(2) Mount the waveform generator to the motor shaft with two flat point setscrews (M4×6 for the ES series; M5×6 for the EL series). Match the end face of the waveform generator to the end face of the motor shaft. One of the setscrews should touch the flat side of the motor shaft perpendicularly. Insert a bush in the other setscrew hole and tighten the screw. Do not over tighten to avoid damage to the motor shaft.
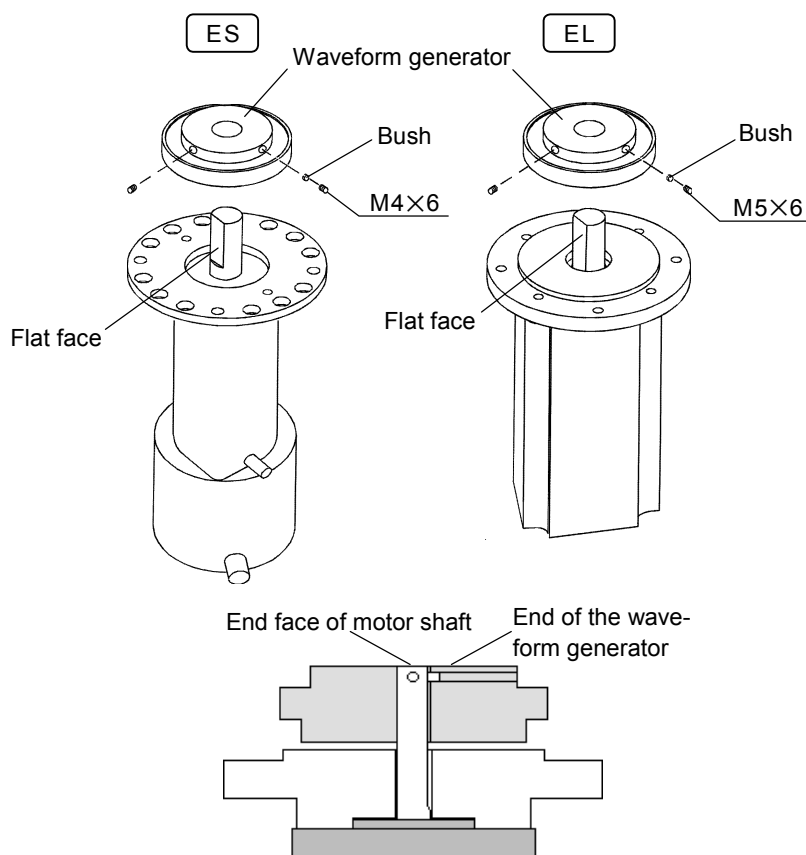
(3) Fasten the Joint #2 motor unit in Arm #2 with the four bolts (M4×10 for the ES series; M4×15 for the EL series). If the wave generator does not fit into the arm easily, move Arm #2 slowly by hand while pushing the waveform generator into place.
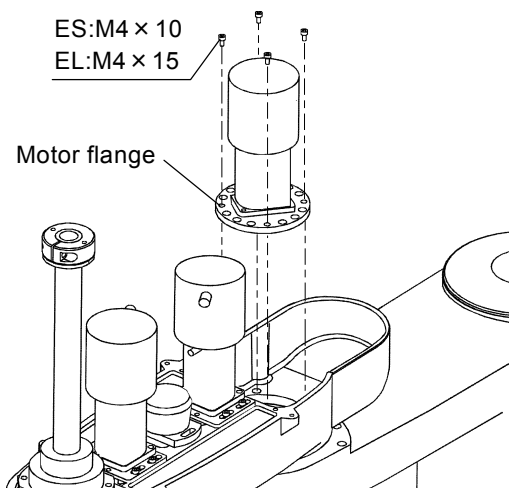
(4) Install the duct plate (3-M4×8).

* If the manipulator is a Protected model, seal the duct plate. Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

M4 × 8

Duct plate
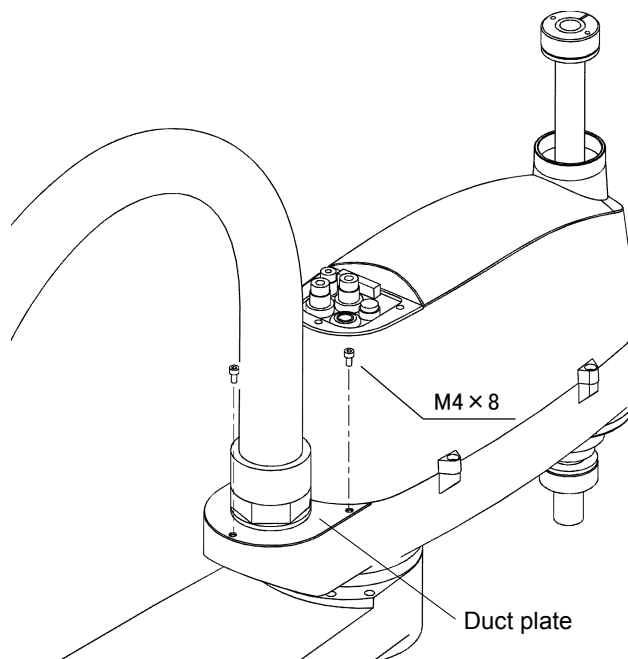
(5) Connect the connectors, X121 and X21.

(6) Fasten the motor cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(7) Install the arm top cover. Be careful not to bend the cables forcibly and push them into the cover. (Refer to chapter *2. Opening the Covers*).

* If the manipulator is a Protected model, seal the arm top cover. Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(8) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #2. (Refer to chapter *11. Calibration*.)

5.3 Replacing the Joint #3 Motor

⚠ CAUTION	■ A brake is provided for the Joint #3 motor. If the motor is replaced, it is necessary to adjust the brake, but be careful not to stretch the board spring of the brake. When removing the rotor hub from the body of the brake, don't pull in the joint direction. Always remove it from the side.

NOTE

☞ A brake is provided for the Joint #3 motor to prevent the end effector from moving down due to its own weight when the power is turned OFF or the motor is turned OFF. This brake will not work while the Joint #3 motor is being replaced. Therefore, lower Joint #3 to its lower limit in advance. Joint #3 operates while the Joint #3 brake release button is pushed with the power turned ON (See Figure 11 in the chapter *End Effectors* in Part 1.) Lower Joint #3, taking care that the end effector does not strike against peripheral equipment. Turn OFF the power before replacing the Joint #3 motor.

Removal : Joint #3

(1) Open the arm top cover and arm bottom cover. (Refer to chapter *2. Opening the Covers*.)

(2) Cut off the wire ties which fasten the Joint #3 motor and cables.

(3) Disconnect the connectors, X131, X31, and X32. To disconnect X131, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the four bolts (M4×10) from the motor plate and remove the pulley from the Z belt. Then, pull the Joint #3 motor unit upward.
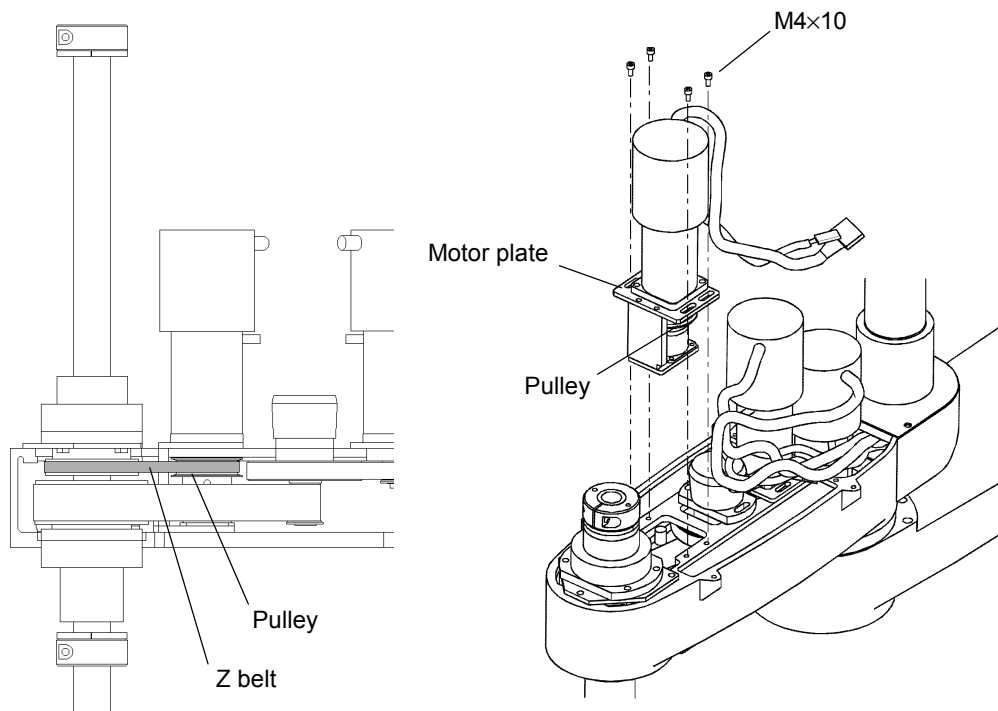
(5)   Cut off the wire ties which fasten the brake cable to the motor.

(6)   Using a hexagon head wrench in the screw holes of the pulley, remove the two flat point setscrews (M4×8) that secure the pulley to the motor shaft.   One of the setscrews has a brass bush inside which must not to be lost.

Bush

Pulley

M4×8
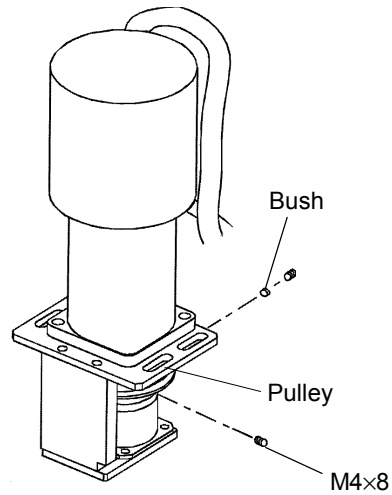
(7)   Remove the two bolts (M4×8) from the motor.   And extract the motor upward.

M4 × 8

Motor plate

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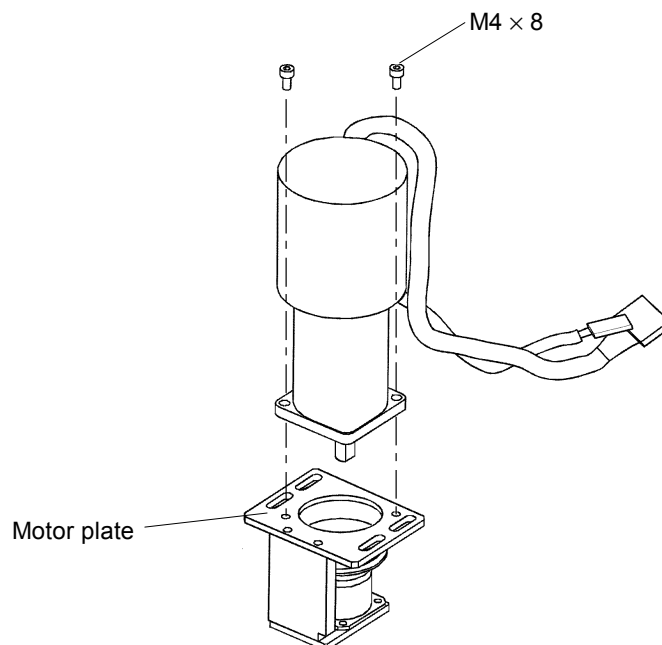
Installation : Joint #3

(1) Slide the pulley and rotor hub horizontally to remove them from the brake so as not to cause damage to the leaf spring. The rotor hub, which is screwed on the pulley, is attracted to the brake magnet.   If you force it to separate, the leaf spring will stretch.
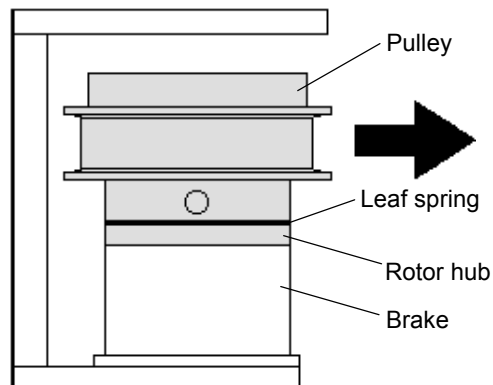
(2) Insert the gap gauge (0.15 mm) (which is mounted in the arm bottom cover between the brake and rotor hub), and set the pulley on the brake.   At this time, the screw holes of the pulley are in the position shown in the figure below.
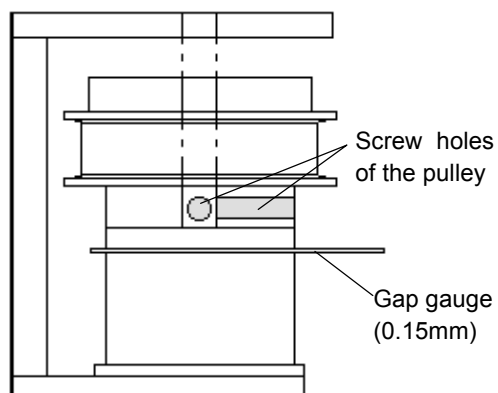
(3)   Place the new motor on the motor plate so that the motor cables turn to the direction of the figure and fasten it with two bolts (M4×8).   The direction of the motor shaft flat face should face one of the screw holes of the pulley.
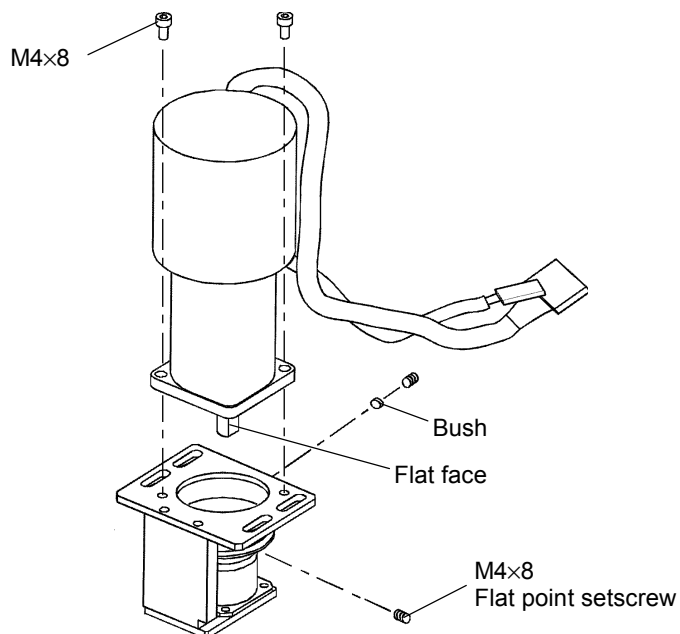
(4)   Secure the pulley to the motor shaft with two flat point setscrews (M4×8).   One of them should touch the flat face in the motor shaft perpendicularly.   Insert a bush to the other setscrew hole, then insert the setscrew and tighten it carefully to avoid damage to the motor shaft.

(5)   After the pulley is secured, pull out the gap gauge.

(6)   Fasten the brake cables to the motor unit to prevent interference with the pulley when installing the Joint #3 motor unit in Arm #2.

(7)   Place the Joint #3 motor unit in the arm.   The motor cables should be facing Joint #2.

(8) Place the Z belt around the Z1 and Z2 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip the Z belt from the pulleys while maintaining proper interval between the pulleys. Fasten the Joint #3 motor plate for the time being with four bolts (M4×10).
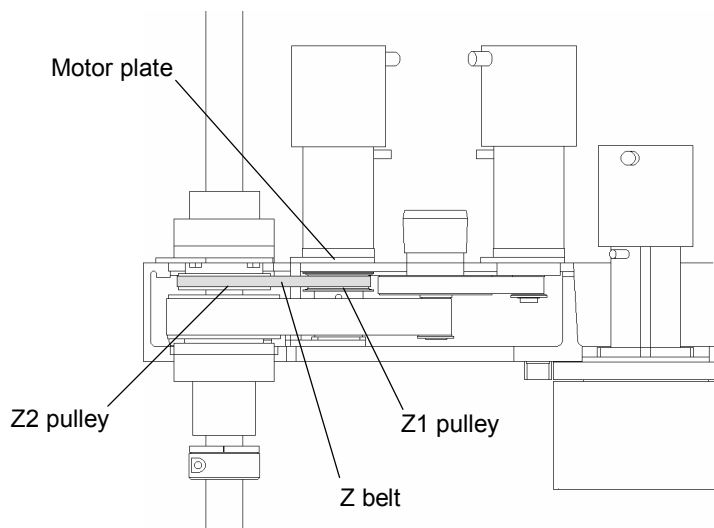
(9) Pass a cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (8) and pull the cord by a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf). Adjust in the range of 20N - 39N (2kgf - 4kgf).
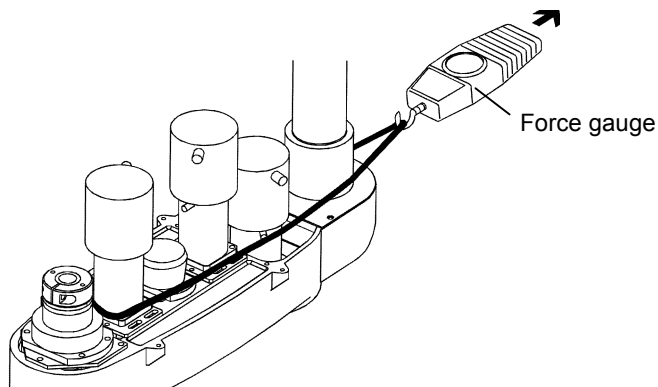
(10) Connect the connectors, X131, X31 and X32.

(11) Fasten the motor cables with wire ties in their original positions. Do not allow unnecessary stain on the cables.

(12) Install the arm top cover and arm bottom cover. (Refer to chapter *2. Opening the Covers*.)

(13) If the manipulator is a Protected model, seal the arm top cover and arm bottom covers. Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(14) The mechanical origin position and teach points will change when the motor is replaced. Be sure to calibrate Joint #3. (Refer to chapter *11. Calibration*.)

5.4 Replacing the Joint #4 Motor

Removal : Joint #4

(1) Open the arm top cover and arm bottom cover. (Refer to chapter *2. Opening the Covers*.)

(2) Cut off the wire ties which fasten the Joint #4 motor and cables.

(3) Disconnect connectors ,X141 and X41. To disconnect X141, pull it out while pushing the presser tongue next to the connector number on the motor side.

(4) Remove the four bolts (M4×10) from the motor plate. And remove the pulley from the U1 belt to remove the Joint #4 motor unit from the arm.
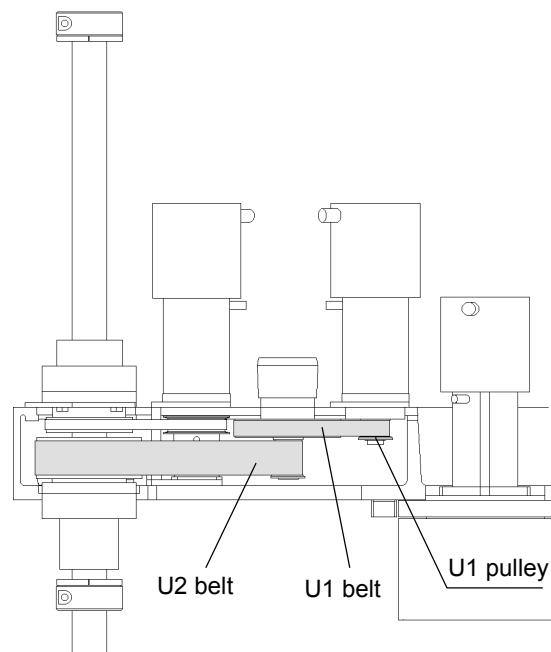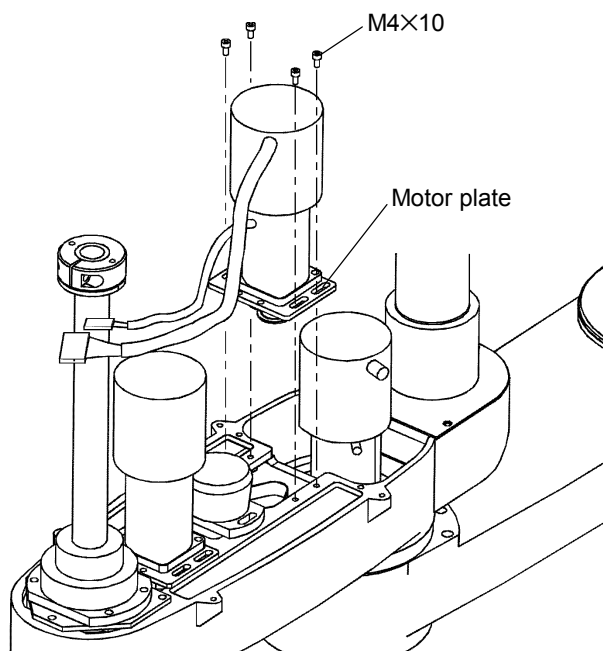
(5) Using a hexagon head wrench in the screw holes of the pulley, remove the two flat point setscrews (M4×8) that secure the pulley to the motor shaft. Remove the pulley from the motor. One of the setscrews has a brass bush inside which must not to be lost.

Bush

M4×8 flat point setscrew
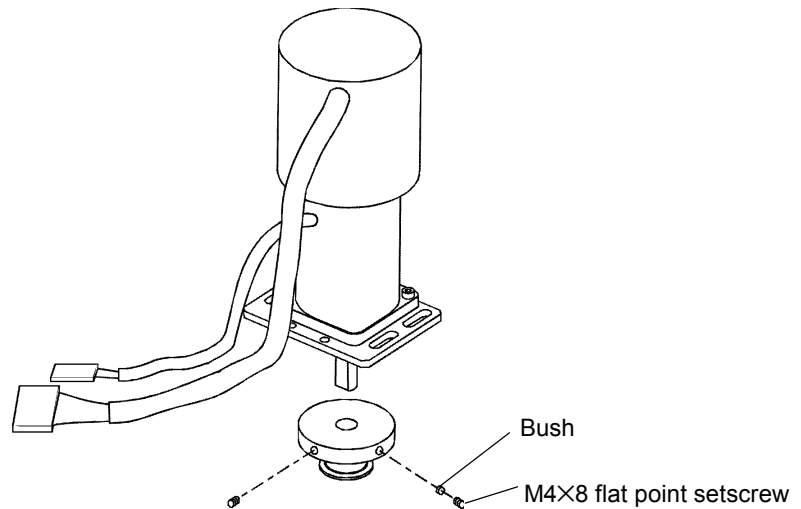
(6) Remove the two bolts (M4×8) from the motor and remove the motor plate.

M4×8
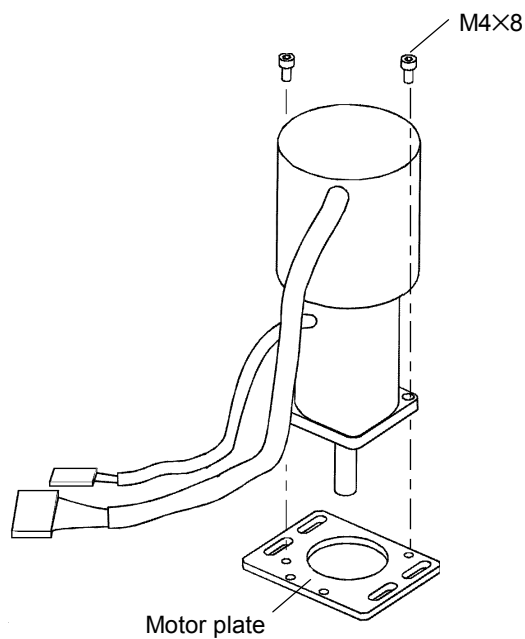
Motor plate

Installation : Joint #4

(1) Attach the new motor onto the motor plate with two bolts (M4×8).

(2) Secure the pulley to the motor shaft with two flat point setscrews (M4×8). Match the end face of the pulley to the end face of the motor shaft. One of the setscrews should touch the flat face in the motor shaft perpendicularly. Insert a bush to the other setscrew hole and tighten the screw so as not to scratch the motor shaft.

Flat face   Bush

M4×8 flat point setscrew
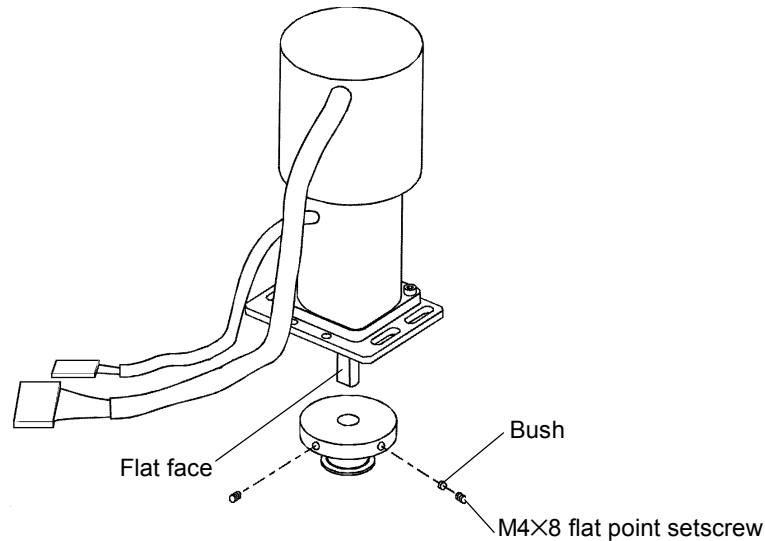
(3) Place the Joint #4 motor unit in Arm #2. The motor cables should be facing Joint #3.

(4) Fit the U1 belt around the large U2 and U1 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units.

Large U2 pulley

U1 pulley

Joint #4 U2 belt

Joint #4 U1 belt
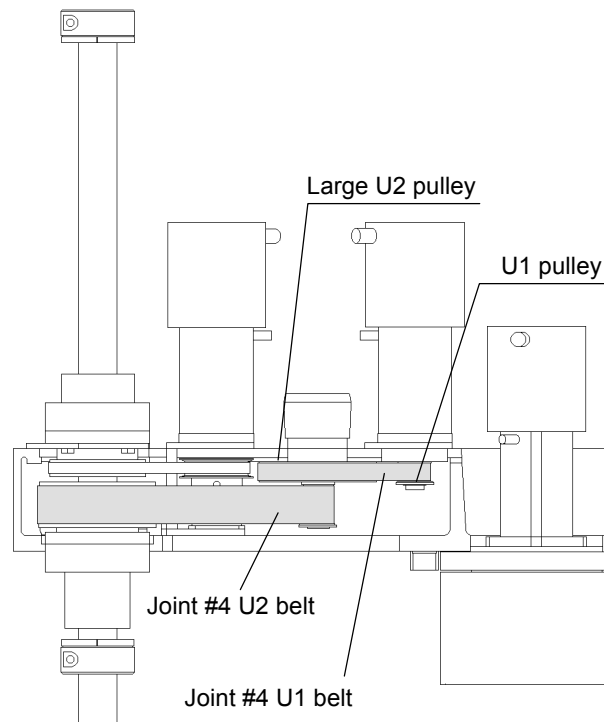
(5)   Fasten the Joint #4 motor plate roughly for the time being with four bolts (M4×10).

4-M4×10
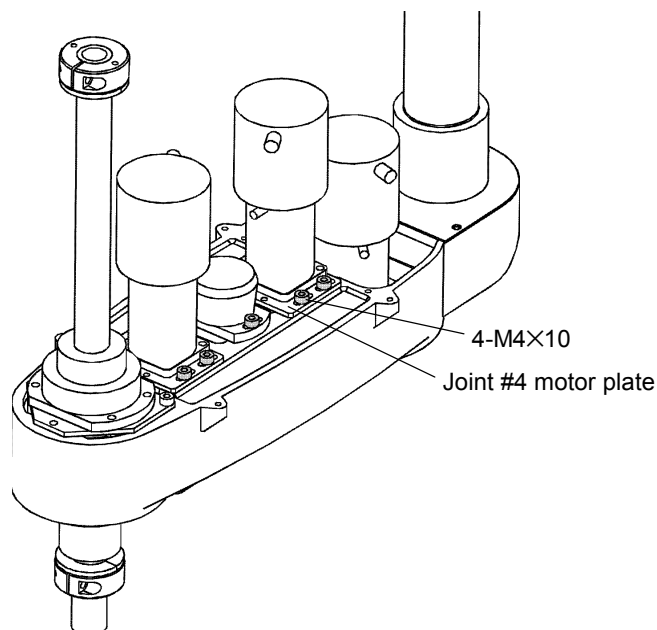
Joint #4 motor plate

(6)   Pass a cord or string near the Joint #4 motor plate.   Loosen the bolts for the Joint #4 motor plate fastened in the step (5) and pull the string using a force gauge or similar tool.   Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 49N (5kgf).   Adjust in the range of 29N - 68N (3kgf - 7kgf).

Force gauge
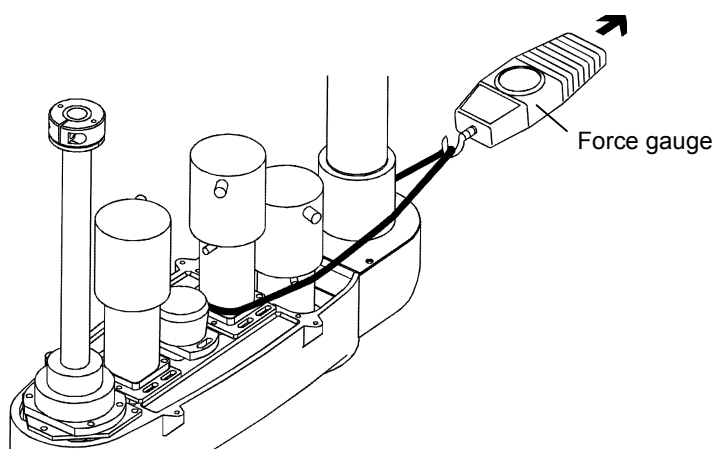
(7)   Connect the connectors, X141 and X41.

(8)   Fasten the motor cables with wire ties in their original positions.   Do not allow unnecessary strain on to the cables.

(9)   Install the arm top cover and arm bottom cover.   (Refer to chapter *2. Opening the Covers*.)

    * If the manipulator is a Protected model, seal the arm top cover and arm bottom cover. Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(10) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #4.   (Refer to chapter *11. Calibration*.)

6. Replacing the Reduction Gear Units

<table>
<tr>
<td rowspan="2">⚠ WARNING</td>
<td>■ Only trained personnel should be allowed to maintain this unit.</td>
</tr>
<tr>
<td>■ When replacing the reduction gear units, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock or malfunction.</td>
</tr>
</table>

<table>
<tr>
<td>⚠ CAUTION</td>
<td>■ Be careful not to apply an excessive shock to the motor shaft when replacing a reduction gear unit. This may shorten the life of the motor and encoder. This also may destroy them.</td>
</tr>
</table>

NOTE
☞

When replacing the reduction gear unit, be sure to always replace the waveform generator, fleck spline, and circular spline all together as one set.

NOTE
☞

To grease the reduction gear unit, use SK-1A (Harmonic Drive Systems) exclusively.   Do not mix with the grease for the ball screw spline (refer to the maintenance parts list at the end of this manual). For the adequate quantity of grease necessary for each manipulator series, refer to the table below as an approximate aid.

Series	Joint #1	Joint #2
ES	approx. 40g	approx. 16g
EL	approx. 80g	approx. 40g

NOTE
☞

When replacing the Joint #2 reduction gear unit, prepare the liquid gasket. (Refer to the maintenance parts list at the end of this manual.)

NOTE
☞

The mechanical origin position and teach points change when the motor or reduction gear unit is replaced.   Whenever the reduction gear unit is replaced, be sure to calibrate the joint. (Refer to chapter *11. Calibration*.)

Types of reduction gear units

The types of reduction gear units used in the ES / EL series manipulators are listed below. Specify the manipulator series and relevant joint when ordering a reduction gear unit for replacement.

Description	Series	Joint	Specification	Old code	New code
Reduction gear unit	ES	#1	SHF-25-80	ZA001007	R13ZA00100700
		#2	SHF-20-50	ZA001008	R13ZA00100800
	EL	#1	SHF-32-100	ZA001006	R13ZA00100600
		#2	SHF-25-80	ZA001007	R13ZA00100700

Location of reduction gear units

Joint #1 reduction gear unit

Joint #2 reduction gear unit
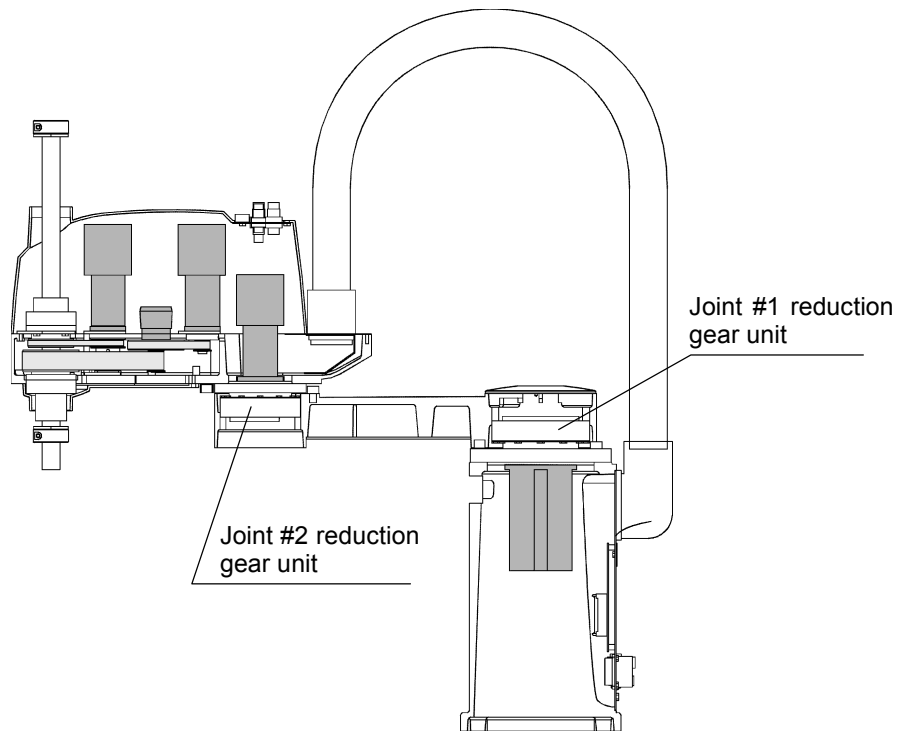
Structure of reduction gear unit

The reduction gear unit consists of the following three parts:

1. Waveform generator

   An ellipsoid cam with ball bearings around the outer circumference.   The inner ring of bearings is secured to the cam, while the outer ring is capable of flexible deformation through the ball bearings.

2. Fleck spline

   A thin, elastic, cup-shaped metal body with gear teeth around the outer circumference of the opening.

3. Circular spline

   A rigid, ring-shaped body with gear teeth on the inner circumference.   The circular spline has twice as many teeth as the fleck spline but at identical pitch.
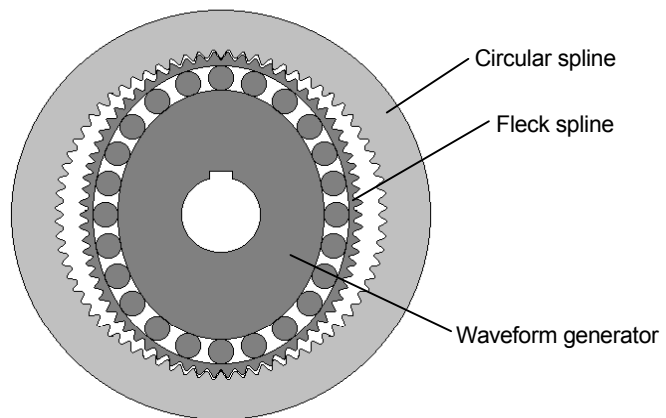
6.1 Replacing the Joint #1 Reduction Gear Unit

* For protected models, contact the suppliers since the following procedure will not apply.

Removal : Joint #1

(1) Remove the bolt (M4×8) from the Joint #1 cover and remove the cover.
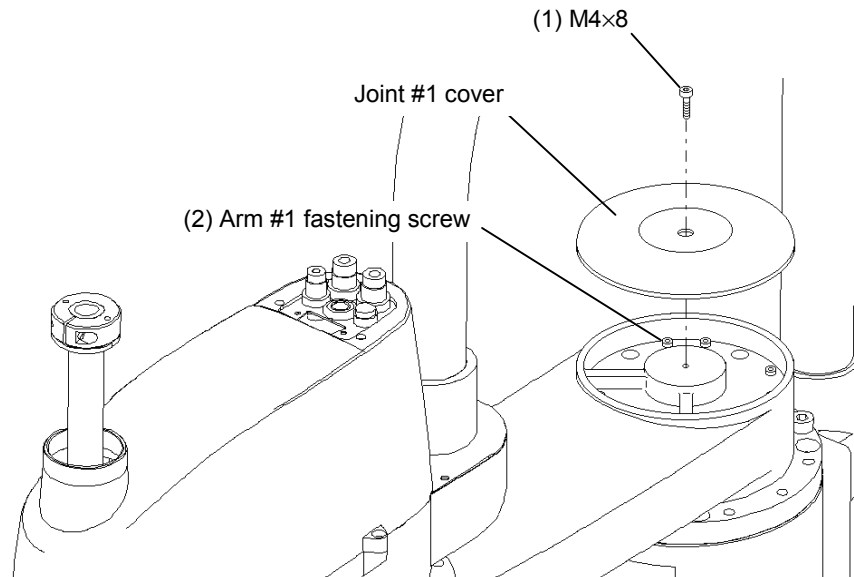
(1) M4×8

Joint #1 cover

(2) Arm #1 fastening screw

(2) Support the arm with more than one person. While the arm is being supported, have another person unscrew the eight fastening bolts (M4×40 for the ES series; M5×55 for the EL series) and remove Arm #1.

⚠ CAUTION	■ When removing or installing Arm #1, there must be two or more people to work on it so that at least one of them can support the arm while others remove the bolts and so on. The arm will drop immediately when the fastening bolts are removed. This is highly dangerous. Also, it may cause damage or malfunction if the arm is dropped or hit at this time.

Joint #1 reduction gear unit
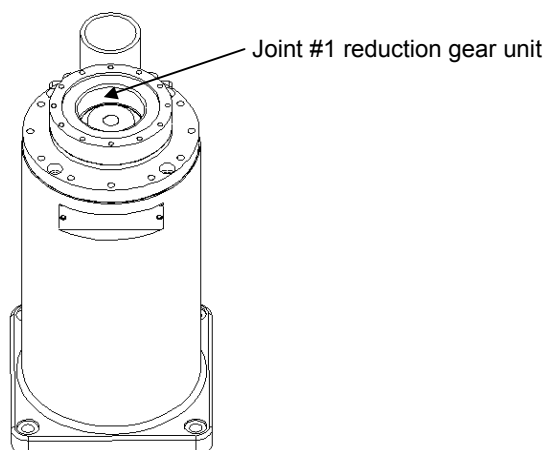
Place the removed arm gently on the floor.

(3)   Remove the power cable and signal cable from the base connector plate.

(4)   Open the base connector plate (refer to chapter *2. Opening the Covers*) and disconnect the signal connector X11 and power connector X110.   To disconnect X110, pull it out while pushing the presser tongue next to the connector number on the motor side.
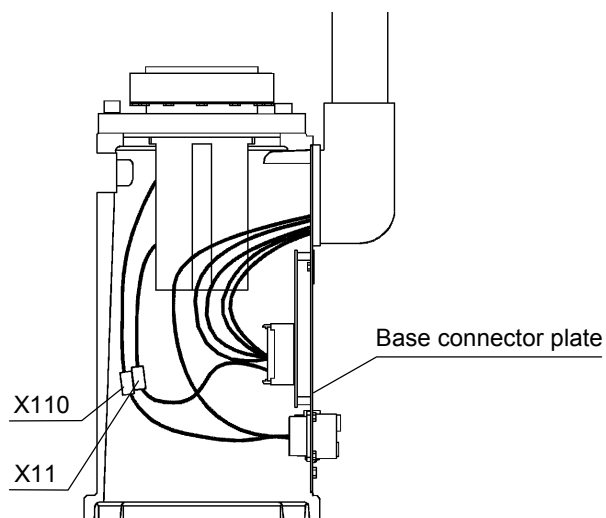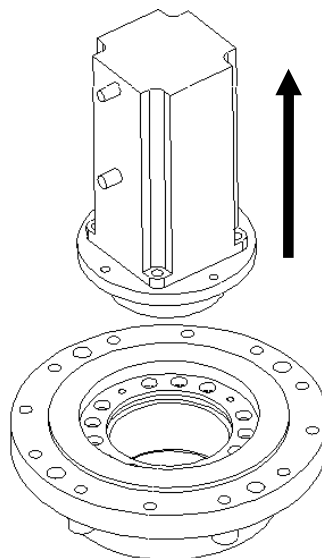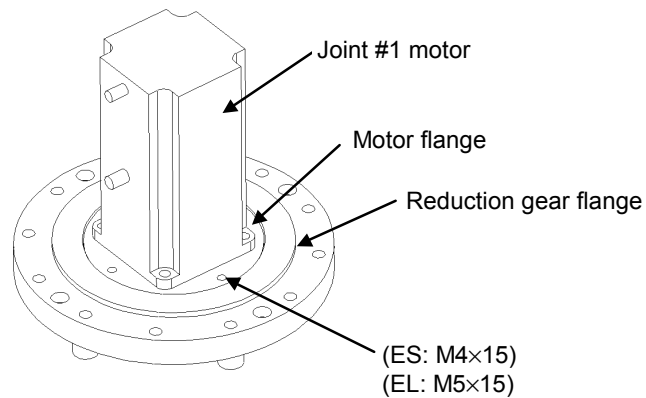

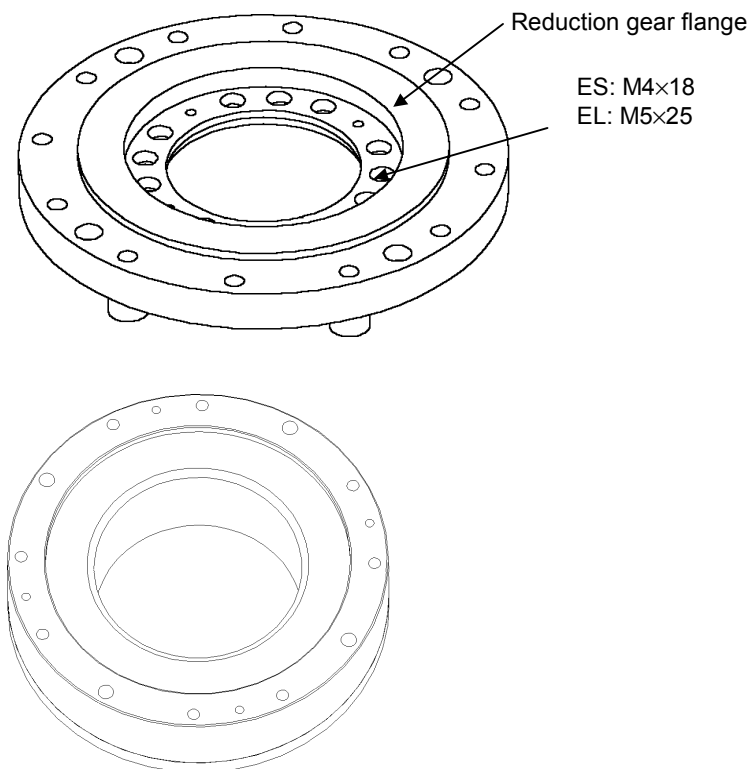(5)   Remove the four bolts (M8×20 for the ES series; M8×25 for the EL series) from the reduction gear flange.
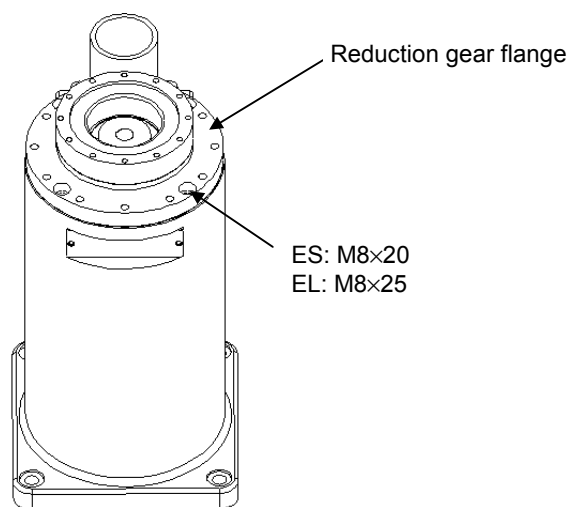
(6)   Lift up the reduction gear unit.
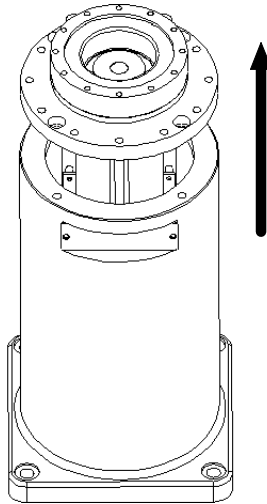
(7)   Remove the four bolts (M4×15 for the ES series; M5×15 for the EL series) from the motor flange and pull the motor flange out of the reduction gear flange.

Joint #1 motor

Motor flange

Reduction gear flange

(ES: M4×15)
(EL: M5×15)

(8) Remove the twelve bolts (M4×18 for the ES series; M5×25 for the EL series) from the reduction gear flange and remove the flange from the circular spline.
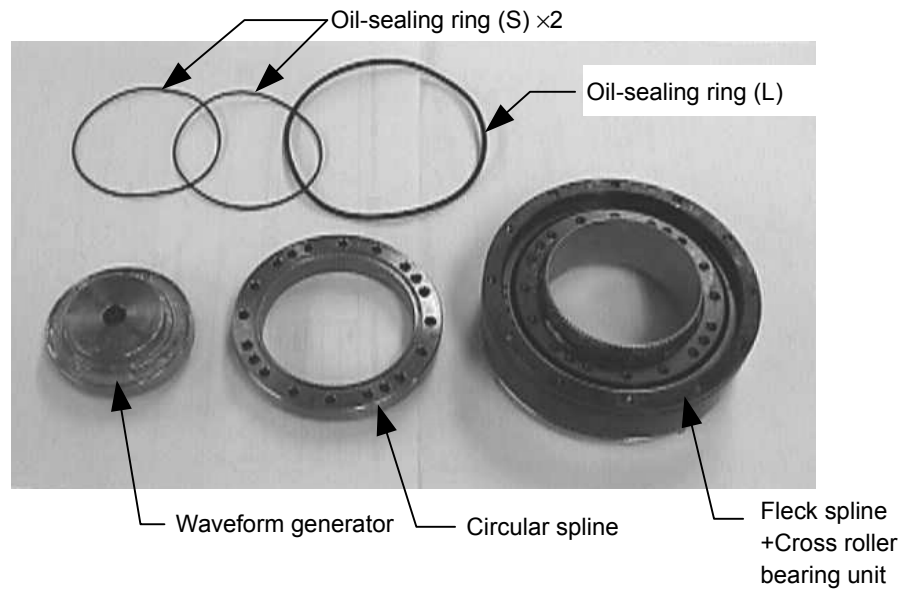
Reduction gear flange

ES: M4×18
EL: M5×25

(9) Using a hexagon head wrench (2.5mm wide) in the screw holes of the waveform generator, remove the two flat point setscrews (M5×6). Remove the waveform generator from the motor. One of the setscrews has a brass bush inside which must not to be lost.

Between the ES and EL series, the direction in which the waveform generator is attached is different.

ES   EL

Waveform generator

Bush

Bush

M5×6

M5×6

Motor flange

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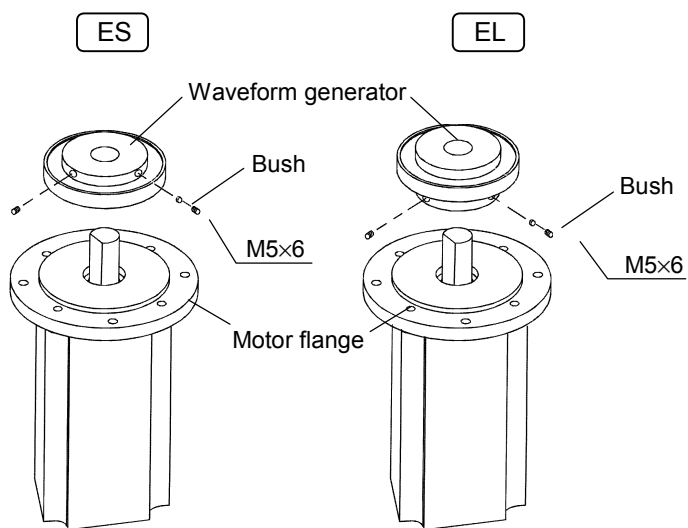
Installation : Joint #1

(1) A new reduction gear unit contains the parts shown below when it is unpacked. However, the oil-sealing ring (L) will not be used here. The circular spline and fleck spline (at the gear grooves) are greased as well as the waveform generator (at the bearings). Wipe off excess grease from the mounting surface.
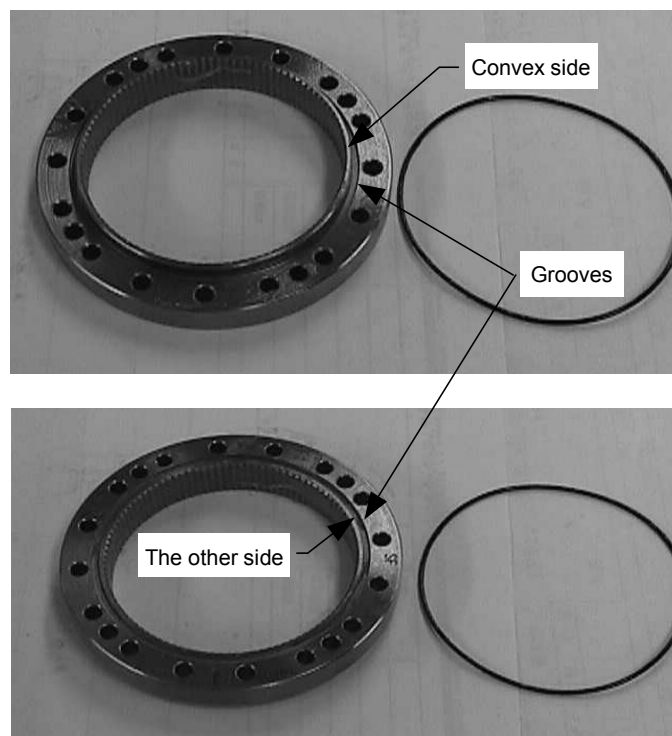

Oil-sealing ring (S) ×2

Oil-sealing ring (L)

Waveform generator   Circular spline   Fleck spline +Cross roller bearing unit

NOTE

Never touch (to loosen or tighten) the bolts holding the fleck spline and cross roller bearing unit together. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the suppliers since they are centered when attached together.

(2) Fit the oil-sealing rings (S) into the grooves on both sides of the new circular spline. Be sure that the rings will not come out of the grooves.

Convex side

Grooves

The other side

(3) Fit the circular spline (with the convex side facing down) into the fleck spline.

(4) As shown below, match the screw holes on the inner ring unit (of the cross roller bearing unit) and the through holes of the circular spline.

(5) Fasten the reduction gear flange onto the circular spline. First, using a hexagon wrench, position the twelve (12) bolts. Loosely fasten each bolt in a crisscross pattern so that the bolts will be fastened evenly. When the bolts are positioned, tighten each bolt securely at the torque specified in the table below using a torque wrench. Tighten each bolt in a crisscross pattern. Be careful not to apply too much force since it may damage the parts.

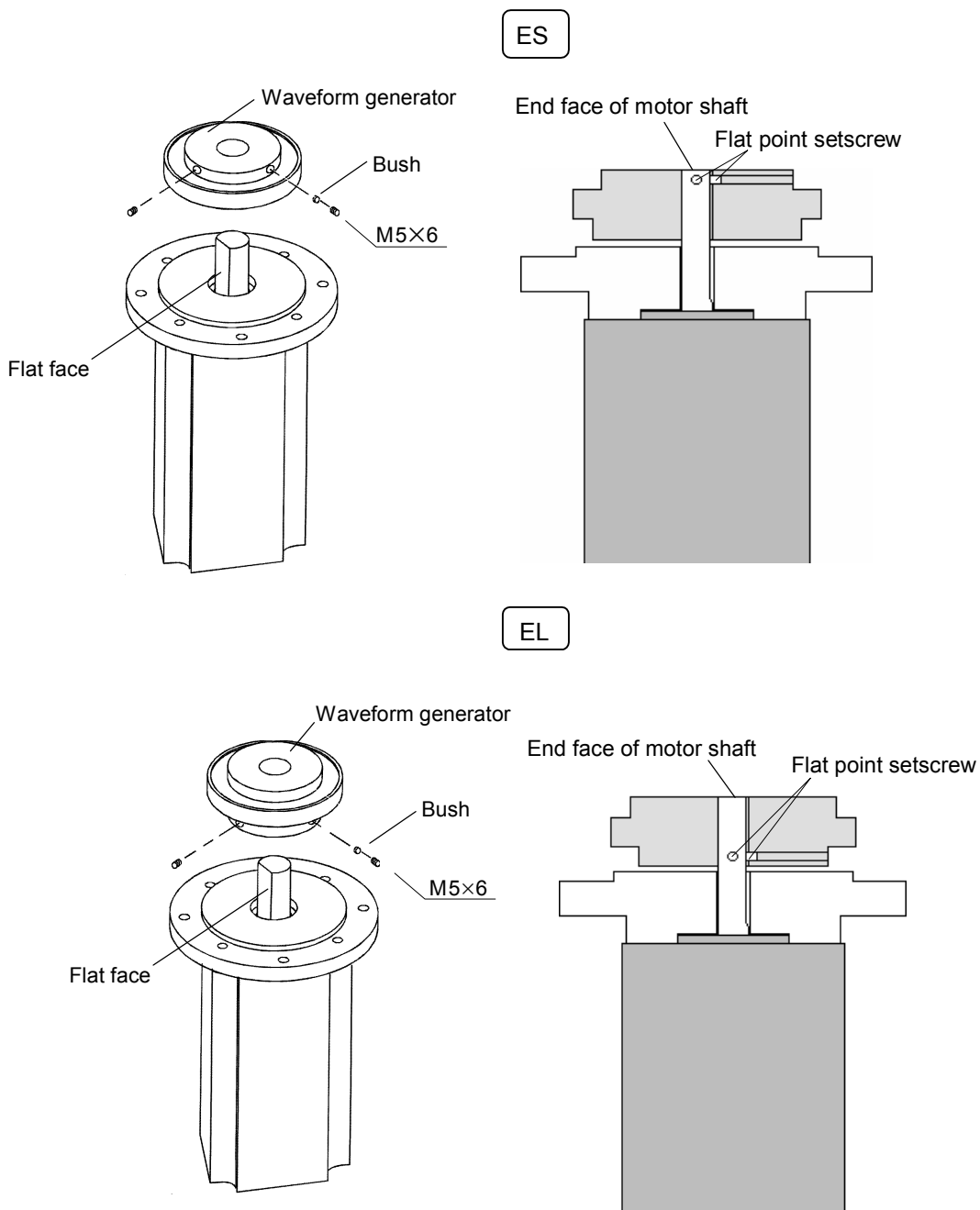| Series	Bolts	Tightening torque of the bolts
ES	12-M4×18	490N·cm (50kgf·cm)
EL	12-M5×25	980N·cm (100kgf·cm)
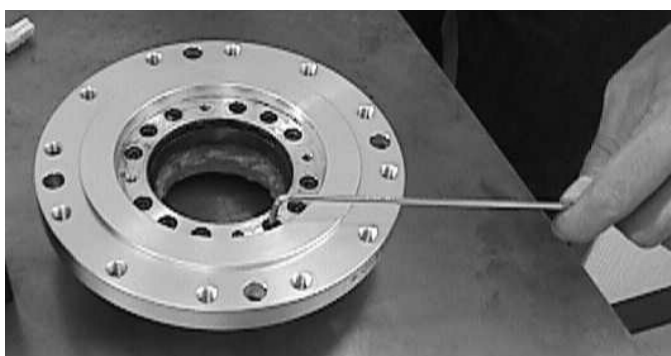
(6) Secure the waveform generator to the motor shaft with two flat point setscrews (M5×6). Match the end face of the waveform generator to the end face of the motor shaft.   One of the setscrews should touch the flat face in the motor shaft perpendicularly.   Insert a bush into the other setscrew hole and tighten the screw carefully to avoid damage to the motor shaft.
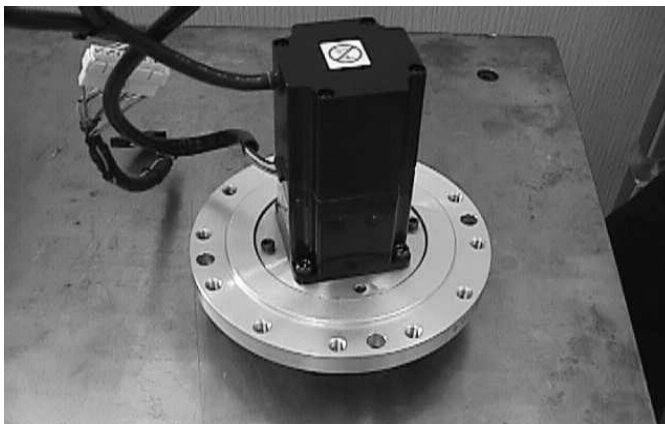
NOTE

☞   Between the ES and EL series, the direction in which the waveform generator is attached is different (See below). ES: The setscrews should be fixed at the end of the motor shaft; EL: The setscrews should be fixed at the foot of the motor shaft.

ES

Waveform generator

Bush

M5×6

Flat face

End face of motor shaft

Flat point setscrew

EL

Waveform generator

Bush

M5×6

Flat face

End face of motor shaft

Flat point setscrew

(7) Secure the motor to the reduction gear unit with four bolts (M4×15 for the ES series; M5×15 for the EL series). Be sure that the motor cable is at the opposite side of the joint label on the reduction gear flange when secured.


(8) Mount the reduction gear flange to the manipulator base and secure it with four bolts (M8×20 for the ES series; M8×25 for the EL series). Be sure that the joint label on the reduction gear flange is at the front.

NOTE
☞   Never touch (to loosen or tighten) the four bolts on the top surface shown in the picture below. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the   suppliers since they are centered when attached together.


SK-1A grease

Joint label on the front side
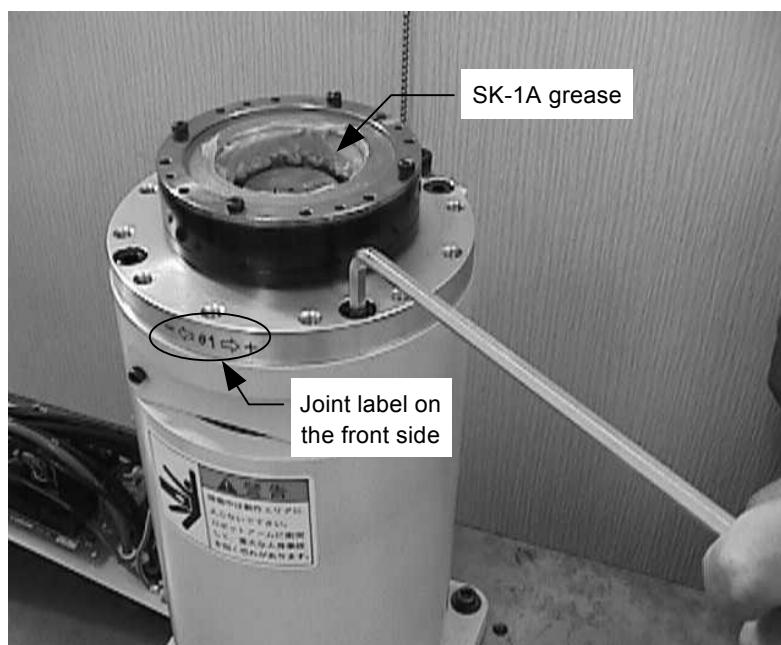
(9) As illustrated above, grease inside the reduction gear unit.   (ES: 40g; EL: 80g)

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(10) Secure Arm #1.   Support the arm with more than one person.   While the arm is being
     supported, have another person fasten eight bolts (M4×40 for the ES series; M5×55 for
     the EL series) to attach Arm #1.   Be careful not to drop or hit the arm.

Fastening bolts
(ES:M4 × 40)
(EL:M5 × 55)
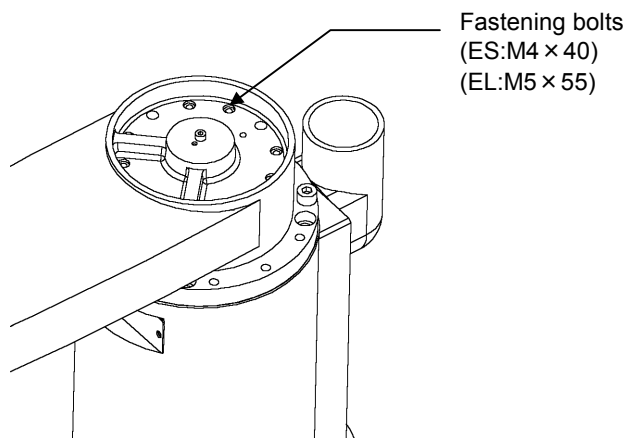
(11) Connect the signal connector X11 and power connector X110.   Then, attach the base
     connector plate to the base.   (Refer to chapter *2. Opening the Covers*.)

Base connector plate

X110

X11
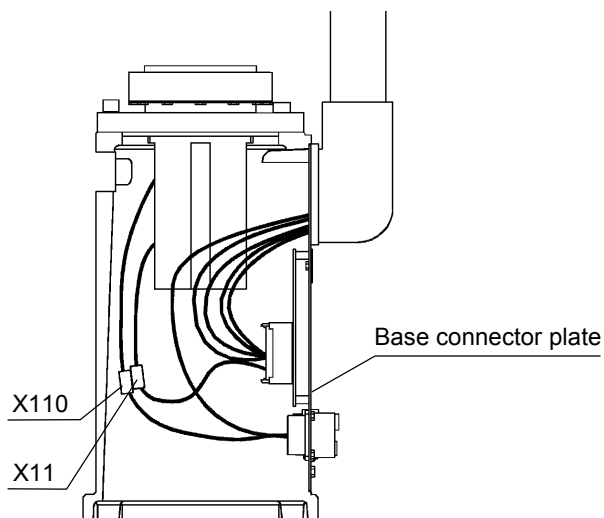
(12) Connect the power cable and signal cable to the base connector plate.

(13) Attach the Joint #1 cover to Arm #1 with a bolt (M4×8).

(14) The mechanical origin position and teach points change when the reduction gear unit is
     replaced.   Be sure to calibrate Joint #1.   (Refer to chapter *11. Calibration*).

## 6.2 Replacing the Joint #2 Reduction Gear Unit

*   For protected models, contact the suppliers since the following procedure will not apply.

Removal : Joint #2

(1)   Open the arm top cover.   (Refer to chapter 2. Opening the Covers.)

(2)   Remove the duct plate from Arm #2 by unscrewing the three bolts (M4×8).
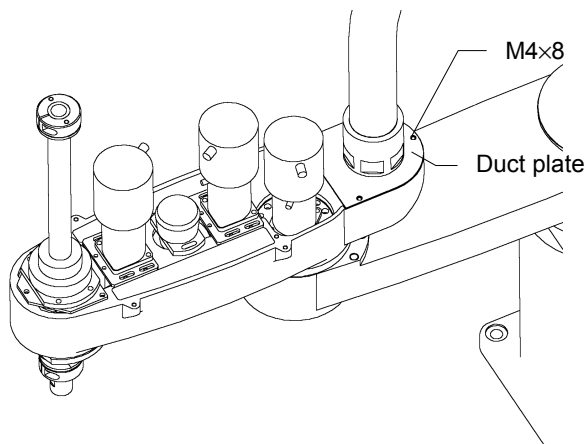
(3)   Cut off the wire ties which fasten the Joint #2 motor and cables.

(4)   Disconnect the signal connector X21 and power connector X121 of the Joint #2 motor. To disconnect X121, pull it out while pushing the presser tongue next to the connector number on the motor side.
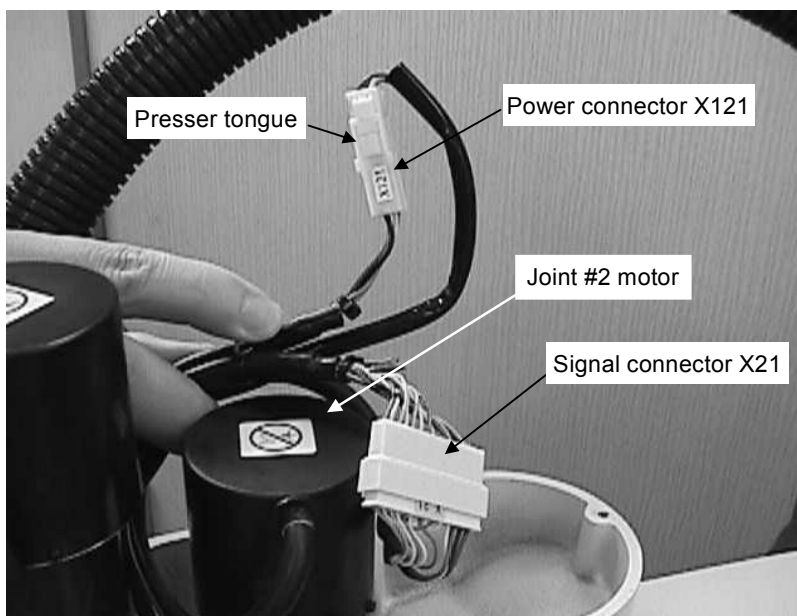

(5)   Support Arm #2 with more than one person.   While the arm is being supported, have another person unscrew the four fastening bolts (M6×18 for the ES series; M8×18 for the EL series) and remove Arm #2 from Arm #1.

| ⚠ CAUTION	■ When removing or installing Arm #2, there must be two or more people to work on it so that at least one of them can support the arm while others remove the bolts and so on. The arm will drop immediately when the fastening bolts are removed. This is highly dangerous. Also, it may cause damage or malfunction if the arm is dropped or hit at this time.

Joint #2 motor

Arm #2

Fastening bolt for Arm #2
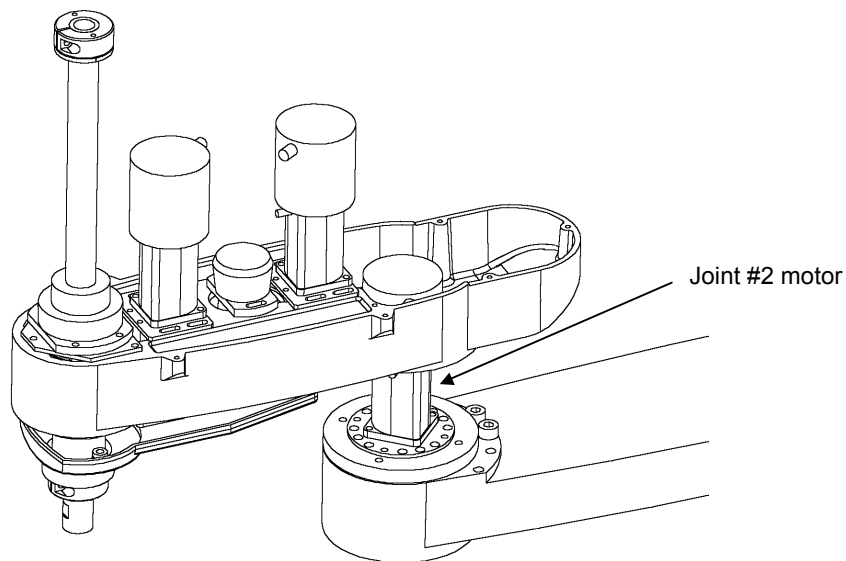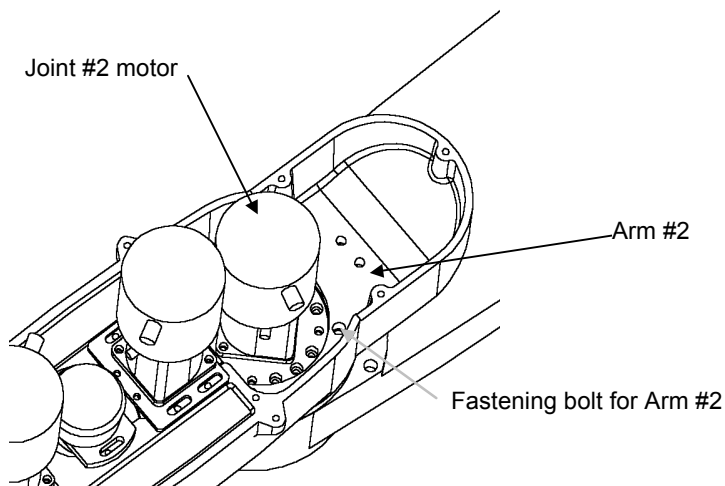
Joint #2 motor

Place the removed arm gently on the floor.

(6) Remove the four bolts (M4×10 for the ES series; M4×15 for the EL series) from the Joint #2 motor flange.

Motor flange

ES: M4×10
EL: M4×15
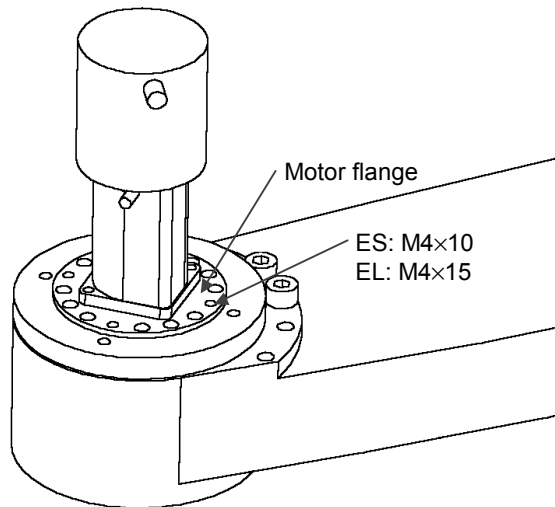
(7) Remove the Joint #2 motor unit from Arm #1.
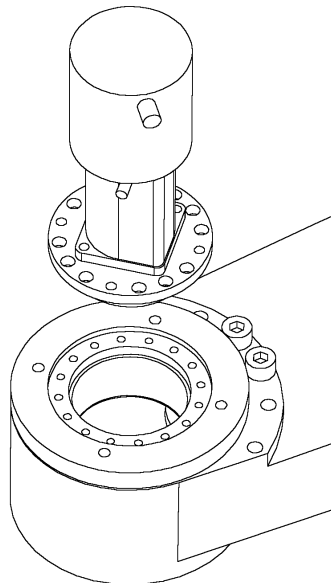
(8) Remove the eight bolts (M3×40 with plain washer for the ES series; M4×45 for the EL series) from the Joint #2 reduction gear unit at the bottom of Arm #1.

ES: M3×40 with plain washer
EL: M4×45

Bottom of Arm #1
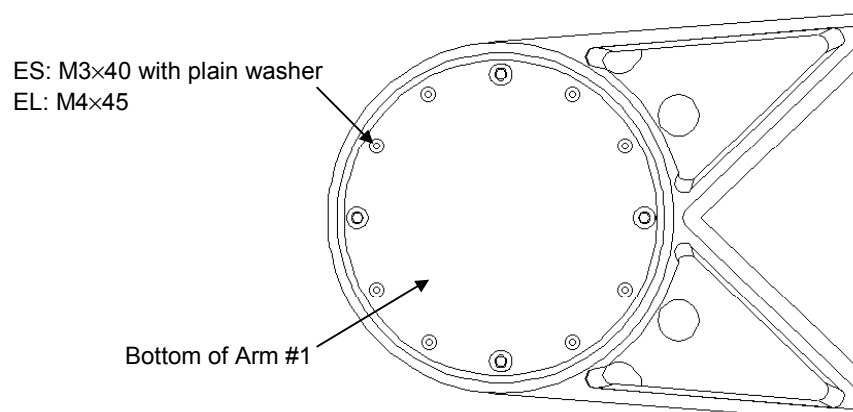
(9) Remove the reduction gear unit from Arm #1. If the unit does not come out easily because of liquid gasket on the junction surface to prevent grease from leaking, use a flat screwdriver between the flange and the arm.
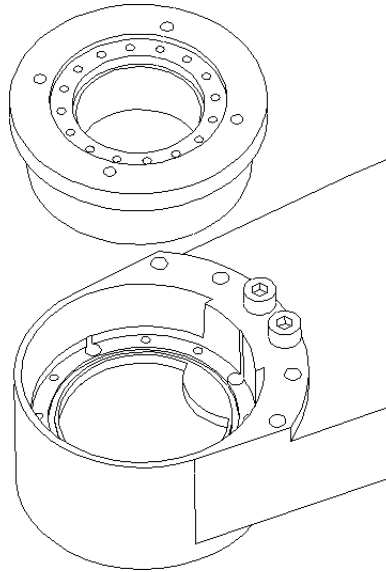
(10) Remove the twelve bolts (M3×18 for the ES series; M4×18 for the EL series) from the reduction gear flange and remove the flange from the circular spline.
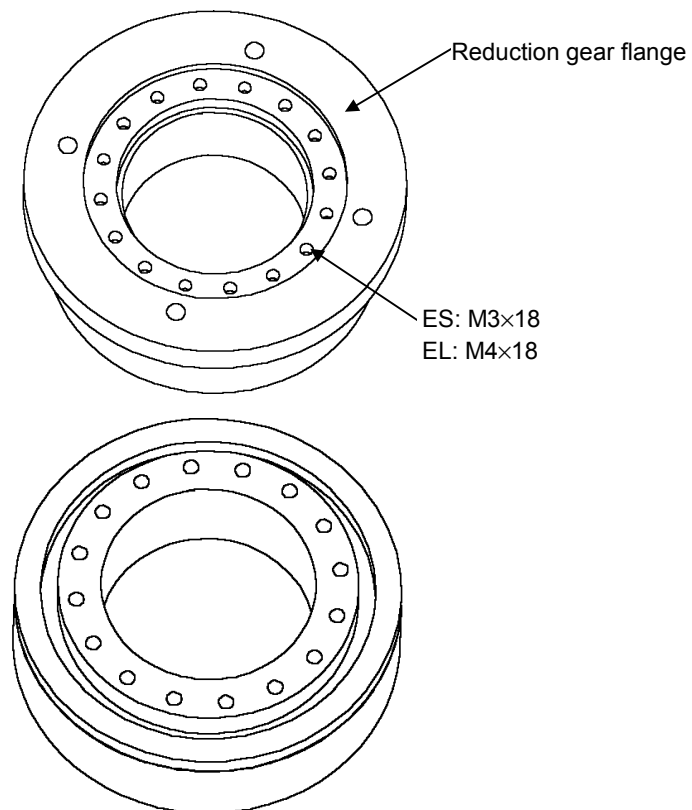
(11) Using a hexagon head wrench in the screw holes of the waveform generator, remove the two flat point setscrews (M4×6 for ES series; M5×6 for the EL series). Remove the waveform generator from the motor. One of the setscrew holes has a brass bush inside which must be paid attention so as not to be lost.
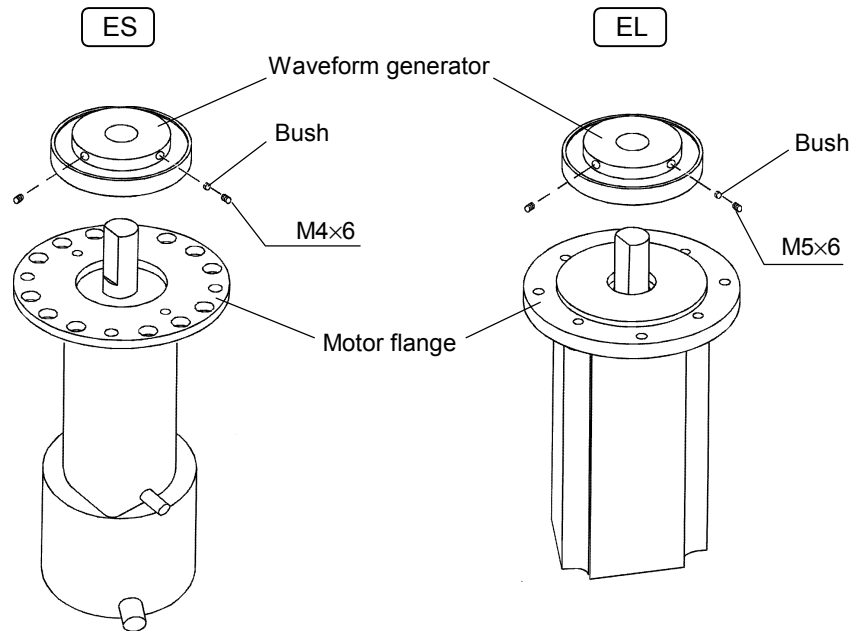
Installation : Joint #2

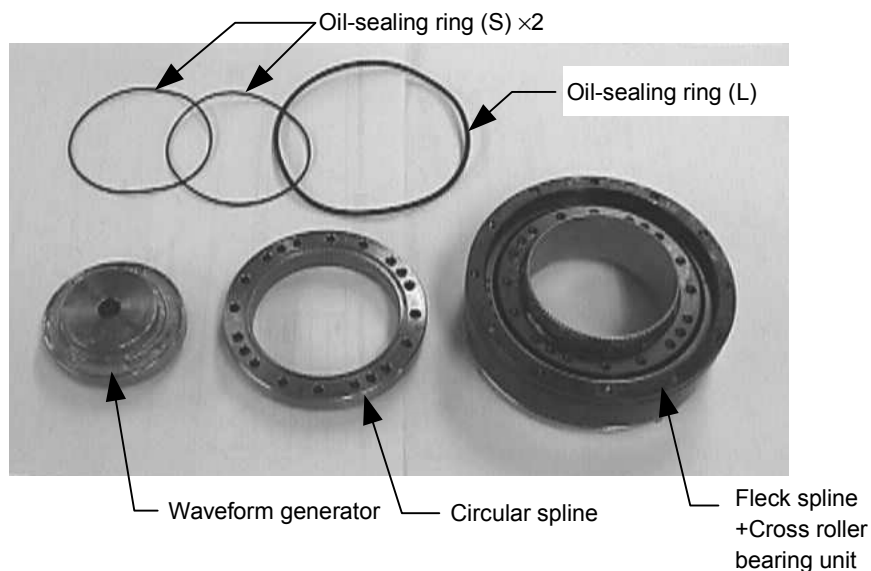(1) A new reduction gear unit contains the parts shown below when it is unpacked. However, the oil-sealing ring (L) will not be used here. The circular spline and fleck spline (at the gear grooves) are greased as well as the waveform generator (at the bearings). Wipe off excess grease from the mounting surface.

Oil-sealing ring (S) ×2

Oil-sealing ring (L)

Waveform generator   Circular spline   Fleck spline
                                                     +Cross roller
                                                     bearing unit

NOTE
☞
Never touch (to loosen or tighten) the bolts holding the fleck spline and cross roller bearing unit together. If the bolts are moved, the fleck spline and cross roller bearing unit must be readjusted at the suppliers since they are centered when attached together.

(2) Fit the oil-sealing rings (S) into the grooves on both sides of the new circular spline. Be sure that the rings will not come out of the grooves.

Convex side

Grooves

The other side

(3) Fit the circular spline (with the convex side facing down) into the fleck spline.

(4) As shown below, match the screw holes on the inner ring unit (of the cross roller bearing unit) and the through holes of the circular spline.

(5) Place the reduction gear flange onto the circular spline.   First, using a hexagon wrench, position the twelve (12) bolts.   Loosely fasten each bolt in a crisscross pattern so that the bolts will be fastened evenly.   When the bolts are positioned, tighten each bolt securely at the torque specified in the table below using a torque wrench.   Tighten each bolt in a crisscross pattern.   Be careful not to apply too much force since it may damage the parts.

Series	Bolts	Tightening torque of the bolts
ES	12-M3×18	245N·cm (25kgf·cm)
EL	12-M4×18	490N·cm (50kgf·cm)

ES: M3×18
EL: M4×18
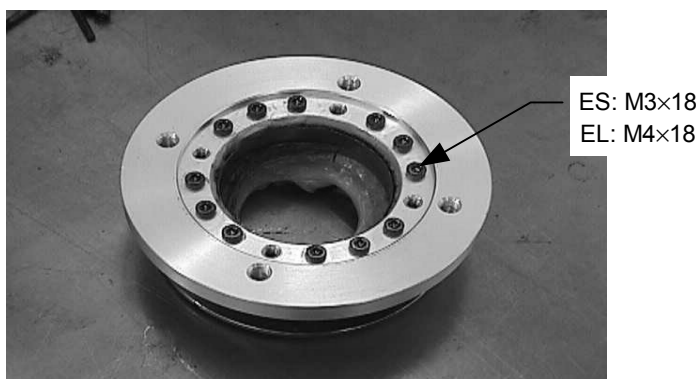
(6) Mount the waveform generator to the motor shaft with two flat point setscrews (M4×6 for ES series; M5×6 for EL series). Match the end face of the waveform generator to the end face of the motor shaft. One of the setscrews should touch the flat face in the motor shaft perpendicularly. Insert a bush to the other setscrew hole and tighten the screw so as not to scratch the motor shaft.
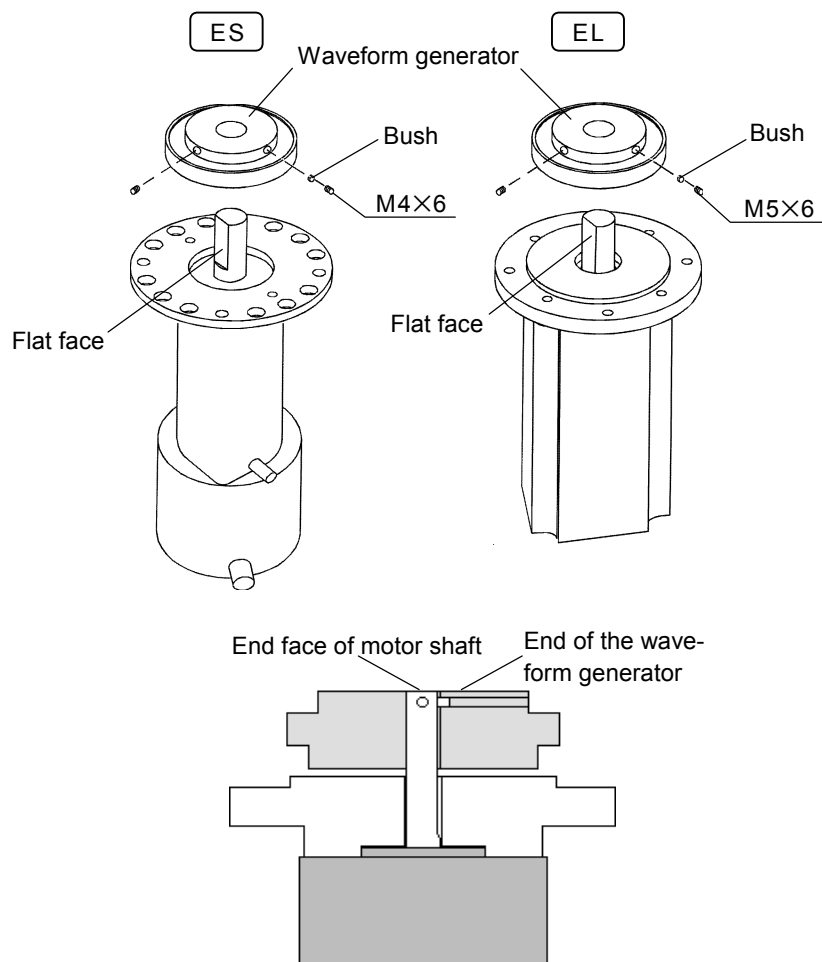
(7) Remove the old liquid gasket and apply new liquid gasket on the junction surface of the reduction gear unit.

(8) Place the Joint #2 reduction gear unit back inside Arm #1 and secure it with eight bolts (M3×40 with plain washer for the ES series; M4×45 for the EL series).
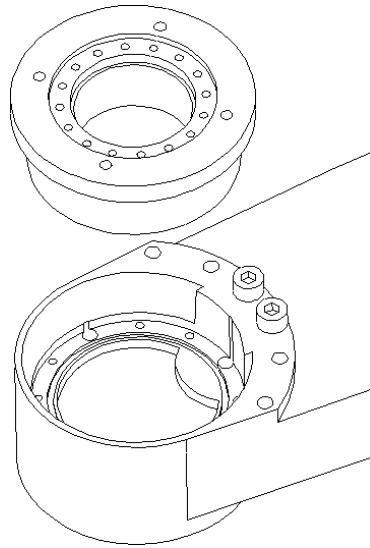
(9) As shown below, grease inside the reduction gear unit (ES: 16g; EL: 40g) and build the motor unit inside Joint #2.

SK-1A grease
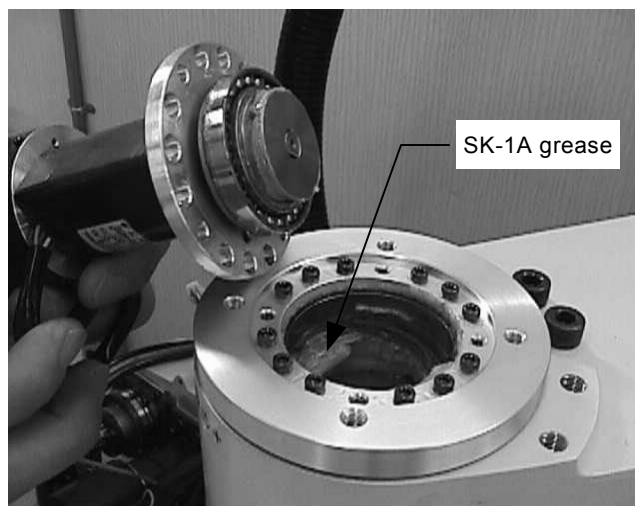
(10) Secure the motor flange with four bolts (M4×10 for the ES model; M4×15 for the EL model) so that the motor cable will come to the position shown in the picture below.

Motor flange

ES: M4×10
EL: M4×15
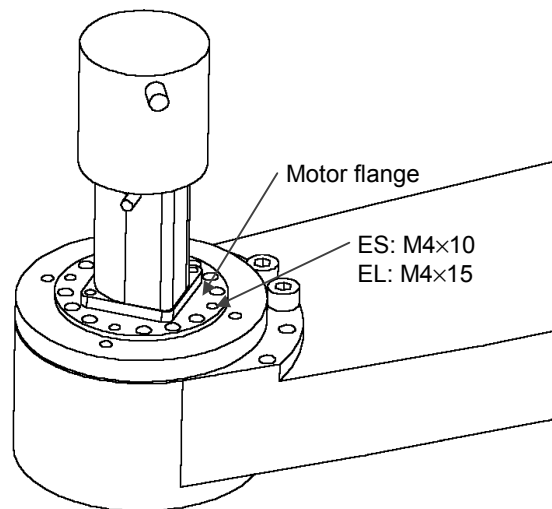
(11) Secure Arm #2.   Support the arm with more than one person.   While the arm is being supported, have another person fasten four bolts (M6×18 for the ES series; M8×18 for the EL series) to attach Arm #2.   Be careful not to drop or hit the arm.
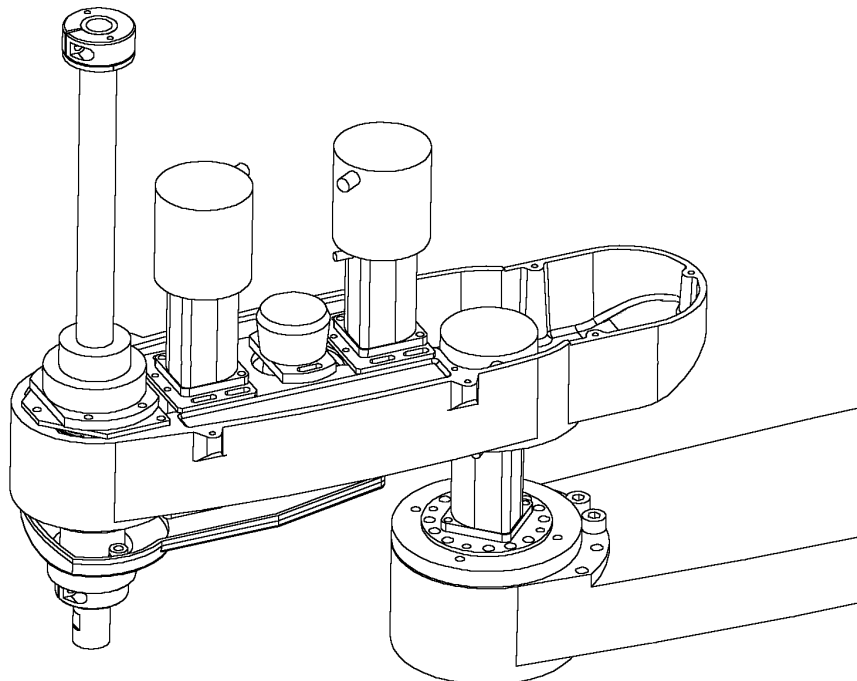
(12) Connect the connectors, X121 and X21 of the Joint #2 motor.
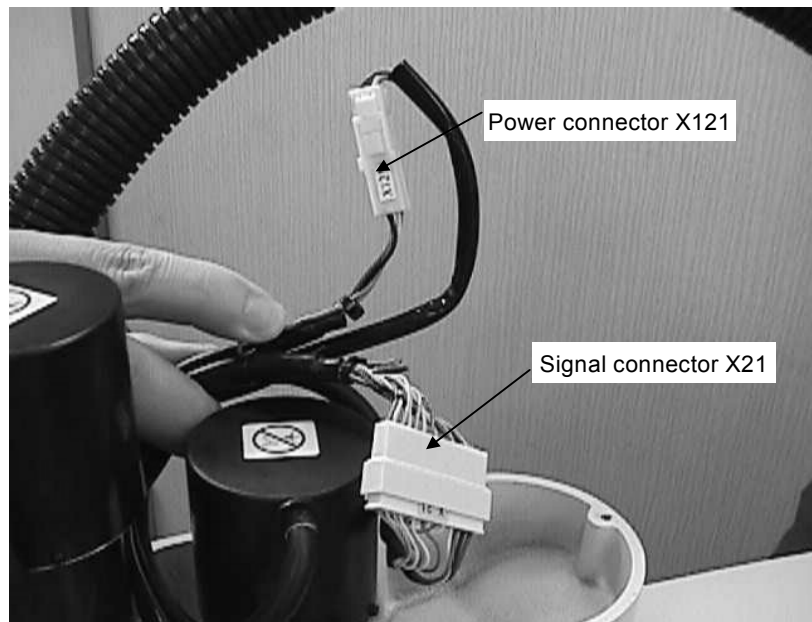
(13) Fasten the motor cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(14) Place the duct plate back on and secure it with three bolts (M4×8).
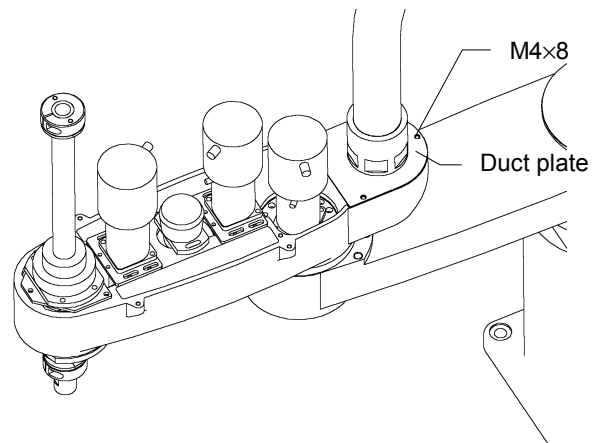
(15) Attach the arm top cover. (Refer to chapter *2. Opening the Covers*).

(16) The mechanical origin position and teach points change when the reduction gear unit is replaced. Be sure to calibrate the Joint #2. (Refer to chapter *11. Calibration*.)

7. Replacing the Brake

⚠	WARNING	■ Only trained personnel should be allowed to maintain this unit. ■ When replacing the brake, make sure the power is turned off and pull out the power plug from the power source. Failure to turn off the power can result in electric shock and malfunction.

⚠	CAUTION	■ When replacing the brake, be careful not to extend the leaf spring on the rotor hub of the brake.

NOTE
☞

The brake on Joint #3, which normally prevents the end effector from dropping under its own weight when either the power or the motor itself is turned off, is rendered inoperable while the brake is being replaced.

Joint #3 moves while the brake release button is held down while the power is ON. (See Figure 11 in the chapter *End Effectors* in Part 1) Lower Joint #3 carefully to prevent from striking against nearby equipment. The power should be OFF while replacing the brake.

Removal

(1) Remove the Joint #3 motor as described in *5.3. Replacing the Joint #3 Motor*, steps (1) through (7).

(2) Slide the pulley and rotor hub horizontally to remove them from the brake so as not to cause a damage to the leaf spring. The rotor hub, which is screwed on the pulley, is attracted to the brake magnet. If you force it to separate, the leaf spring will stretch.
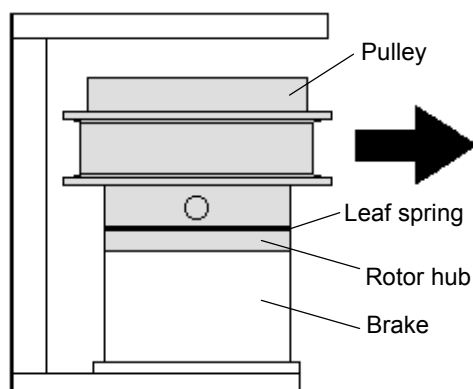
(3) Cut off the wire tie that fastens the brake cable to the brake plate.

(4) Remove four bolts (M3×5) that fasten the brake to the brake plate, then remove the brake from the brake plate.
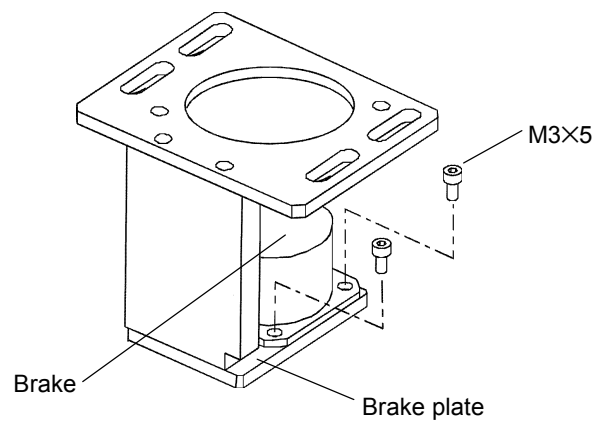
(5) Remove the rotor hub from the end of the pulley. (3-M2×3 machine screw)
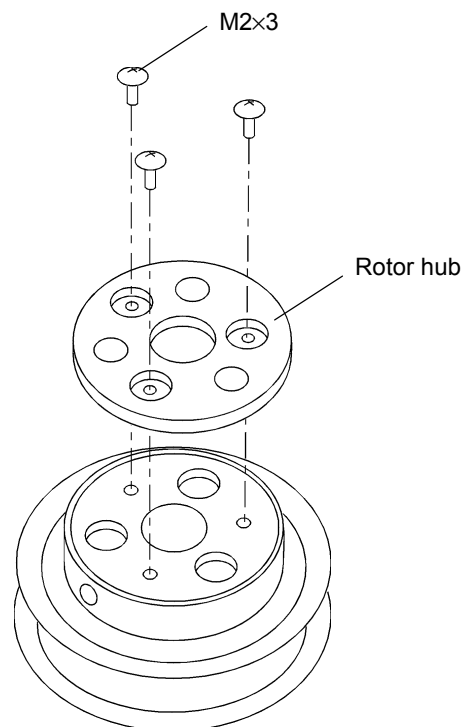
Installation

(1) Fasten the rotor hub of the new brake to the surface of the pulley securely with three machine screws (M2×3).

(2) Fasten the new brake to the brake plate with four bolts (M3×5).

(3) Fasten the brake cable to the brake plate with a wire tie to prevent interference with the pulley.

(4) Put a gap gauge (0.15 mm) which was pasted inside the arm bottom cover between the brake and rotor hub and set the pulley on the brake.   At this time, the positions of the pulley setscrew holes are as shown in the figure below.
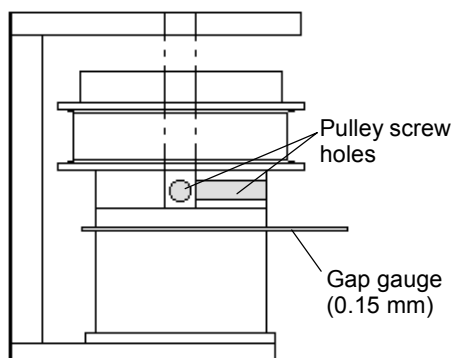
(5) Place the new motor to the motor plate so that the motor cables turn to the direction of the figure below and fasten it with two bolts (M4×8).   The direction of the motor shaft flat face should face one of the screw holes of the pulley.
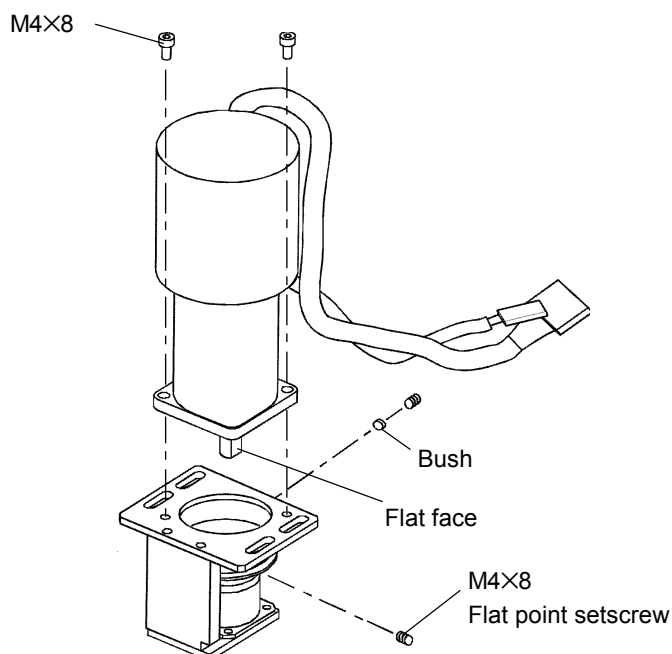
(6) Secure the pulley with two flat point setscrews (M4×8).   One of the screws should touch the flat face in the motor shaft perpendicularly.   Insert the bush into the other screw hole and tighten the screw so as not to scratch the motor shaft.

(7) After the pulley is secured, pull out the gap gauge.

(8) Place the Joint #3 motor unit in the arm.   The motor cables should be facing Joint #2.

(9) Fit the Z belt around the Z1 and Z2 pulleys.   Ensure that the gear grooves of the belt and pulleys engage properly.   Be careful not to slip the Z belt from the pulleys when holding proper interval between the pulleys.   Fasten the Joint #3 motor plate for the time being using four bolts (M4×10).

Motor plate

Z2 pulley

Z1 pulley

Joint #3 Z belt
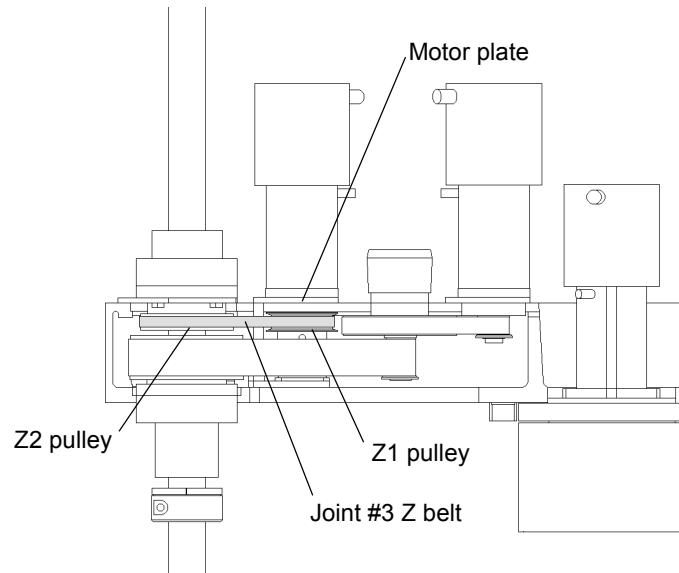
(10) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (9) and pull the cord using a force gauge or similar tool.   Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf).   Adjust in the range of 20N - 39N (2kgf - 4kgf).

Force gauge
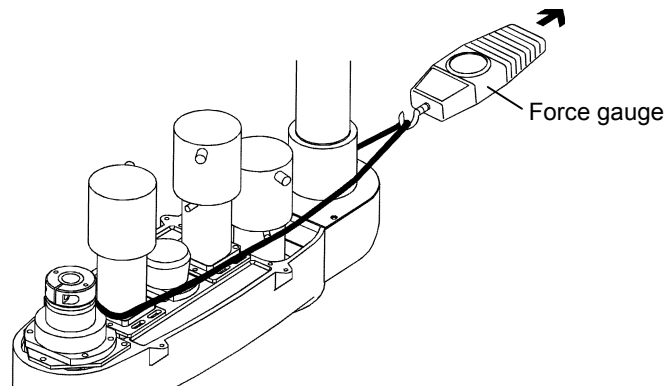
(11) Connect the connectors, X131, X31 and X32.   Fasten the cables with wire ties in their original positions.   Do not allow unnecessary strain on the cables.

(12) Install the arm top cover and arm bottom cover.   (Refer to chapter *2. Opening the Covers*.)

   *   If the manipulator is a Protected model, seal the arm top cover and arm bottom cover.   Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(13) The mechanical origin position and teach points change when the motor is replaced. Be sure to calibrate Joint #3.   (Refer to chapter *11. Calibration*.)

8. Replacing the Timing Belts

⚠ WARNING	■ Only trained personnel should be allowed to maintain this part. ■ When replacing the timing belts, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock and malfunction.

NOTE
☞
Lower Joint #3 carefully to prevent it from colliding with nearby equipment.   Joint #3 can be moved while the brake release button (See Figure 11 in the chapter *End Effectors* in Part 1) is being pushed when the power is turned ON.   The brake on the joint #3 motor, which normally prevents the end effector lowering under its own weight when either the power or the motor itself is turned OFF, does not work while the timing belt is being replaced.

The power should be OFF while replacing the timing belt.

NOTE
☞
Once the timing belt is removed or replaced, the origin position changes. As a result, the teach points you have been using also deviate from position. In order to use the original teach points, you need to adjust the origin position.

You need to choose one point from among the currently held teach points.   The accuracy of the selected point should be easy to check.   Adjust the origin point as described in chapter *11. Calibration*.

Types of timing belts

The timing belt is used one on Joint #3 and two on Joint #4.   Specify the manipulator type name and corresponding joint name when ordering a replacement timing belt.

Joint	Name	Specification	Old code	New code
#3	Z belt	264-2GT-6	ZA003214	R13ZA00321400
#4	U1 belt	264-2GT-9-T434N1	ZA003213	R13ZA00321300
	U2 belt	264-2GT-20-T434N1	ZA003212	R13ZA00321200

Locations of timing belts

155
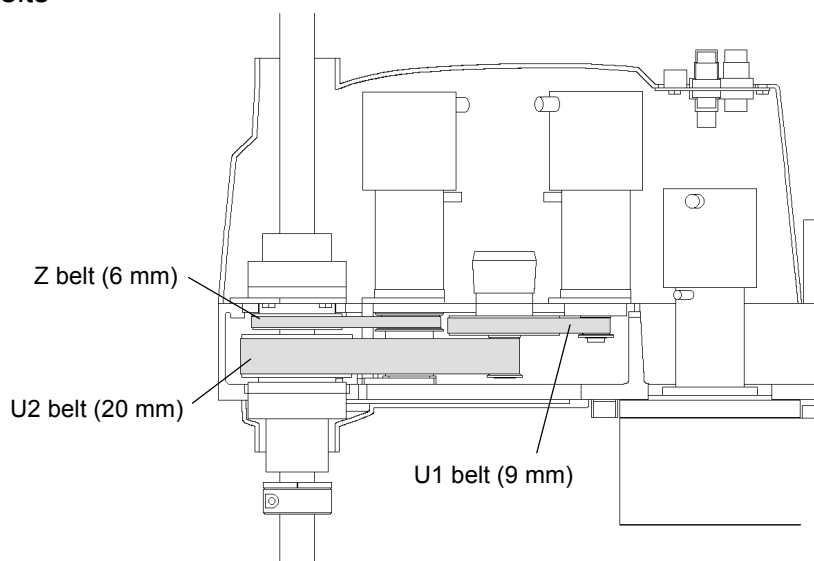
8.1 Replacing the Z belt

Removal : Z belt

    (1)   Remove the Joint #3 motor unit as described in *5.3 Replacing the Joint #3 Motor* steps (1) through (4).

    (2)   Remove the bolts (3-M4×10) from the spline plate.
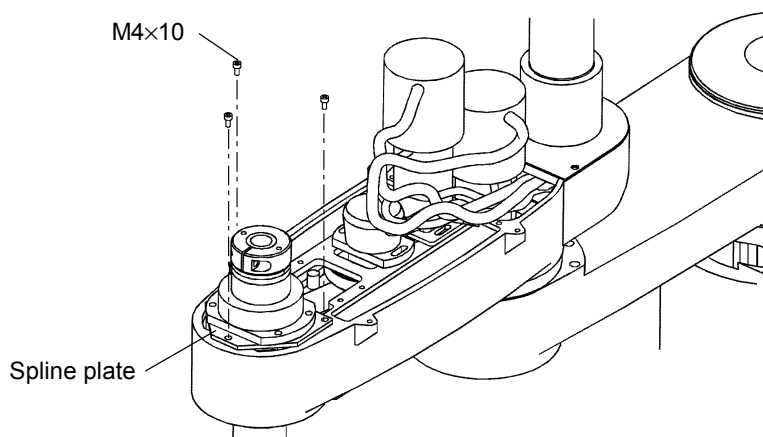
    (3)   Lift the spline plate and draw the Z belt up, make it through under the spline plate, and pull the Z belt upward.
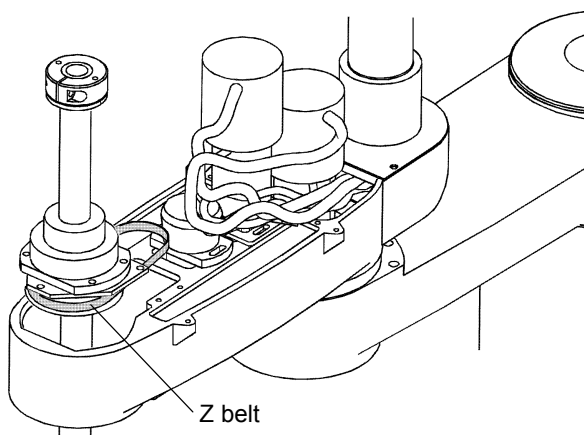
Installation : Z belt

    (1)   Place a new Z belt on the shaft from above, and lift the spline plate to allow the belt to be positioned under it.

    (2)   Fit the spline plate (with the belt attached on the spline plate pulley) on the arm.

Spline plate

Spline plate pulley
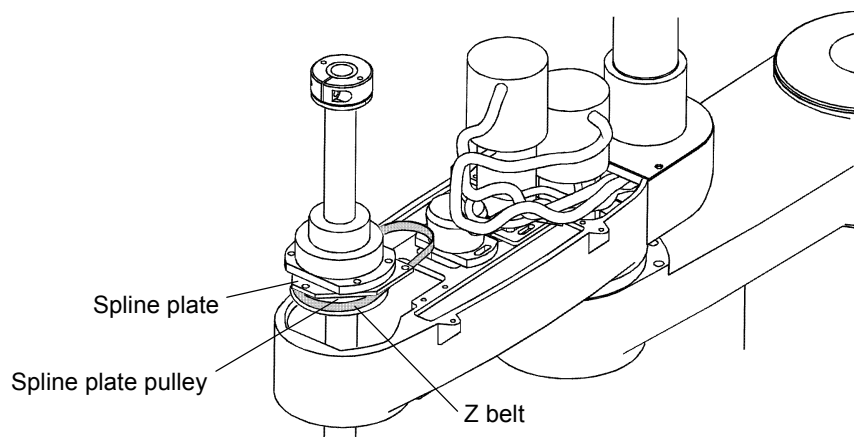
Z belt

    (3)   Fasten the spline plate with three bolts (M4×10).

    (4)   Place the Joint #3 motor unit in the arm.   The motor cables should be facing Joint #2.

    (5)   Place the Z belt around the Z1 and Z2 pulleys. Ensure that the gear grooves of the belt and pulleys engage properly.   Be careful not to slip the Z belt from the pulleys while maintaining proper interval between the pulleys.   Fasten the Joint #3 motor plate for the time being using four bolts (M4×10).

Motor plate

Z2 pulley

Z1 pulley

Z belt

157
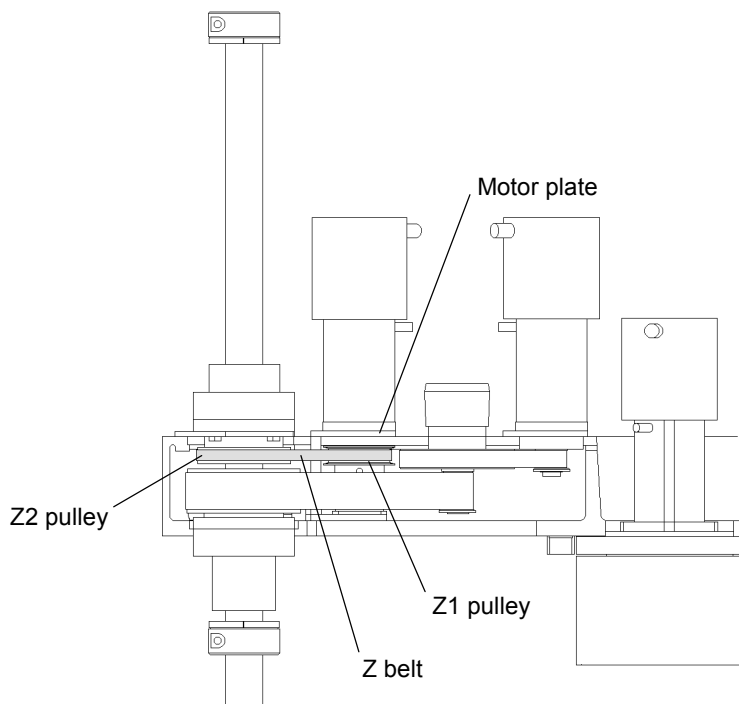
(6) Pass a suitable cord or string around the Joint #3 motor near its motor mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (5) and pull the cord using a force gauge or similar tool.   Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf).   Adjust in the range of 20N - 39N (2kgf - 4kgf).

Force gauge
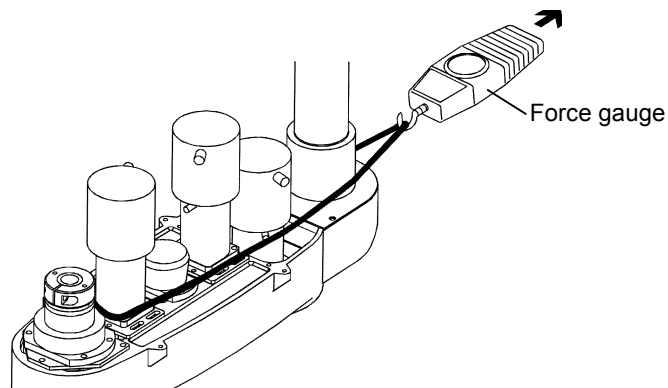
(6) Connect the connectors, X131, X31 and X32.   Fasten the motor cables with wire ties in their original positions.   Do not allow unnecessary strain on the cables.

(7) Install the arm top cover and arm bottom cover. (Refer to chapter 2. Opening the Covers.)

   * If the manipulator is a Protected model, seal the arm top cover and arm bottom cover. Refer to the section *Sealing the Manipulator in chapter 13. Protected Model.*

(8) The mechanical origin position of the Joint #3 motor and teach points change when the motor is replaced.   Be sure to calibrate Joint #3 as described in chapter *11. Calibration*.

8.2 Replacing the U1 Belt

Removal : U1 Belt

(1) Open the arm top cover and arm bottom cover. (Refer to chapter *2. Opening the Covers.*)

(2) Loosen the four bolts (M4×10) holding the Joint #4 motor plate.
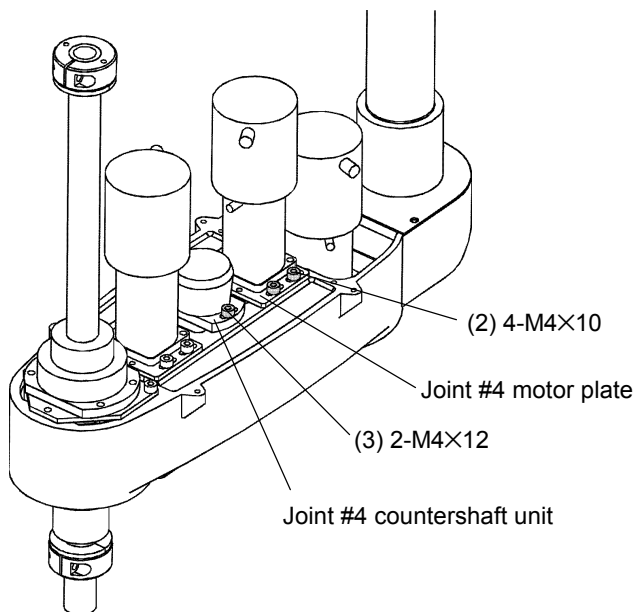
(2) 4-M4×10

Joint #4 motor plate

(3) 2-M4×12

Joint #4 countershaft unit

(3) Loosen the two bolts (M4×12) holding the Joint #4 countershaft unit.

(4) Remove the U2 belt from the small U2 pulley (the lower side).

Large U2 pulley

U1 belt

U2 belt
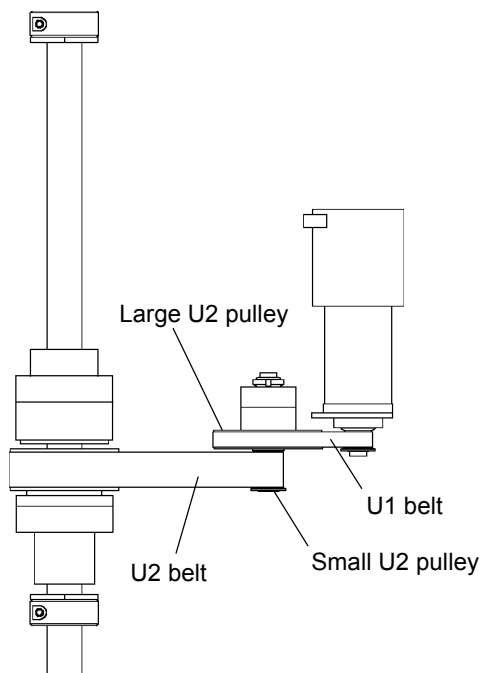
Small U2 pulley

(5) Remove the U1 belt from the large U2 pulley (the upper side).

Installation : U1 Belt

(1) Fit a new U1 belt around the U1 and the large U2 pulleys. And then, fit the U2 belt to the U2 small pulley. Ensure that the gear grooves of the belts and pulleys engage properly.
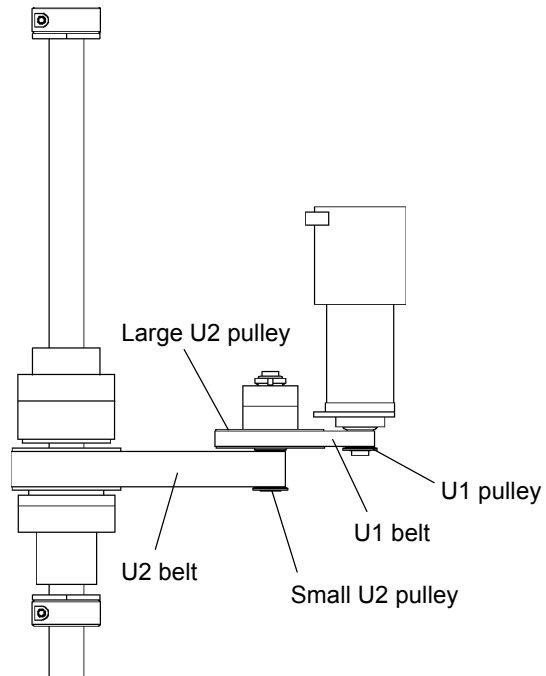
(2) Position the Joint #4 countershaft unit and Joint #4 motor plate on the arm. Be careful not to slip the belts from the pulleys while maintaining proper interval between the units. Mount them loosely for the time being using the following bolts: 2-M4×12 for the Joint #4 countershaft unit; 4-M4×10 for the Joint #4 motor plate.
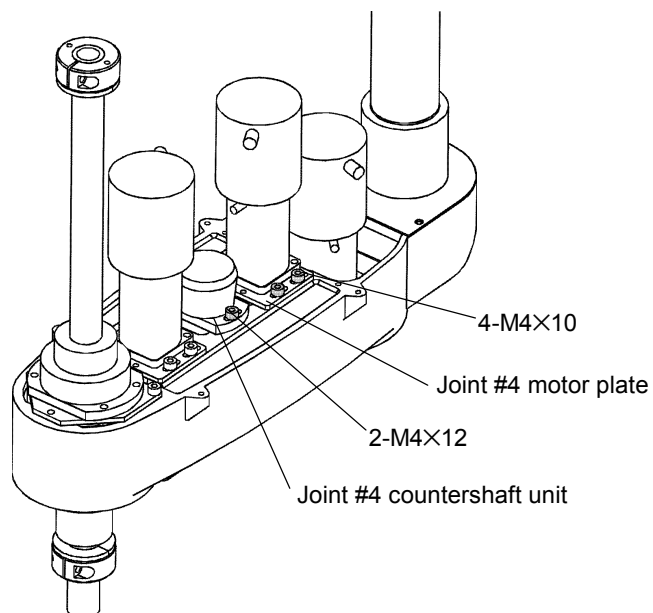
(3) Pass a suitable cord or string around the Joint #4 motor near the countershaft plate. Loosen the bolts for the Joint #4 countershaft plate fastened in the step (2) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf). Adjust in the range of 78N - 117N (8kgf - 12kgf).
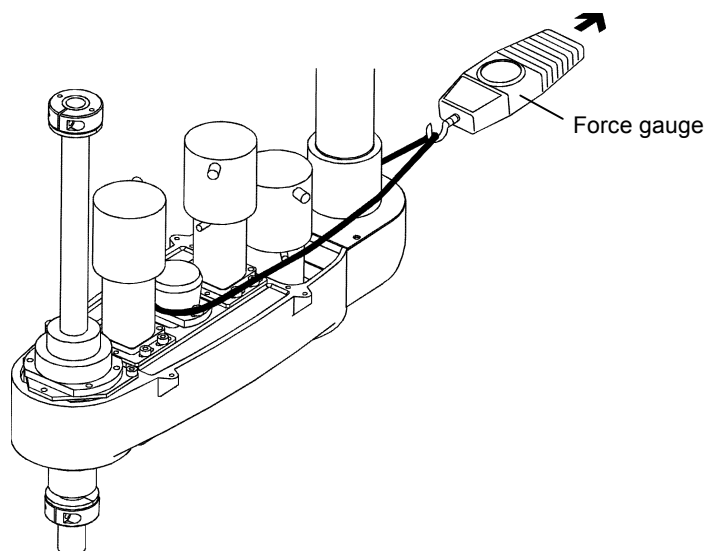
Force gauge

(4) Pass a suitable cord or string around the Joint #4 motor near its mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (2) and pull the cord using a force gauge or similar tool. Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 49N (5kgf). Adjust in the range of 29N - 68N (3kgf - 7kgf).


Force gauge
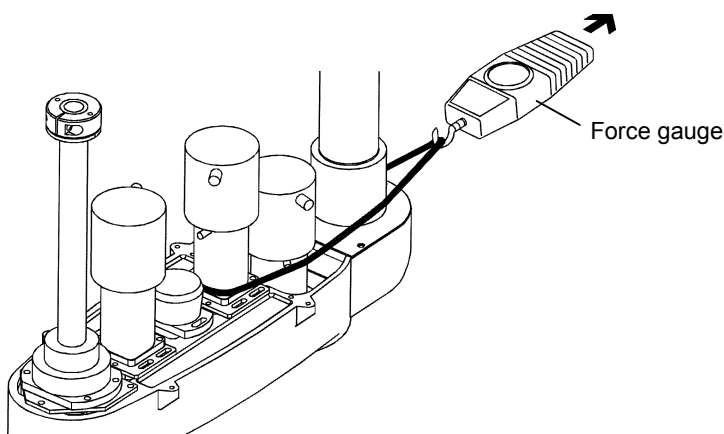
(5) Install the arm top cover and arm bottom cover. (Refer to chapter *2. Opening the Covers.*)

   * If the manipulator is a Protected model, seal the arm top cover and arm bottom cover. Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model*.

(6) The mechanical origin position and teach points change when the timing belts are replaced. Calibrate Joint #3 and Joint #4 as described in chapter *11. Calibration*.

8.3 Replacing the U2 Belt

Removal : U2 Belt

(1)　Remove the Joint #3 motor unit as described in *5.3 Replacing the Joint #3 Motor* steps (1) through (4).

(2)　Loosen the four bolts (M4×10) holding the Joint #4 motor plate.
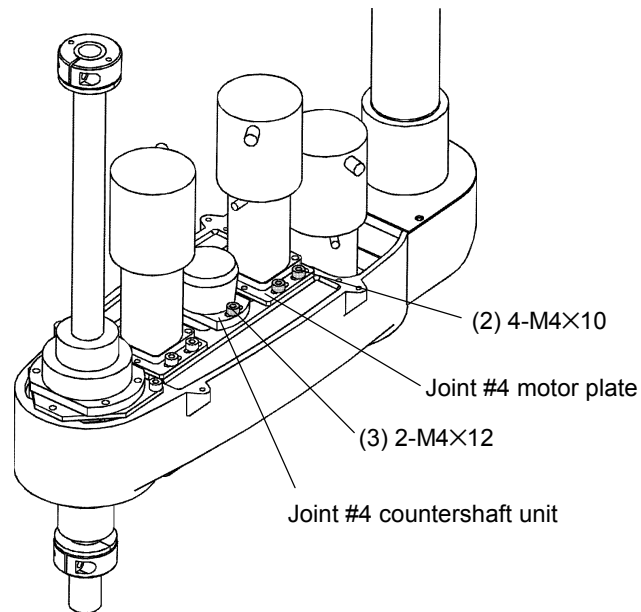
(2) 4-M4×10

Joint #4 motor plate

(3) 2-M4×12

Joint #4 countershaft unit

(3)　Loosen the two bolts (M4×12) holding the Joint #4 countershaft unit.

(4)　Remove the U2 belt from the small U2 pulley (the lower side).

Large U2 pulley

U1 belt

U2 belt

Small U2 pulley
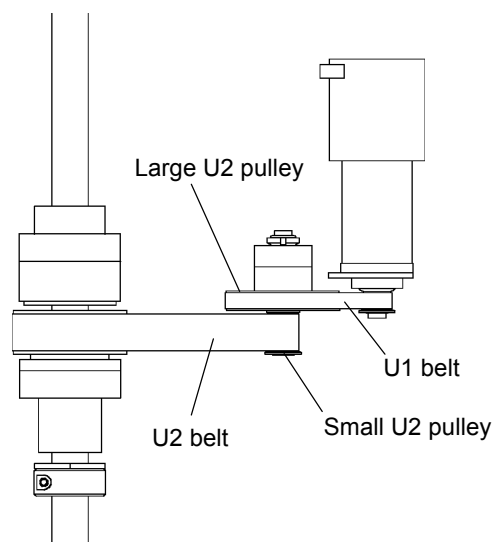
(5)   Remove the bolts (3-M4×10) from the spline plate.

M4×10
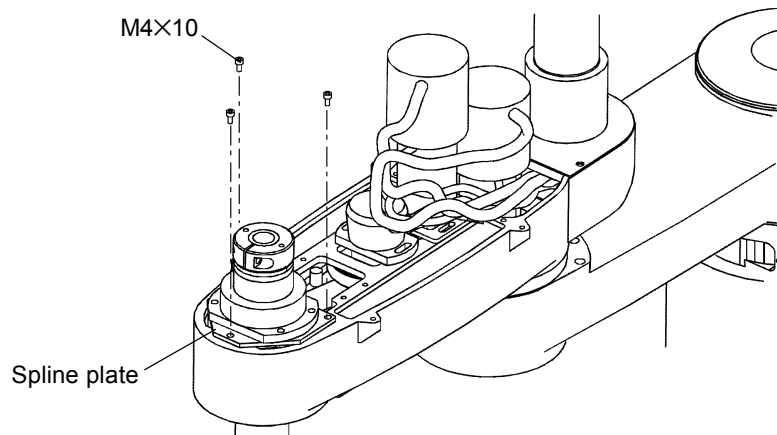
Spline plate

(6)   Lift the spline plate, and then extract the Z belt and the U2 belt from the shaft upward.
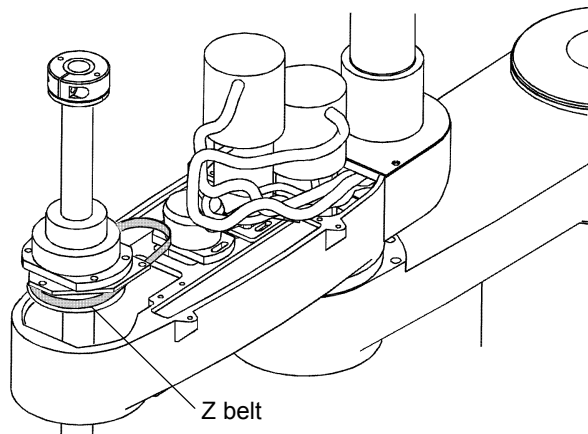
Z belt

Installation : U2 Belt

     (1)   Pass a new U2 belt and the Z belt through the shaft from above, and lift the spline plate to make those belts through.

     (2)   Place the Joint #3 motor unit in the arm.   The motor cables should be facing Joint #2.

     (3)   Fit the new U2 belt around the U3 and the small U2 pulleys.   And, fit the Z belt around the Z2 and the Z1 pulleys.   Ensure that the gear grooves of the belts and pulleys engage properly.
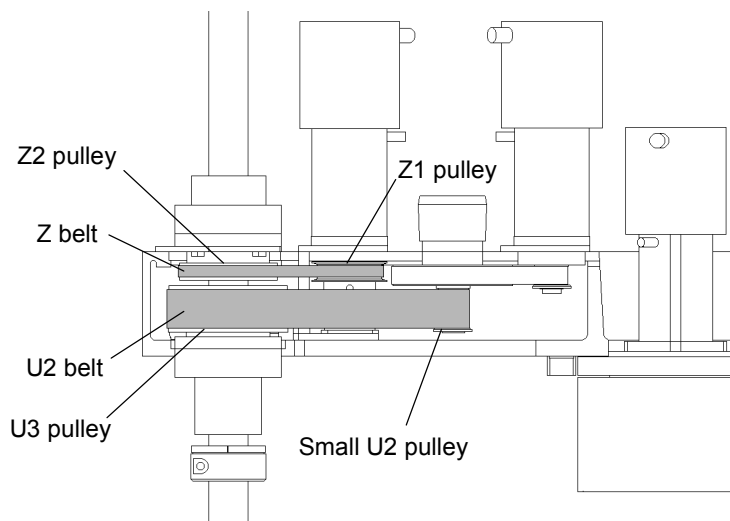
     (4)   Secure the spline plate with three bolts (M4×10).

   (5)   Position the Joint #3 motor plate, Joint #4 countershaft unit and Joint #4 motor plate on the arm.   Be careful not to slip the belts from the pulleys while maintaining proper interval between the units.   Secure them lossely for the time being using the following bolts: 4-M4×10 for the Joint #3 motor plate; 2-M4×12 for the Joint #4 countershaft unit; 4-M4×10 for the Joint #4 motor plate.

(6) Pass a suitable cord or string around the Joint #4 countershaft unit near its mounting plate.   Loosen the bolts for the Joint #4 countershaft plate fastened in the step (5) and pull the cord using a force gauge or similar tool.   Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf).   Adjust in the range of 78N - 117N (8kgf - 12kgf).

Force gauge

(7) Pass a suitable cord or string around the Joint #4 motor near its mounting plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (5) and pull the cord using a force gauge or similar tool.   Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 49N (5kgf).   Adjust in the range of 29N - 68N (3kgf - 7kgf).

Force gauge

165

(8) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (5) and pull the cord using a force gauge or similar tool.   Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf).   Adjust in the range of 20N - 39N (2kgf - 4kgf).

Force gauge

(9) Connect the connectors, X131, X31 and X32.   Fasten the cables with a wire tie on their original positions.   Do not push them forcibly.

(10) Install the arm top cover and arm bottom cover.   (Refer to chapter *2. Opening the Covers*.)

 * If the manipulator is a Protected model, seal the arm top cover and arm bottom cover.   Refer to the section *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(11) The mechanical origin position and teach points change when the timing belts are replaced.   Calibrate Joint #3 and Joint #4 as described in chapter *11. Calibration*.

9. Replacing the Ball Screw Spline Unit

⚠ WARNING	■ Only trained personnel should be allowed to maintain this unit.
	■ When replacing this unit, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in electric shock and malfunction.

NOTE
☞
When the motor and timing belts are removed while replacing the ball screw spline unit, the mechanical origin position and therefore teach points change.   (The mechanical origin position is offset from the position saved in the Control Unit's/Controller's memory.)   The operation to offset the mechanical origin position is called "calibration."

For calibration, the most suitable point to check the calibration accuracy must be selected from the teach points.   (Refer to chapter *11. Calibration*.)

Types of ball screw spline units

There are six types of the ball screw spline unit.   Specify the Z code when ordering a ball screw spline unit for replacement.

Name	Stroke of Joint #3	Specification	Old code	New code
Ball screw spline unit for Z170	170 mm	BNS2020A-385B	ZA001208	R13ZA00120800
Ball screw spline unit for Z320	320 mm	BNS2020A-535B	ZA001209	R13ZA00120900
Clean model Ball screw spline unit for Z150	150 mm	BNS2020A-385B+CL	ZA001216	R13ZA00121600
Clean model Ball screw spline unit for Z300	300 mm	BNS2020A-535B+CL	ZA001217	R13ZA00121700
Protected model Ball screw spline unit for Z150	150 mm	BNS2020A-385B+P	ZA001218	R13ZA00121800
Protected model Ball screw spline unit for Z300	300 mm	BNS2020A-535B+P	ZA001219	R13ZA00121900

Location of the ball screw spline unit

Ball screw spline unit
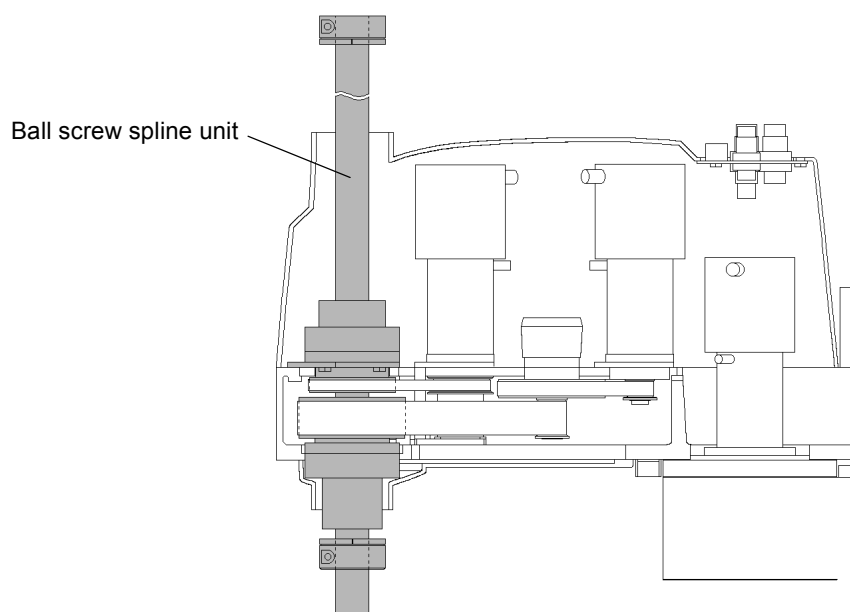
9.1 Replacing the Ball Screw Spline Unit

Removal

(1) Remove the end effector from the shaft.

   ∗ If the manipulator is a Clean model, remove the bellows. Refer to the section *12.2 Replacing the Bellows* in chapter *12. Clean Model Maintenance*.

   ∗ If the manipulator is a Protected model, remove the bellows. Refer to the section *13.8 Replacing the Bellows* in chapter *13. Protected Model Maintenance*.

(2) Remove the Joint #3 motor unit. Refer to section *5.3 Replacing the Joint #3 Motor* steps (1) through (4).

(3) Remove the Z and U2 belts from the shaft. Refer to section *8.3 Replacing the U2 Belt* steps (2) through (6).

(4) Remove the four bolts (M4×10) from the ball screw spline shaft under Arm #2.
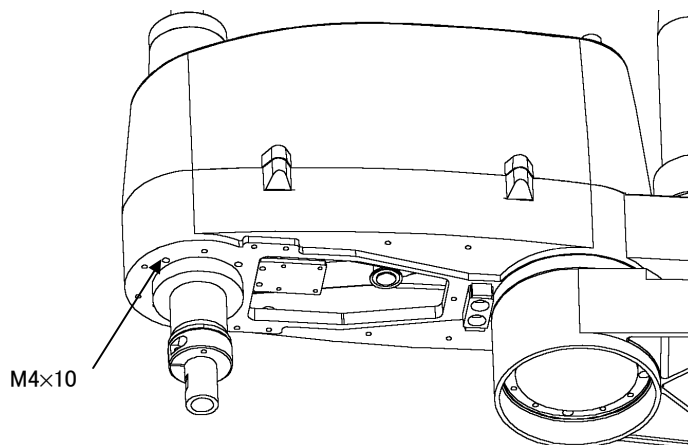
M4×10

(5) Pull the ball screw spline unit out of Arm #2.

Installation

(1) Fit the U2 and Z belts into the shaft of a new ball screw spline unit. Place the ball screw spline unit inside the arm.

(2) Tighten four bolts (M4×10) at the ball screw spline unit under the arm. Beware so that the timing belts will not be pinched between the nut and arm.
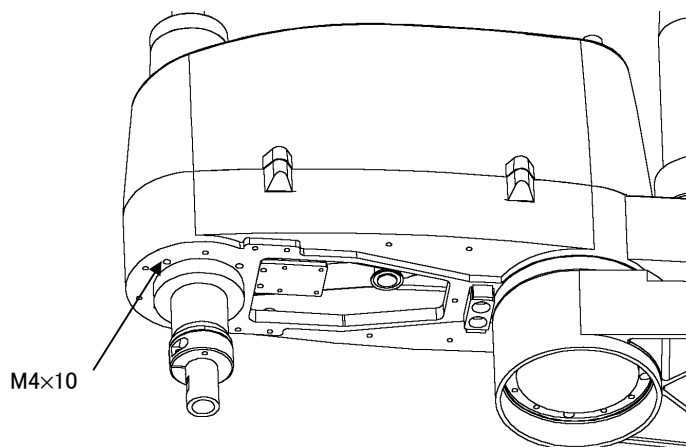
M4×10

(3) Temporarily tighten three bolts (M4×10) on the spline plate.

M4×10
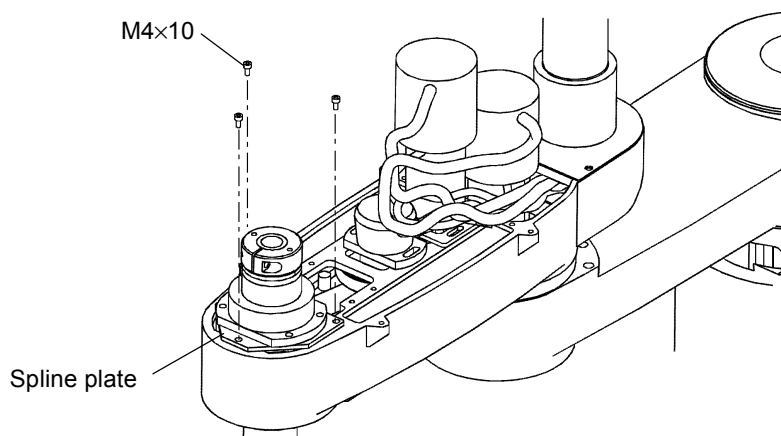
Spline plate

(4) Move the shaft up and down several times and tighten the bolts on the spline plate (temporarily tightened before) securely.

(5) Place the Joint #3 motor unit in the arm. The motor cables should be facing Joint #2.

(6) Fit the U2 belt around the U3 and small U2 pulleys. Fit the Z belt around the Z2 and
     Z1 pulleys. Ensure that the gear grooves of the belts and pulleys engage properly.
     Also, for the U1 belt around the U1 and rage U2 pulleys, ensure that the gear groves of
     the belt and pulleys are engaging properly.
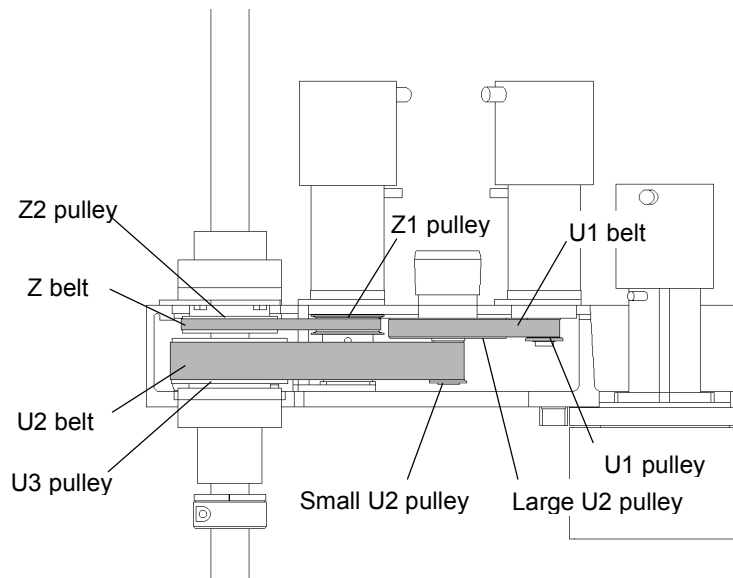
Z2 pulley

Z1 pulley   U1 belt

Z belt

U2 belt

U3 pulley   Small U2 pulley   Large U2 pulley   U1 pulley

(7) Position the Joint #3 motor plate, Joint #4 countershaft unit and Joint #4 motor plate
     on the arm. Be careful not to slip the belts from the pulleys while maintaining proper
     interval between the units. Mount them loosely for the time being using the following
     bolts: 4-M4×10 for the Joint #3 motor plate; 2-M4×12 for the Joint #4 countershaft
     unit; 4-M4×10 for the Joint #4 motor plate.

4-M4×10

Joint #4 motor plate

2-M4×12

Joint #4 countershaft unit

4-M4×10

Joint #3 motor plate

(8)   Pass a suitable cord or string around the Joint #4 countershaft unit near its mounting plate.   Loosen the bolts for the Joint #4 countershaft plate fastened in the step (7) and pull the cord using a force gauge or similar tool.   Fasten the Joint #4 countershaft securely where the U2 belt is pulled at 98N (10kgf).   Adjust in the range of 78N - 117N (8kgf - 12kgf).
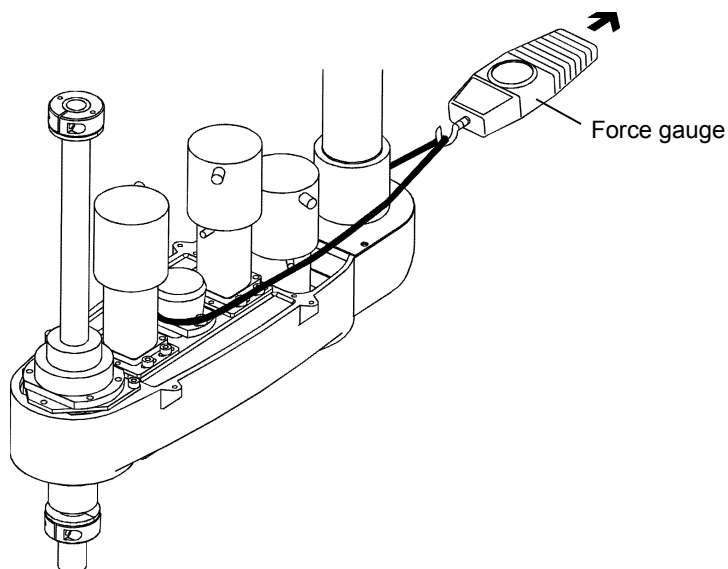
Force gauge

(9)   Pass a suitable cord or string around the Joint #4 motor near its mounting motor plate. Loosen the bolts for the Joint #4 motor plate fastened in the step (7) and pull the cord using a force gauge or similar tool.   Fasten the Joint #4 motor plate securely where the U1 belt is pulled at 49N (5kgf).   Adjust in the range of 29N - 68N (3kgf - 7kgf).

Force gauge

(10) Pass a suitable cord or string around the Joint #3 motor near its mounting plate. Loosen the bolts for the Joint #3 motor plate fastened in the step (7) and pull the cord using a force gauge or similar tool. Fasten the Joint #3 motor plate securely where the Z belt is pulled at 29.4N (3kgf). Adjust in the range of 20N - 39N (2kgf - 4kgf).

Force gauge

(11) Connect the connectors, X131, X31 and X32. Fasten the motor cables with wire ties in their original positions. Do not allow unnecessary strain on the cables.

(12) If the motion range of Joint #3 was limited by the lower-limit mechanical stop, change the position of lower-limit mechanical stop to the previous position. Refer to chapter *8. Motion Range and Robot Coordinates* in Part 1.

(13) Install the arm top cover and arm bottom arm cover. (Refer to chapter *2. Opening the Covers*.)

   ∗ If the manipulator is a Protected model, reseal the covers. For detail on sealing the covers, refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance.*

(14) Grease the shaft (refer to *Greasing the Ball Screw Spline Unit* on the next page).

   ∗ If the manipulator is a Clean model, attach the bellows to the manipulator. Refer to the section *Replacing the Bellows* in chapter *12. Clean Model Maintenance.*

   ∗ If the manipulator is a Protected model, attach the bellows to the manipulator. Refer to the section *Replacing the Bellows* in chapter *13. Protected Model Maintenance.*

(15) Install the end effector.

(16) The mechanical origin position and teach points change when the timing belts are replaced. Calibrate Joint #3 and Joint #4. Refer to chapter *11. Calibration.*

9.2 Greasing the Ball Screw Spline Unit

When greasing the ball screw spline unit, follow the procedure on this page.

* If the manipulator is a Clean model, refer to the section *Greasing the Ball Screw Spline Unit* in chapter *12. Clean Model Maintenance.*

* If the manipulator is a Protected model, refer to the section *Greasing the Ball Screw Spline Unit* in chapter *13. Protected Model Maintenance.*

RC+
SPEL 95

(1) Disengage the motors from servo control using the motor <OFF> button on the Robot Control Panel and keep the Drive Unit power ON.

300

(1) Disengage the motors by the MOTOR OFF command while keeping the Controller power ON.

(2) Move the arm to a position where Joint #3 can be moved in full stroke. If necessary, cover the surrounding area so that grease will not damage the end effector and peripheral equipment, etc.

(3) Lower the shaft manually to its lower limit while pushing the Joint #3 brake release button.
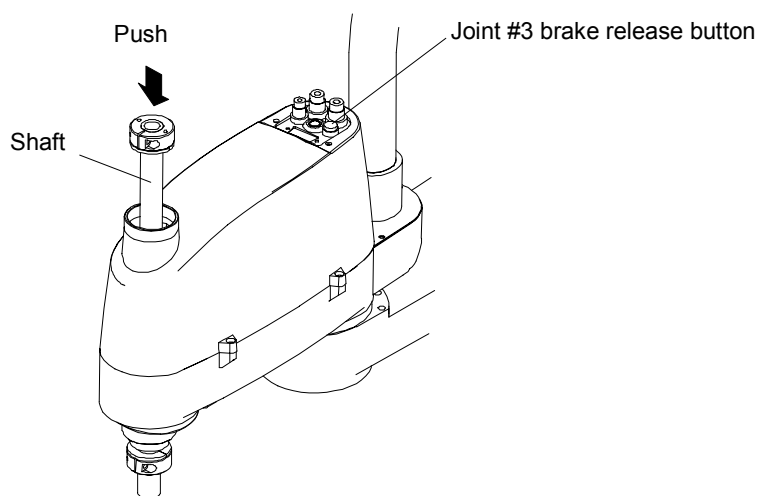
(4) Fill the grooves on the lower end of the shaft with grease.

(5) Raise the shaft manually to its upper limit while pushing the brake release button.

(6) Fill the grooves on the upper end of the shaft with grease.

(7) Move the shaft up and down several times to smooth out the grease on the shaft. Wipe off excess grease.

10. Replacing the Signal Relay Board

⚠ **WARNING**
- Only trained personnel should be allowed to maintain this board.
- When replacing this board, make sure the power is turned off and pull out the power plug from the power source. Failure to turn off the power can result in electric shock and malfunction.

NOTE
☞ Before turning OFF the power for the replacement, keep the power of the manipulator ON for more than 30 minutes. It is necessary for the super-capacitor of each motor to retain the position data.

The charged motor can retain the position data for about 2 hours after its cable is disconnected. (Motors whose serial number start with "0" can retain the data for about 2 days.)

The position data cannot be retained beyond the time duration mentioned above after which it will be lost. If this happens, Error 5016/Error 195 will occur when the power is turned ON. In this case, all the joints need to be calibrated all over again. (Refer to chapter *11. Calibration*.)

10.1 Replacing the Signal Relay Board

∗ If the manipulator is a Protected model, refer to the section *Replacing the Signal Relay Board* in *13. Protected Model Maintenance*.

Removal

(1) Disconnect cables from the base connector plate. Open the base connector plate forward. (Refer to chapter *2. Opening the Covers*.)

(2) Remove all connectors from the signal relay board. Open up the top and bottom clips and pull off connectors, X10, X20, X30, X40, and X50.

(3) Remove the four screws (M3×6) from the signal relay board on the base connector plate and remove the relay board.

M3×6
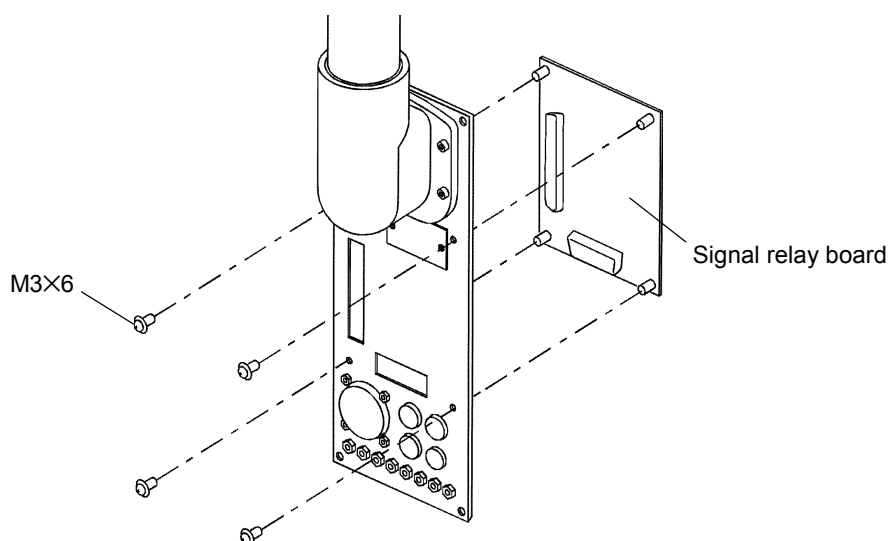
Signal relay board

Installation

(1) Install a new signal relay board onto the base connector plate with four M3×6 screws.
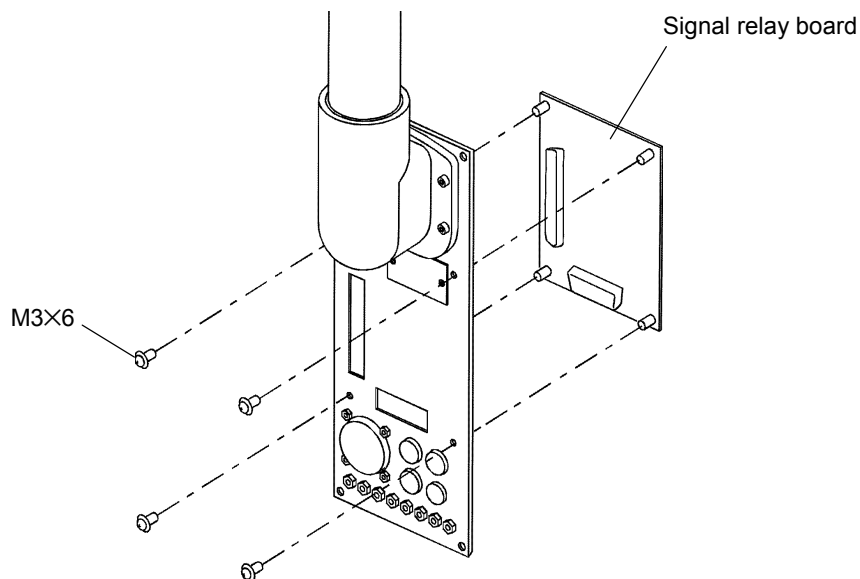
(2) Securely connect the connectors, X10, X20, X30, X40, and X50.

⚠ CAUTION	■ Be sure to connect the signal connectors securely. Do not bend the cables sharply or damage them in any way. Abnormal signals may cause the malfunction of the robot.

(3) Mount the base connector plate on the back of the manipulator. (Refer to chapter *2. Opening the Covers*.)

(4) Connect the cables to the base connector plate.

(5) Turn ON the Controller power and test it with a few teach points to make sure that the teach positions have not been offset. When you have confirmed that the position data has been retained, replacement is completed. If there is any position found to be offset, calibrate the manipulator by referring to chapter *11. Calibration*.

10.2 Replacing the Lithium Battery

When the lithium battery power is low, an error will occur when EPSON RC+ / SPEL 95(SRC5**) / SRC-3** starts to warn the user about the low battery status.   When this happens, the position data of the motors will be lost and all the joints need to be calibrated all over again (refer to chapter *11. Calibration*).

The life for a lithium battery is 3 years.   Even if the manipulator is constantly connected to power, it is necessary to replace the lithium battery every 3 years.

NOTE

☞

The manipulator must be connected to power for more than 30 minutes before the lithium battery is to be replaced.

Each motor's super-capacitor must be charged to retain position data in memory.   The motor can retain position data for about 2 hours after being disconnected from the battery on the signal relay board.   (The motors for those manipulators whose serial number starts with "0" can retain position data for about 2 days.)   If the motor is disconnected from the battery for more than the above hold-time, the position data will be lost and errors will occur when software is started.

    RC+   : Error 5016
    SPEL 95   : Error 5016
    SRC-3**   : Error 195

When this happens, all the joints must be recalibrated (refer to chapter *11. Calibration*).

Removal

(1)   Disconnect cables from the base connector plate.   Open the base connector plate forward.   (Refer to chapter *2. Opening the Covers*.)

(2)   Remove the four screws (M3×6) from the signal relay board on the base connector plate and remove the relay board.   Pull out the signal relay board carefully so as not to stretch or bend the cables since the cables and connectors are still connected to it. Pulling it too hard may cause cable disconnection.

(3)   Disconnect the X4 connector of the battery unit from the board.   Cut off the wire ties securing the lithium battery unit to remove it.
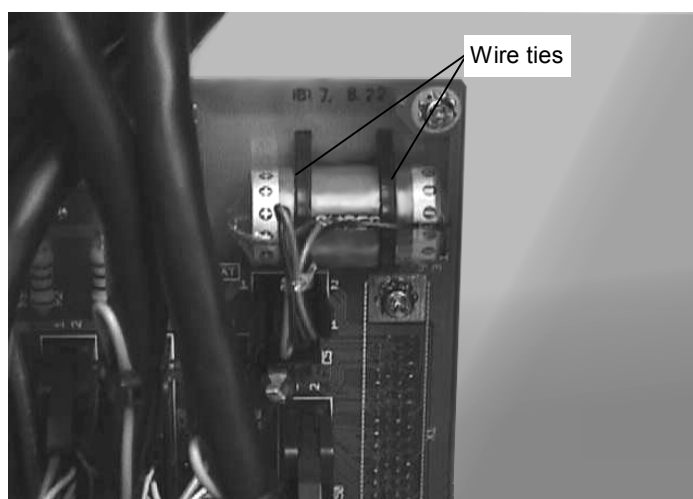
Installation

(1) Connect the X4 connector of the new battery unit.

(2) Using two wire ties, secure the battery unit to the board.
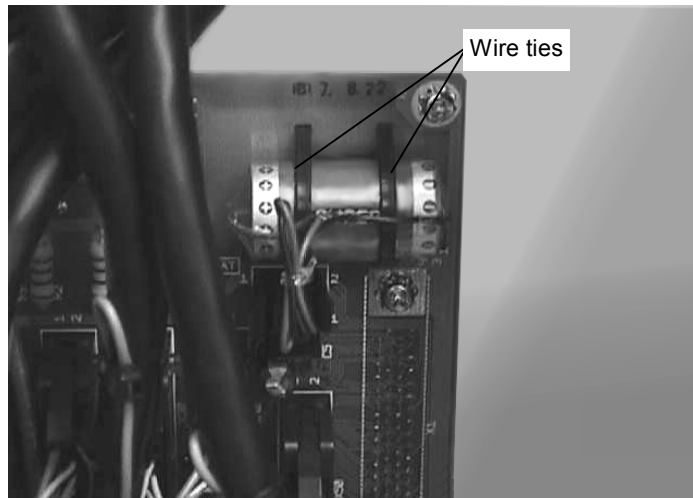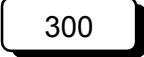
(3) Using four screws (M3×6), install the signal relay board onto the base connector plate.

(4) Mount the base connector plate to the manipulator base. (Refer to chapter *2. Opening the Covers*.)

    ∗ If the manipulator is a Protected model, reseal the base connector plate. Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.

(5) Connect the cables to the base connector plate.

(6) Turn ON the Drive Unit / Controller power and test it with a few teach points to make sure that the teach positions have not been offset. When you have confirmed that the position data has been retained, replacement is completed. If there is any position found to be offset, calibrate the manipulator by referring to chapter *11. Calibration*.

11. Calibration

The electrical and mechanical origins for each joint motor must be calibrated to ensure proper operation of the robot. The origin position changes when motors are replaced or belts are adjusted, and the previously used teach points are lost.
The process of realigning the origin position is called "origin calibration".

This chapter includes calibration instructions for three different controller types, designated by the following icons:

| RC+ | Procedure when using EPSON RC+ Robot Control System.

| SPEL 95 | Procedure when using SPEL 95 / SRC5** controllers.

| 300 | Procedure when using SRC-3** controllers.

Refer to section in this chapter that pertains to the controller you are using.

11.1 Calibration for EPSON RC+ Controller

Refer to the EPSON RC+ on-line help for details of commands used in this section.

During the following steps, you may have to open the safeguard to gain access to the manipulator, depending on the system setup. With the safeguard open, the manipulator motors will turn OFF unless attend mode is ON. When executing Monitor Window commands, attend mode must be OFF.

Common procedure for calibration

RC+

For both the ES and EL series manipulators, calibration steps (1) to (10) are the same for all four joints.

(1) Turn ON the power of the RC520 Drive Unit and RC520 PC Control Unit after moving all joints to within motion range. Check if an error occurs. If an error does not occur, proceed to next step.

Error F-5001 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new. To change the capacitor, leave the power ON for 3 or more minutes.

(2) Manually move joints to be calibrated into approximately the 0 pulse position.

Joint #1 : 0 pulse position : aligned with X-axis in robot coordinate system
(See figure below).
Joint #2 : 0 pulse position : parallel with Arm #1 (i.e., straight) regardless of Joint #1 direction.
Joint #3 : 0 pulse position : uppermost position in working area.
Joint #4 : 0 pulse position : flat surface on the shaft facing in the top of Arm #2 direction.

(Rear)

(3) Open the acrylic plate on the sensor monitor on the base connector plate.

NOTE 👉 For protected models, remove four bolts (M3×8) from the encoder reset cover and open the cover on the base connector plate.   The encoder reset cover has an O-ring that must not be lost.   (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(4) Set the DIP switch bits corresponding to the joints to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second.

(6) Right click on the SPEL Runtime Drivers system tray icon and select Restart SPEL Drivers.   Open the [Robot Control Panel] dialog and click the Motor <ON> button. Error F-5136 will be displayed.   Click the <RESET> button.   The error should clear.

(7) Return all DIP switch bits to the OFF position.

(8) Close the acrylic plate on the sensor monitor.

NOTE 👉 For protected models, attach the O-ring to the encoder reset cover and fasten the cover to the base connector plate with four bolts (M3×8).   (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(9) Visually determine the current position, and enter that as the 0 pulse position using the CALPLS command.

```
> CALPLS 0,0,0,0
```

(10) Execute CALIB commands for the joints requiring point alignment.

<Example>
```
> CALIB 1                          ' Calibrate Joint #1.
```

From this point forward, the method used for Joint #3 differs from that used with Joint #1, #2 and #4.   To continue, refer to the corresponding section below.

NOTE 👉 Joint #3 should be calibrated before other joints. Joint #3 can interfere with the calibration of other joints if it is too low.

Calibrating Joint #3

RC+

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control.   Because of the error due to origin offset, the same position will not be obtained.   Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #3 motor: ±13.4 mm
One revolution of the Joint #4 motor: ±22.5°

We will use P1 in these steps.   Move Joint #3 above this point using the JUMP command.
<Example>

```
> JUMP P1:Z(0)                    ' Set Joint #3 high to prevent interference with
                                    surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>
```
> PLIST 1
P1 = [A], [B], [C], [D] /0
```

(13) Calculate the number of Joint #3 pulses at this point from the coordinate value that was noted in step (11).   Multiply [C] by the Joint #3 resolution (307.2 pulse/mm) and round off after the decimal point.   This value is called [E].

```
[E] = [C] × 307.2  (Round E off after the decimal point)
```

(14) Substitute the [E] value using the CALPLS command and input.   [E] is always negative.

```
> CALPLS 0,0,[E],0
```

(15) Using the Jog & Teach dialog, jog Joint #3 to the original position.

(16) Execute the CALIB command for Joint #3.

```
> CALIB 3
```

(17) Display the number of pulses at this position using the PULSE command and check that it matches the value of [E] obtained in step (13) above.

<Example>
```
>PULSE
PULSE: [a] pls [b] pls [c] pls [d] pls
```

(18) Move to another teach point and check the position.

Calibrating Joint #1, #2, and #4

RC+

Joint #1, #2 and #4 are all calibrated by the same method.   Calibrating two or more joints at the same time can affect accuracy.   For best accuracy, calibrate each joint one at a time.

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) For each joint, select a current teach point that is easy to verify for accuracy, and move the robot to that point using servo control.   Because of the error due to origin offset, the same position will not be obtained.   Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #4 motor: ±22.5°

We will use P1 in these steps.   Move Joint #3 above this point using the JUMP command.
<Example>
```
> JUMP P1:Z(0)                   ' Set Joint #3 high to prevent interference with
                                   surrounding machinery.
```

(12) Display the number of pulses at this position using the PULSE command and note the four values.

<Example>
```
> PULSE
PULSE 16000 pls 10000 pls     0 pls    -10 pls
```

(13) Enter the numbers noted in step (12) using the CALPLS command.

<Example>
```
> CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the joint being calibrated and Joint #3.

<Example>
```
> SFREE 1,3                      ' Joints #1 and #3 can now be moved manually.
```

(15) Manually move the joint to be calibrated, and determine the proper original position. When moving Joint #3, move while pushing the Joint #3 break release button.

(16) Execute the CALIB command for the joint to be calibrated.

<Example>
```
>CALIB 1                         ' Joint #1 is calibrated.
```

(17) Display the number of pulses in this position using the PULSE command and check that they match the values obtained in step (12) on previous page.

<Example>
```
>PULSE
PULSE: 16000  pls 10000 pls    0  pls   -10  pls.
```

(18) Restore servo control to the calibrated joint with the SLOCK command.

<Example>
```
>SLOCK 1,3                         ' Joints #1 and #3 is under servo control.
```

(19) Move to another teach point and check the position.

Accurate calibration of Joint #2

RC+

For accurate calibration of Joint #2, calculation of robot working point coordinates is most important in the following cases.

- ◆ Entering coordinate values to register the teach point. (MDI teaching)

- ◆ Switching the arm orientation between right and left at a given point.

- ◆ Using the PALLET command.

- ◆ During CP control (such as linear or circular interpolation).

- ◆ Using the LOCAL command.

- ◆ For statements using relative coordinates < Example, P1+X100 >.

If the methods above require accuracy of Joint #2, then calibrate for both right and left arm orientations.   Note that this method cannot be used if Joint #4 has excessive run-out.

(1) Display HOFS values using the HOFS command and note the [A], [B], [C], and [D] values.

<Example>
```
>HOFS
 [A], [B], [C], [D]          ' HOFS values for Joint #1 - #4.
```

(2) Select a point for teaching that is within the region accessible to both right and left arm and is easy to verify for accuracy.   Define P1 using the following statement.

<Example>
```
> P1=P*
```

(3) Display the number of pulses at the P1 position using the PULSE command.   Note the Joint #2 value [F1].

<Example>
```
> PULSE
PULSE: [E] pls [F1] pls [G] pls [H] pls
```

(4) Switch positioning of left and right orientation and move to the same point.

<Example>

```
> MOTOR ON
> JUMP P1:Z(0)/L          ' To change from right to left orientation.
                          ' (Use /R at end of statement for left to right)
> SFREE                   ' All joints can now be moved manually.
```

(5) The position in left orientation mode is different from the position in right orientation mode.   This gap must be adjusted manually after lowering Joint #3 to P1 position.   In order to lower Joint #3 to P1, push Joint #3 down while pushing the brake release button.   Then execute SLOCK.

```
> SLOCK                   ' All joints are under servo control.
```

(6) Display the number of pulses at the P1 position again using PULSE, and note the Joint #2 value [F2].

<Example>

```
> PULSE
PULSE: [E] pls [F2] pls [G] pls [H] pls
```

(7) Calculate the new HOFS value from the values that were noted: add the left and right pulse numbers [F1] and [F2], then add to [B] in step (1) on previous page, and take the mid-way value.   Incorporate + and - signs in the calculation.   The new HOFS value is called [I].

```
> I = B + (F1 + F2) / 2
```

(8) Substitute [I] in the HOFS command and execute.   For other joint values, use the values that were noted in step 1 above.

```
> HOFS [A], [I], [C], [D]
```

(9) Move to another teach point and confirm the position.

11.2 Calibration for SPEL 95 / SRC5** Controller

Refer to the on-line help of SPEL 95 for details of commands used in this section.

Common procedure for calibration

SPEL 95

For both the ES and EL series manipulators, calibration steps (1) to (10) are the same for all four joints.

(1) Turn ON the power of the robot after moving all joints into the motion range. Confirm that an error occurs.   If an error does not occur, proceed to next step.
Error F-5001 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new.   To change the capacitor, leave the power on for 3 or more minutes.   (The error display does not change.)

(2) Manually move joints to be calibrated into approximately the 0 pulse position.

Joint #1 : 0 pulse position :   aligned with X-axis in robot coordinate system (See the figure below).

Joint #2 : 0 pulse position :   parallel with Arm #1 (i.e., straight) regardless of Joint #1 direction.

Joint #3 : 0 pulse position :   uppermost position in working area.

Joint #4 : 0 pulse position :   flat surface on the shaft facing in the top of Arm #2 direction.

(Rear)

(3) Open the acrylic plate on the sensor monitor on the base connector plate.

NOTE ☞ For protected models, remove four bolts (M3×8) from the encoder reset cover and open the cover on the base connector plate.   The encoder reset cover has an O-ring that must not be lost.   (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(4) Set the DIP switch bits corresponding to the joints to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second. (The error display does not change.)

(6) Exit SPEL 95, and then start it again.   Open the [Robot Control Panel] dialog and click the Motor <ON> button.   Error F-5136 will be displayed.   Click the <RESET> button.   The error should clear.

(7) Return all DIP switch bits to the OFF position.

(8) Close the acrylic plate on the sensor monitor.

NOTE ☞ For protected models, attach the O-ring to the encoder reset cover and fasten the cover to the base connector plate with four bolts (M3×8).   (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(9) Visually determine the current position, and enter that as the 0 pulse position with the CALPLS command

```
> CALPLS 0,0,0,0
```

(10) Execute the CALIB command for the joints requiring point alignment.

```
<Example>
>CALIB 1                              ' Calibrate Joint #1.
```

From this point forward, the method used for Joint #3 differs from that used with Joint #1, #2 and #4.   To continue, refer to the corresponding section below.

NOTE ☞ Joint #3 should be calibrated before other joints.   Joint #3 can interfere with the calibration of other joints if it is too low.

Calibrating Joint #3

SPEL 95

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control.

Because of the error due to origin offset, the same position will not be obtained. Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Joint #1 motor: ±4.5°
One revolution of the Joint #2 motor: ±7.2°
One revolution of the Joint #3 motor: ±13.4 mm
One revolution of the Joint #4 motor: ±22.5°

We will use P1 in these steps. Move Joint #3 above this point using the JUMP command.
<Example>
```
>JUMP P1:Z(0)                    'Set Joint #3 high to prevent interference with
                                  surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>
```
>PLIST 1
P1=[A],[B],[C],[D]
```

(13) Calculate the number of Joint #3 pulses at this point from the coordinate value which was noted in step (12). Multiply [C] by the Joint #3 resolution (307.2 pulse/mm) and round off after the decimal point. This value is called [E].

[E] = [C] × 307.2 (Round E off after the decimal point)

(14) Substitute the [E] value using the CALPLS command and input. [E] is always negative.
```
>CALPLS 0,0,[E],0
```

(15) Move Joint #3 with the jog key and determine the proper original position.

(16) Execute the CALIB command for Joint #3.
```
>CALIB 3
```

(17) Display the number of pulses at this position using the WHEREE command and check that it matches the value of [E] obtained in step (13) above.

<Example>
```
>WHERE
Pulse 1:[a] 2:[b] 3:[c] 4:[d]        'Joints #1 - #4 pulses.
```

(18) Move to another teach point and check the position.

Calibrating Joint #1, #2, and #4

SPEL 95

Joint #1, #2, and #4 are all calibrated by the same method.   Calibrating two or more joints at the same time can affect accuracy.   For best accuracy, calibrate each joint one at a time.

First, perform steps (1) to (10) in the Common procedure for calibration section.

(11) For each joint, select a current teach point that is easy to verify for accuracy, and move the robot to that point using servo control.   Because of the error due to origin offset, the same position will not be obtained.   Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the joint #1 motor: ±4.5°
One revolution of the joint #2 motor: ±7.2°
One revolution of the joint #4 motor: ±22.5°

We will use P1 in these steps.   Move Joint #3 above this point using the JUMP command.

<Example>
```
> JUMP P1:Z(0)                   ' Set Joint #3 high to prevent interference with
                                   surrounding machinery.
```

(12) Display the number of pulses at this position using the WHERE command and note the four values.

<Example>
```
> WHERE
pulse 1:16000  2:10000  3:0  4:-10    ' Joints #1 - #4 pulses.
```

(13) Enter the numbers noted in step 12 using the CALPLS command.

<Example>
```
>CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the joint being calibrated and Joint #3.

<Example>
```
> SFREE 1,3                   ' Joints #1 and #3 can now be moved manually.
```

(15) Manually move the joint to be calibrated, and determine the proper original position. When moving Joint #3, move while pushing the joint #3 break release button.

(16) Execute the CALIB command for the joint to be calibrated.

<Example>
```
>CALIB 1                   ' Joint #1 is calibrated.
```

(17) Display the number of pulses at this position using the WHERE command and check that they match the values obtained in step (12) above.

<Example>
```
>WHERE
  Pulse 1:16000  2:10000  3:0  4:-10   'Joints #1 - #4 pulses.
```

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(18) Use the SLOCK command to put the free joints back under servo control.

<Example>
>SLOCK 1,3   ' Joints #1 and #3 are under servo control

(19) Move to another teach point and check the position.

Accurate calibration of Joint #2

SPEL 95

For accurate calibration of Joint #2, calculation of robot working point coordinates is most important in the following cases.

- ◆ Entering coordinate values to register working point for teaching. (MDI teaching)

- ◆ Switching the arm mode between right and left at a given point.

- ◆ Using the PALLET command.

- ◆ During CP control (such as liner or circular interpolation).

- ◆ Using the LOCAL command.

- ◆ For statements using relative coordinates < Example, P1+X100 >.

If the above methods do not obtain the required accuracy of Joint #2, calibrate for both right and left arm orientations.   Note that this method cannot be used in the event of run-out due to rotation of Joint #4.

(1) Display HOFS values using the HOFS command and note the [A], [B], [C], and [D] values.

<Example>
>HOFS
[A]   [B]   ' HOFS values for Joints #1 and #2.
[C]   [D]   ' HOFS values for Joints #3 and #4.

(2) Select a point for teaching that is within the region accessible to both right and left orientation and is easy to verify for accuracy.   Define P1 using the following statement.

<Example>
>P1=P*

(3) Display the number of pulses at the P1 position using the WHERE command.   Note the Joint #2 value [F1].

<Example>
> WHERE
Pulse 1:[E] 2:[F1] 3:[G] 4:[H]   ' Joints #1 - #4 pulses.

(4) Switch positioning of left and right orientation and move to the same point.

<Example>
> MOTOR ON
> JUMP P1:Z(0)/L   ' To change from right to left orientation.
                          ' (/R at end of statement for left to right)
> SFREE   ' All joints can now be moved manually.

(5) The position in left orientation mode is different from the position in right orientation mode.   This gap must be adjusted manually after lowering Joint #3 to P1 position.   In order to lower Joint #3 to P1, push Joint #3 down while pressing the brake release button.   Then execute SLOCK.

```
> SLOCK                           '  All joints are under servo control.
```

(6) Display the number of pulses at the P1 position again using WHERE, and note the Joint #2 value `[F2]`.

<Example>
```
> WHERE
Pulse 1:[E]  2:[F2]  3:[G]  4:[H]      'Joints #1 - #4 pulses.
```

(7) Calculate the new HOFS value from the values that were noted: add the left and right pulse numbers `[F1]` and `[F2]`, add to `[B]` in step 1 above, and take the mid-way value.   Incorporate + and - signs in the calculation.   The new HOFS value is called `[I]`.

```
> I = B + (F1 + F2) / 2
```

(8) Substitute `[I]` using the HOFS command and input.   For other joint values, use the values that were noted in step (1) on previous page.

```
> HOFS [A],[I],[C],[D]
```

(9) Move to another teach point and confirm the position.

11.3 Calibration for SRC-3** Controllers

Refer to the SPEL for Windows online help for details on the commands used in this section.

Common procedure for calibration

300

For both the ES and EL series manipulator, calibration steps (1) to (10) are the same for all four axes.

(1) Turn ON the power of the controller after moving all axes into the motion range. Confirm that an error occurs.   If an error does not occur, proceed to next step.
Error 195 occurs when the capacitor in the motor encoder is insufficiently charged because, for example, the motor is new.   To change the capacitor, leave the power ON for 3 or more minutes.

(2) Manually move axes to be calibrated into approximately the 0 pulse position.

Axis #1 : 0 pulse position   :   aligned with X-axis in robot coordinate system
                                               (See the figure below).
Axis #2 : 0 pulse position   :   parallel with Arm #1 (i.e., straight) regardless of axis
                                               #1 direction.
Axis #3 : 0 pulse position   :   uppermost position in working area.
Axis #4 : 0 pulse position   :   flat surface on shaft tip facing in the top of arm #2
                                               direction.
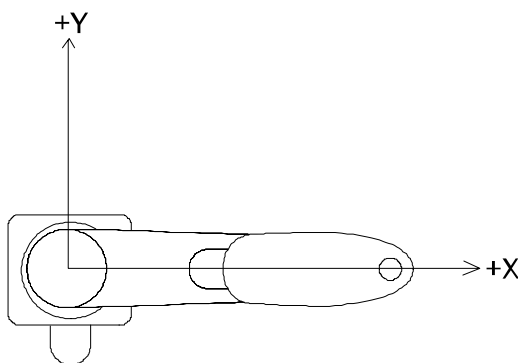
(Rear)

(3) Open the acrylic plate on the sensor monitor on the base connector plate.
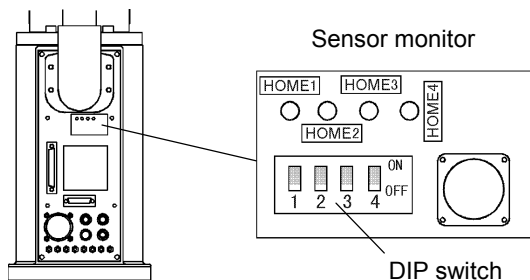
NOTE

For protected models, remove four bolts (M3×8) from the encoder reset cover and open the cover on the base connector plate.   The encoder reset cover has an O-ring that must not to be lost.   (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(4) Set the DIP switch bits corresponding to the axes to be calibrated to the ON position.

(5) Hold down the reset switch for at least one second. (The error display does not change.)

(6) Turn the controller power OFF and ON again. Error 165 will be displayed. Repeat power cycle.   The error should clear.

(7) Return all DIP switch bits to the OFF position.

NOTE

☞ For protected models, attach the O-ring to the encoder reset cover and fasten the cover to the base connector plate with four bolts (M3×8). (Refer to *Sealing the Manipulator* in chapter *13. Protected Model Maintenance*.)

(8) Close the acrylic plate on the sensor monitor.

(9) Visually determine the current position, and enter that as the 0 pulse position with the CALPLS command.

```
> CALPLS 0,0,0,0
```

(10) Execute CALIB commands for axes requiring point alignment.
     <Example>

```
>CALIB 1                    ' Calibrate Axis #1.
```

From this point forward, the method used for the Axis #3 differs from that used with Axis #1, #2 and #4.

NOTE

☞ The Axis #3 should be calibrated before other axes. The Axis #3 can interfere with the calibration of other axes if it is too low.

Calibrating Axis #3

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) Select a current teach point, which is easy to verify for accuracy, and move the robot to that point using servo control.   Because of the error due to origin offset, the same position will not be obtained.   Although the error is less than one revolution of the motor, care should be taken to avoid interference with surrounding machinery.

One revolution of the Axis #1 motor: ±4.5°
One revolution of the Axis #2 motor: ±7.2°
One revolution of the Axis #3 motor: ±13.4 mm
One revolution of the Axis #4 motor: ±22.5°

We will use P1 in these steps.   Move Axis #3 above this point using the JUMP command.
 <Example>

```
> JUMP P1:Z0                          ' Set the Axis #3 high to prevent interference
                                        with surrounding machinery.
```

(12) Display the coordinates of this position with the PLIST command and note the [C] value.

<Example>
```
> PLIST 1
P1 = [A], [B], [C], [D] /0
```

(13) Calculate the number of Axis #3 pulses at this point from the value which was noted in step (12).   Multiply the [C] by Axis #3 resolution (307.2 pulse/mm) and round off after the decimal point.   This value is called [E].

 `[E] = [C] × 307.2` (Round E off after the decimal point)

(14) Substitute the [E] value in the CALPLS command and execute.   [E] is always negative.

```
> CALPLS 0,0,[E],0
```

(15) Move Axis #3 with the jog key and determine the proper original position.

(16) Execute the CALIB command for Axis #3.

```
>CALIB 3
```

(17) Display the number of pulses at this position using the PULSE command and check that it matches the value of `[E]` obtained in step (13) above.

<Example>
```
> PULSE
[a]   [b]                          ' Axes #1 and #2 pulses.
[c]   [d]                          ' Axes #3 and #4 pulses.
```

(18) Move to another teach point and check the position.

Calibrating Axes #1, #2, and #4

300

Axes #1, #2, and #4 are all calibrated by the same method.   Calibrating two or more Axes at the same time can affect accuracy.   For best accuracy, calibrate each axis one at a time.

First, perform steps (1) to (10) in the *Common procedure for calibration* section.

(11) For each axis, select a current teach point that is easy to verify for accuracy, and move to that point.   Because of the error due to origin offset, the same position will not be obtained.   Although the error is less than one revolution of the motors, care should be taken to avoid interference with surrounding machinery.

One revolution of Axis #1 motor: ±4.5°
One revolution of Axis #2 motor: ±7.2°
One revolution of Axis #4 motor: ±22.5°

We will use P1 in these steps.   Move Axis #3 above this point using the JUMP command.
 <Example>
```
> JUMP P1:Z0
```
' Set Axis #3 high (Z0) to prevent interference with surrounding machinery.

(12) Display the number of pulses in this position using the PULSE command and note the four values.

<Example>
```
> PULSE
16000  10000
    0    -10
```
' Axes #1 and #2 pulses.
' Axes #3 and #4 pulses.

(13) Enter the numbers which were noted in step (12) using the CALPLS command.

 <Example>
```
> CALPLS 16000,10000,0,-10
```

(14) Use the SFREE command to free the axis being calibrated and Axis #3.

<Example>
```
> SFREE 1,3
```
' Axes #1 and #3 can now be moved manually.

(15) Manually move the axis to be calibrated, and determine the proper original position. When moving Axis #3, move while pushing the brake release button for Axis #3.

(16) Execute the CALIB command for the axis to be calibrated.

<Example>
```
> CALIB 1
```
' Axis #1 is calibrated.

(17) Display the number of pulses in this position using the PULSE command and check that they match the values obtained in step (12) on previous page.

<Example>
```
> PULSE
16000   10000               ' Axes #1 and #2 pulses.
    0      -10               ' Axes #3 and #4 pulses.
```

(18) Use the SLOCK command to put the free axes back under servo control.

<Example>
```
>SLOCK 1,3                   ' Axis #1 and #3 are under servo control.
```

(19) Move to another teach point and check the position.

Accurate calibration of Axis #2

For accurate calibration of Axis #2, calculation of robot working point coordinates is most important in the following cases.

- ◆ Entering coordinate values to teach a point.

- ◆ Switching the arm orientation between right and left at a given point.

- ◆ Using the PALET command.

- ◆ During CP control (such as liner or circular interpolation).

- ◆ Using the LOCAL command.

- ◆ For statements using relative coordinates. < Example, P1+X100 >

If the methods above require accuracy of Axis #2, then calibrate for both right and left arm orientations.   Note that this method cannot be used if Axis #4 has excessive run-out.

(1) Display HOFS values using the HOFS command and note values [A], [B], [C], and [D].

<Example>
```
> HOFS
[A] [B]                      ' HOFS values for Axes #1 and #2.
[C] [D]                      ' HOFS values for Axes #3 and #4.
```

(2) Select a point for teaching that is within the region accessible to both right and left arm and is easy to verify for accuracy.   Carry out teaching and call the point P1.

<Example>
```
> P1=P*
```

(3) Display the number of pulses at the P1 position using the PULSE command.   Note the Axis #2 value [F1].

<Example>
```
> PULSE
[E] [F1]                     ' Axes #1 and #2 pulses.
[G] [H]                      ' Axes #3 and #4 pulses.
```

(4)   Switch the arm mode from right to left and move to the same point.

<Example>

```
> MOTOR ON
>JUMP P1:Z0/L              ' To change from right to left arm.
                           ' (/R at end of statement for left to right)
> SFREE                    ' All axes can now be moved manually.
```

(5)   The position with left arm mode is different from the position with right arm mode. This gap must be adjusted manually after lowering Axis #3 to the P1 position. In order to lower Axis #3 to P1, push Axis #3 down while pushing the brake release button.

```
> SLOCK                    ' All axes are under servo control.
```

(6)   Display the number of pulses at the P1 position again using PULSE, and note the axis #2 value [F2].

<Example>

```
> PULSE
[E]  [F2]                  ' Axes #1 and #2 pulses.
[G]  [H]                   ' Axes #3 and #4 pulses.
```

(7)   Calculate the new HOFS value from the values which were noted previously: add the left and right pulse values [F1] and [F2], add to [B] in step (1) on previous page, and take the mid-way value. Incorporate + and - signs in the calculation. The new HOFS value is called [I].

```
> I = B + (F1 + F2) / 2
```

(8)   Substitute [I] in the HOFS command and execute. For other Axis values, use the values that were noted in step (1) on previous page.

```
>HOFS [A], [I], [C], [D]
```

(9)   Move to another teach point and confirm the position.

12. Clean Model Maintenance

The Clean models for the ES / EL series includes additional features that reduce dust emitted by the manipulator to enable use in clean room environments (See NOTE). This chapter describes the differences between Standard and Clean models for the ES / EL series.

NOTE
☞
Clean model requirements specify a maximum of 10 particles (0.13 μm or more in diameter) in 28317 cm^3 (1cft) sample-air around the center of the motion range.

12.1 Greasing the Ball Screw Spline Unit

For information on how to work with the ball screw spline unit, refer to chapter *9. Replacing the Ball Screw Spline Unit*.
Follow the standards specifications concerning the type of grease to use and the areas to be greased. Note that the bellows must be removed before greasing the shaft.

NOTE
☞
Removing the bellows to enable greasing emits a large amount of dust. Therefore, take the unit to an outer room such as the room in front of the clean room's entrance, or set up a dust emission prevention device before removing the bellows in the clean room.

NOTE
☞
When greasing, do not allow any grease to get on the outside of the bellows. Grease may drip. Cover peripheral units with a sheet if necessary.

RC+   **SPEL 95**   (1) Disengage the motors by the MOTOR OFF while keeping the Drive Unit power ON.

300   (1) Disengage the motors by the MOTOR OFF while keeping the Controller power ON.

(2) Raise the shaft manually to its upper limit while pushing the brake release button.

(3) In order to bring the upper bellows upwards, unfasten the clamp band at the bottom of the upper bellows. You need a cross point driver to unfasten the clamp band.
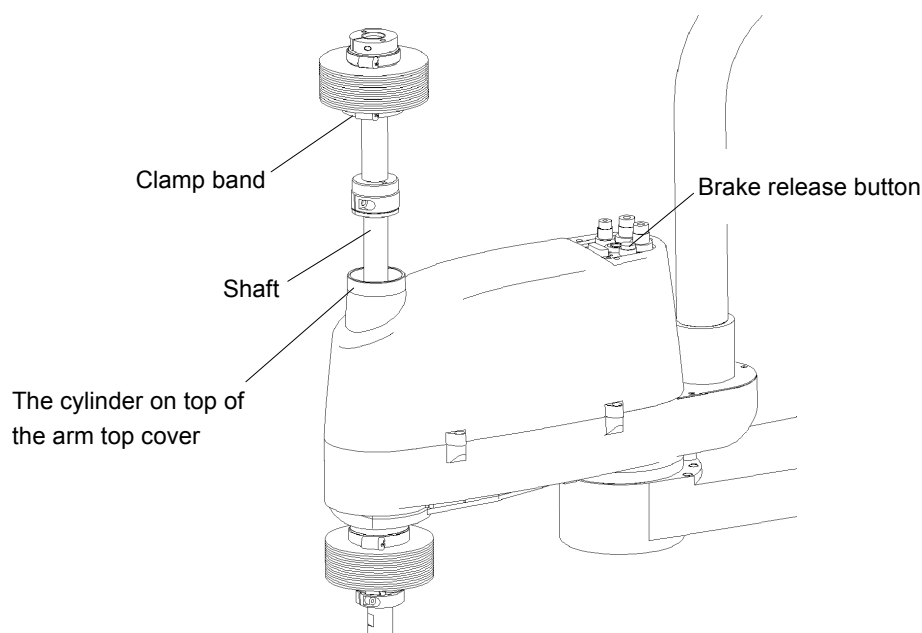
Clamp band

Brake release button

Shaft

The cylinder on top of the arm top cover

(4) Fill the groove of the ball screw spline shaft with grease.   Apply it directly by hand. Wipe off excess grease from the shaft.

(5) Push the shaft all the way down to the lower limit while pressing the brake release button.

(6) Remove the lower bellows, use a screwdriver to loosen the clamp band at the top of the lower bellows, then slide the lower bellows downward.
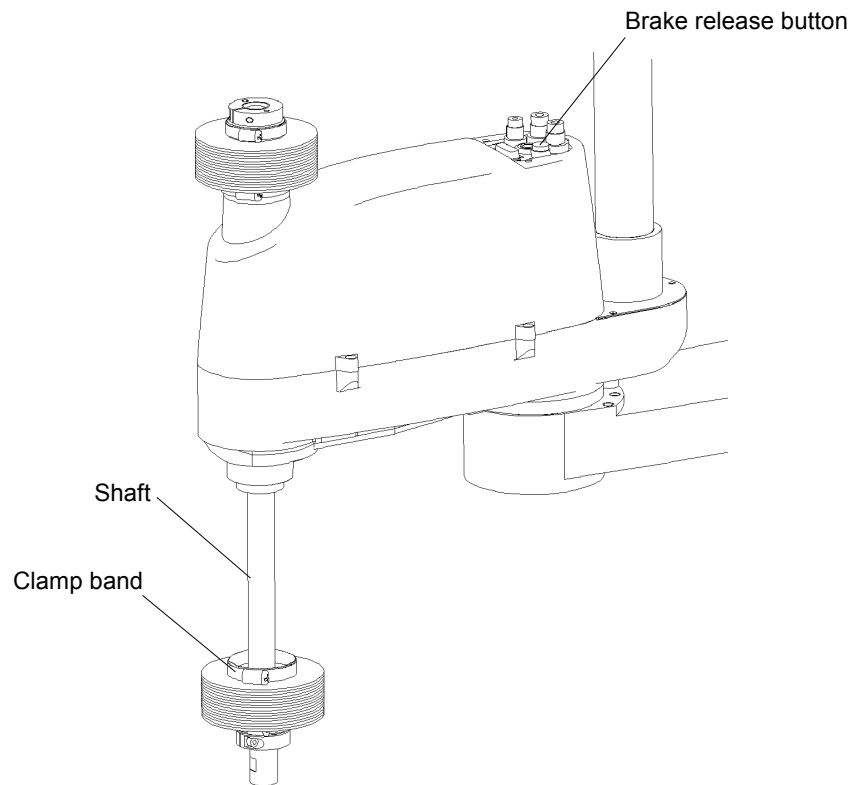
Brake release button

Shaft

Clamp band

(7) Fill the groove of the ball screw spline shaft with grease.   Apply it directly by hand. Wipe off excess grease from the shaft.

(8) Move the shaft up and down several times to spread grease all over the shaft while pushing the brake release button.   Wipe off excess grease from the shaft.

(9) Reattach the upper bellows, lift the bottom of the bellows until it covers at least 10 mm of the cylindrical part of the arm top cover, then turn the clamp band screws to fasten it.

(10) Reattach the lower bellows, lift the top of the bellows until it covers at least 10 mm of the cylindrical part of the arm bottom cover, then turn the clamp band screws to fasten it.

12.2 Replacing the Bellows

If the bellows should become damaged, follow the steps described below for replacing the bellows.

The specification and replacement method are the same for the upper and lower bellows. However, detach the end effector from the shaft beforehand when you remove the lower bellows.

NOTE
☞
Removing the bellows to enable greasing emits a large amount of dust.   Therefore, take the unit to an outer room, such as the room in front of the clean room's entrance, or set up a dust emission prevention device before removing the bellows in the clean room.

RC+   SPEL 95

(1) Disengage the motors by the motor <OFF> button while keeping the Drive Unit power ON.

300

(1) Disengage the motors by the MOTOR OFF command while keeping the Controller power ON.

(2) Using a screwdriver, loosen the screws of the clamp bands that secure the upper bellows and lower bellows.   (See the greasing diagram in the previous section.)

(3) Remove the bellows from the cover, then slide the bellows toward the end of shaft.

(4) Remove the bearing case from the old bellows.   The bearing case's larger hole fits onto the cover side and its smaller hole fits onto the shaft side.

(5) Attach the bearing case on both ends of the bellows.   The blue plastic casings comes in two sizes, one wider and the other narrower, to fit in with each respective ends of the bellows.   The wider end of the bellows should be attached to the arm top cover while the narrower end should be attached to the user cable duct.

(6) Slide the wide end of the bellows over the shaft first.   The wide end of the bellows should be slid past the cover by at least 10 mm, over which the clamp should be fastened.

(7) Attach the blue plastic casing on the shaft where the bellows are to be secured and bring the bellows over so that the bellows are covering the base of the shaft before fastening the bellow's end with the clamp band.   Fasten the screw of the clamp band on the arm tip side.   You may want to adjust the position of Joint #3 relative to Arm #2 to facilitate easier mounting of the bellows.   Joint #3 can be moved up and down manually if you hold down the brake release button.

(8) After attaching the bellows, push and hold the brake release button on the top of the cover and manually raise and lower Joint #3, rotate Joint #4, and make sure that the bellows can expand and contract smoothly, without requiring excessive force.

13. Protected Model Maintenance

The Protected model for ES / EL series features shielding on the manipulator specifically for use in a dusty, wet or oily environment.   The degree of the protective shielding is equivalent to IP65.   This chapter herein describes its differences from the standard ES / EL models.

13.1 Safety Precautions

Add the following items to the Safety Precautions outlined in the beginning Part 2: Maintenance.

⚠ WARNING	■ Invasion of water or dust may cause the electric shock or malfunction. Do not expose a manipulator, connectors, and pins to water or dust during maintenance operation. ■ Do not expose a manipulator to water or dust during its power cable connector is disconnected. Invasion of water or dust may cause the electric shock or malfunction. ■ Seals will be torn when you perform maintenance operation. Be sure to reseal them after you finish the maintenance operation. If sealing is defective, the water or dust may invade the manipulator and may cause electric shock or malfunction.

13.2 Sealing the Manipulator

The following figure shows all parts of the manipulator that must be sealed to prevent moisture and dust. The figure also specifies the type of sealing for each part as types A, B, C, and D.

If you break any of the seals, be sure to restore all sealing and air tightness after you finish the maintenance operation.

	Name	Specification	NOTE
A	Silicon Rubber Sheet	A sheet of 1 mm-thick silicon rubber to be used for sealing covers with liquid gasket	Make sure the rubber sheet has been sealed up with the cover all around by tightening the bolts on the cover. Do not fasten the bolts too tight. Fastening too tight may cause the rubber to be bulged out or torn.
B	Rubber Packing	A ring-shaped rubber packing to be applied on the duct joint with liquid gasket This packing does not need to be detached when you follow the maintenance operation method described in this manual.	Make sure that the rubber packing has been sealed up. Do not screw the duct joint too tight. Screwing the joint too tight may cause the rubber to be bulged out or torn.
C	O-ring packing	A rubber packing to be applied on bellows, flange of reduction gear, encoder reset cover and main cable elbow fitting.	Make sure that the rings are not squeezed nor deformed.
D	*Liquid gasket	The liquid gasket supplied with the manipulator to be applied on the cover, plate, duct joint, cable bracket, bolts, cable seal box, and receptacle.	When using for covers, plates and duct joint, apply the gasket on its joint after installing the cover, plate or duct joint. When using for cable bracket, bolts, cable seal box and receptacle, apply the gasket on one of the surfaces to be put together before assembling. Wipe the surplus. The gasket dries in about 30 minutes and becomes rubbery in 15 to 16 hours in normal temperature. For more details, refer to the instructions printed on the liquid gasket box.

*The liquid gasket for protected model is different from the gasket for standard and clean model. Use the liquid gasket (1212).

13.3 Internal Layout

The outline and name of internal configuration are shown below.
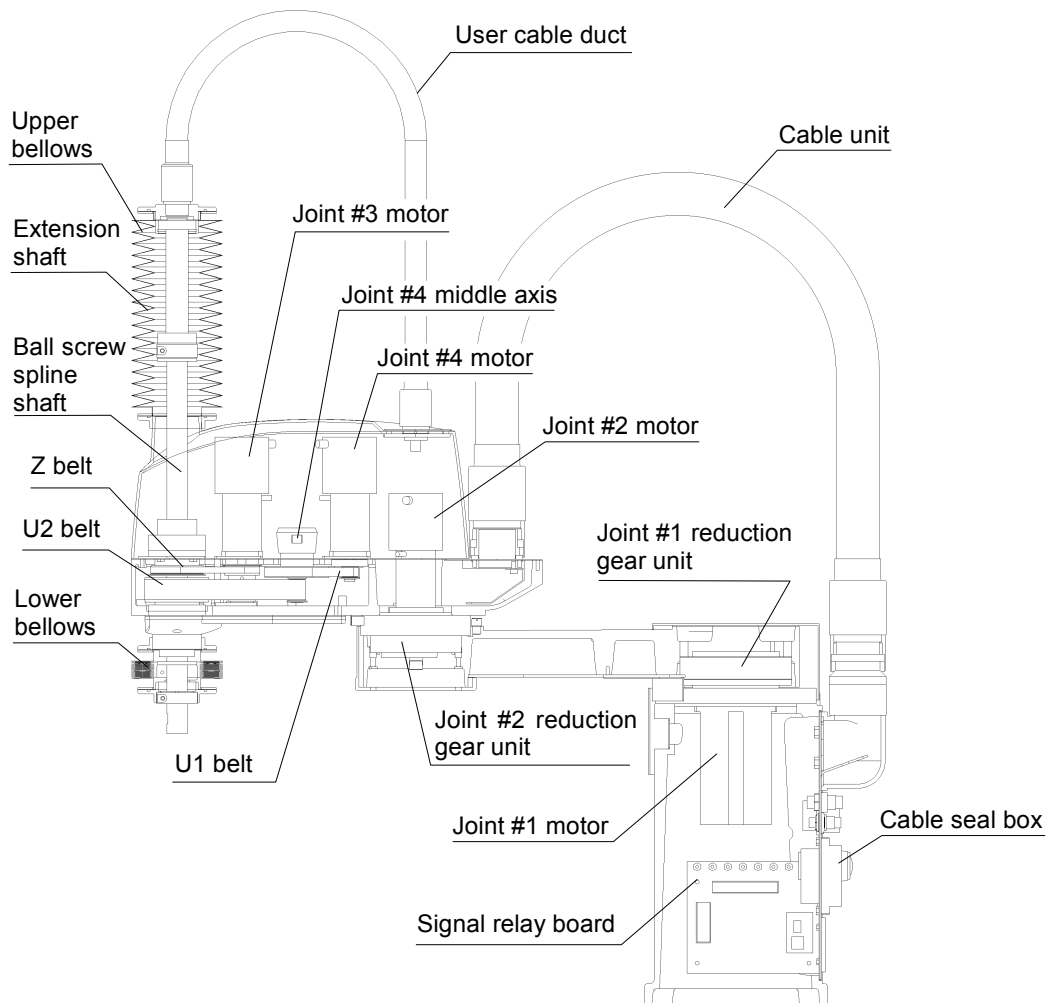
13.4 Replacing the Cable Unit

⚠ **WARNING**	■ When connecting or disconnecting the cables, make sure the power is turned OFF and pull out the power plug from the power source. Failure to turn OFF the power can result in a robot may malfunction. ■ When replacing the cable unit, remove the cable (the power cable, signal cable, and user's wiring and piping) connected to the manipulator before replacing the cable unit.

For basic information, refer to chapter 3. *Replacing the Cable Unit*.

NOTE ☞   Before turning OFF the power for the replacement, keep the power of the manipulator ON for more than 30 minutes. It is necessary for the super-capacitor of each motor to retain the position data.

The charged motor can retain position data for about 2 hours when its cable is disconnected. (Motors whose serial number start with "0" can retain the data for about 2 days.)

Since the power is supplied to each motor from the lithium battery on the signal relay board via signal connector, the position data of the motor will be retained after the main power is turned OFF. However, when the signal connector is removed, the position data will only be retained by the super-capacitor.

The position data Cannot be retained beyond the time duration mentioned above after which it will be lost. If this happens, errors will occur when the power is turned ON.

     RC+   : Error 5016
     SRC5**/SPEL 95   : Error 5016
     SRC-3**   : Error 195

In this case, all the joints need to be calibrated again. (Refer to chapter *11. Calibration*.)

NOTE ☞   When exchanging the cable unit, it is necessary to reconnect the connectors inside the arm top cover and base. In doing so, refer to the wiring schematics in this chapter so that the connectors will be properly reconnected. Also, when installing the new cables into the cover, carefully locate the cables, remembering how they were inside the cover before replacement, so that they will not be bent forcibly or pinched. If the cables are bent forcibly or pinched when reinstalling the cover, it may cause cable disconnection or such failures.

For the details of each connector and its connection, refer to the chapter *4. Connector Pin Assignments*.

Removal

RC+   SPEL 95   (1) Turn OFF the Drive Unit power.

300   (1) Turn OFF the Controller power.

(2) Disconnect all the connectors and tubes from the base connector plate.

(3) Remove the six bolts (4-M4×8 and 2-M4×16) from the base connector plate and open the cover forward. Be careful not to pull the base connector plate forcibly since the strain on the cables may cause wire disconnection and/or damage to silicon rubber sheet. Also, remember the approximate cable arrangement so that the cables can be reconnected similarly during replacement.

(4) Remove the four mounting bolts (M6×12) from the main cable elbow fitting.
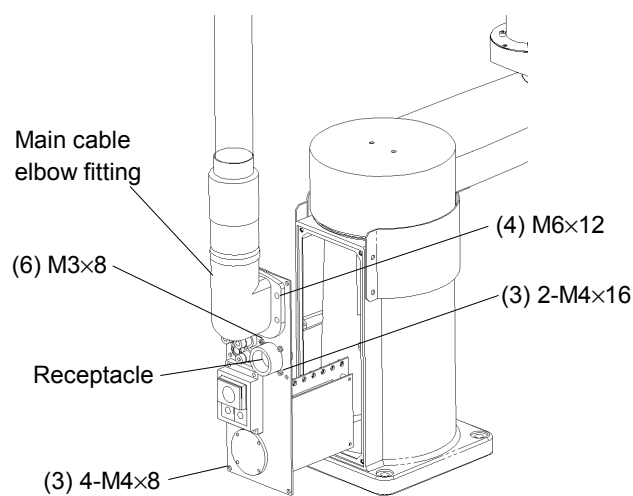
(5) Cut off the wire tie inside the main cable elbow fitting.
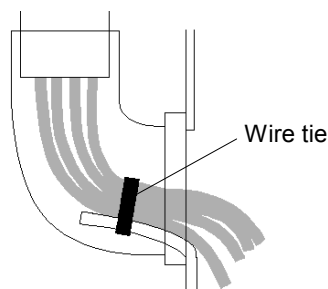
(6) Remove the four bolts (M3×8) from the receptacle and receptacle itself. If the receptacle does not come out easily because of the liquid gasket on the junction surface, use a flat screwdriver between the receptacle and the base connector plate.

(7) Disconnect the ground wires and pneumatic tubes from the base connector plate. Each pneumatic tube can be pulled out by first pushing the fitting release ring. The ground wire terminals are fastened with bolts (M4×8).

(8) Open the arm top cover. (Refer to the chapter 2. Opening the Covers.) Be careful not to pull the arm top cover forcibly since the strain on the connected cables may cause wire disconnection. Also, pay attention to and remember the approximate cable arrangement so that the cables can be reconnected similarly during replacement.

(9) Referring to the *Wiring Schematic 1* in this chapter, disconnect the ground wires and pneumatic tubes off the arm. To disconnect each pneumatic tube, pull it out by first pushing the fitting release ring. The ground wire terminals are secured with bolts (M4×8).

(10) Referring to the wiring schematics in this chapter, disconnect the connectors from the base and arm. To disconnect the power connector, pull it out while pushing the presser tongue next to the connector number on the motor side.

NOTE

☞   For manipulators whose serial number start with "1," their motors must be connected to the signal relay board of the new cable unit within 2 hours. Otherwise, the motor will lose the position data and it is necessary to calibrate again.

(11) Remove the duct plate from the arm (3-M4×12 bolts).
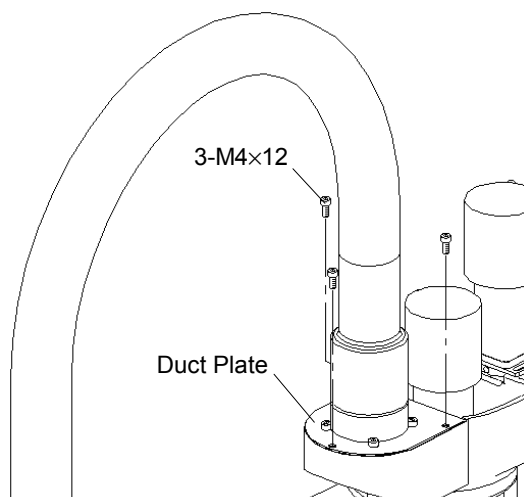
(12) If there are any wire ties binding the cables, cut them off. Remove the cable unit.

Installation

For maintenance, the cable unit is provided with an elbow fitting on one end. The other end has a sealed duct rotating mechanism on the mounting bracket.

(1) Let the wires go through the base connector box. Secure the main cable elbow fitting using four bolts (M6×12). Please make sure that the O-ring securely fits in the groove on the main cable elbow fitting's clamp face so that the ring will not slip from the groove or get pinched.

(2) Apply liquid gasket on the clamp face before the cable bracket is secured on the arm. Mount the cable bracket with three bolts (M4×12). Apply liquid gasket on the bearing surface of bolts, too.

(3) Referring to the wiring schematics on the following pages, connect all connectors properly.

⚠ CAUTION	■ Connect the signal cable securely. Do not allow unnecessary strain on the signal cable or bend it extremely. This may damage the signal cable and cause the robot to malfunction.

(4) Referring to the section *Wiring Schematic 1* in this chapter, connect the ground wires and pneumatic tubes properly.

(5) Apply liquid gasket on the clamp face before the receptacle is secured on the base connector plate with four bolts (4-M3×8).

(6) Bind the cables with wire ties as they were before the unit replacement. The following must be paid attention to when binding the cables with a wire tie:

- The cables must not touch the pulley, timing belt or other movable parts or areas.

- Do not pinch the cables when closing the cover.

- Do not allow unnecessary strain on the cables. The cables must be arranged so that they will not be forcibly bent. Unnecessary strain on the cables may cause wire disconnection inside.

- The cables inside the duct must be long enough so that they will not be pulled during operation.

(7) Install the base connector plate. Seal the base connector plate and manipulator base with liquid gasket.

(8) Install the arm top cover. Seal the cover and arm with liquid gasket.

13.5 Wiring Schematic 1

To remove the cable unit, remove the connectors in the arm top cover and base. These connectors are connected as shown in the figure below. For more information, see the block diagram on the next page and the wiring list in *4. Connector Pin Assignments*.

User cable duct

Fittings for φ4/6 pneumatic tube (×2)
Fitting for φ4 pneumatic tube (×1)
User connector X51, X52

Cable unit

Connectors
Joint #3 Power   X131
Joint #3 Signal   X31
Joint #3 Brake   X32
Joint #3 Brake
release button   X33
Joint #4 Power   X141
Joint #4 Signal   X41

Connectors
Joint #2 Power   X121
Joint #2 Signal   X21

Wire tie

Wire tie

Ground

Receptacle

Joint #1 Power connector X110
Joint #1 Signal connector X11

Fittings for φ6
pneumatic tube (×2)

Fitting for φ4
pneumatic tube (×1)

φ4 pneumatic tube (×3)
User cable (×15)

Ground×8

Signal connector   X1
(connects with following
connectors on the other side:
   Joint #1   X10
   Joint #2   X20
   Joint #3   X30
   Joint #4   X40)

Signal cable
User cable

User connector (connects
with X50 on the other side)

13.6 Wiring Schematic 2

13.7 Greasing the Ball Screw Spline Unit

For basic information about the ball screw spline unit, refer to chapter *9. Replacing the Ball Screw Spline Unit*.
Follow the standards specifications concerning the type of grease to use and the areas to be greased.   Note that the bellows must be removed before greasing the shaft.

⚠ WARNING	■ When you open the bellows, do not allow water or any foreign substance to get inside. Otherwise, electric shock or malfunction can occur when power is connected.

When greasing, do not allow any grease to get on the outside of the bellows.   Grease may drip.   Cover peripheral units with a sheet if necessary.

RC+   **SPEL 95**

(1) Disengage the motors using the motor <OFF> button or command while keeping the Drive Unit power ON.

300

(1) Disengage the motors using the MOTOR OFF command while keeping the Controller power ON.

(2) Raise the shaft manually to its upper limit while pushing the brake release button.

(3) Remove the six bolts (M4×6) from the lower mounting ring of the upper bellows, then slide the upper bellows upward.
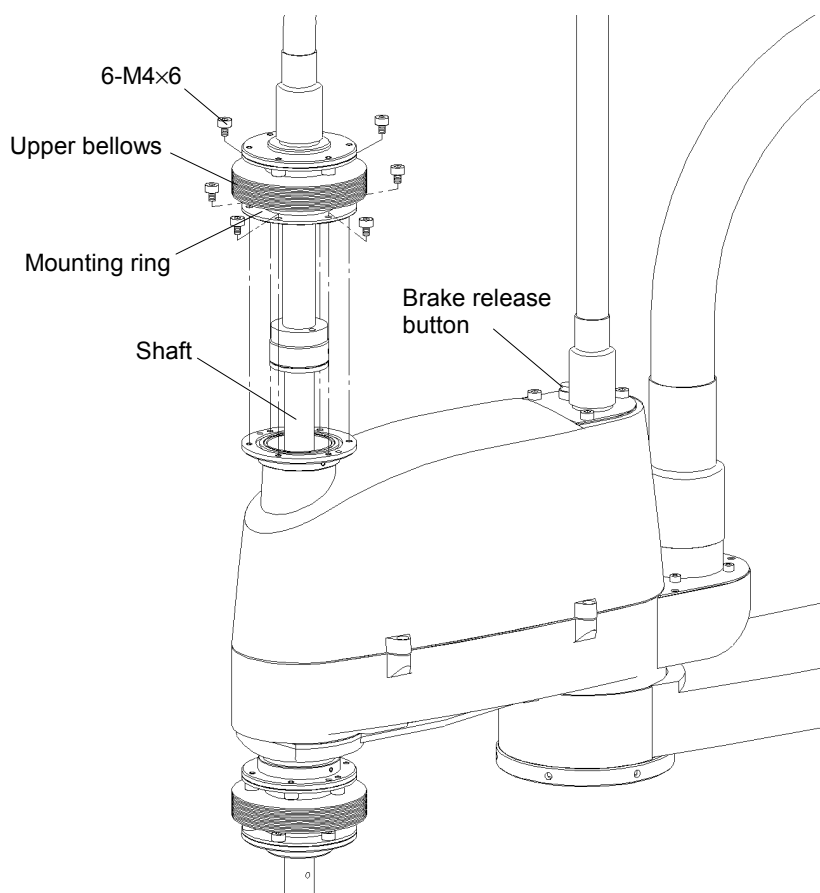
6-M4×6
Upper bellows
Mounting ring
Brake release button
Shaft

(4) Fill the groove of the ball screw spline shaft with grease.   Apply it directly by hand. Wipe off excess grease from the shaft.

(5) Push the shaft all the way down to the lower limit while pushing the brake release button.

(6) Remove the six bolts (M4×6) from the upper mounting ring of lower bellows, then slide the bellows downward.
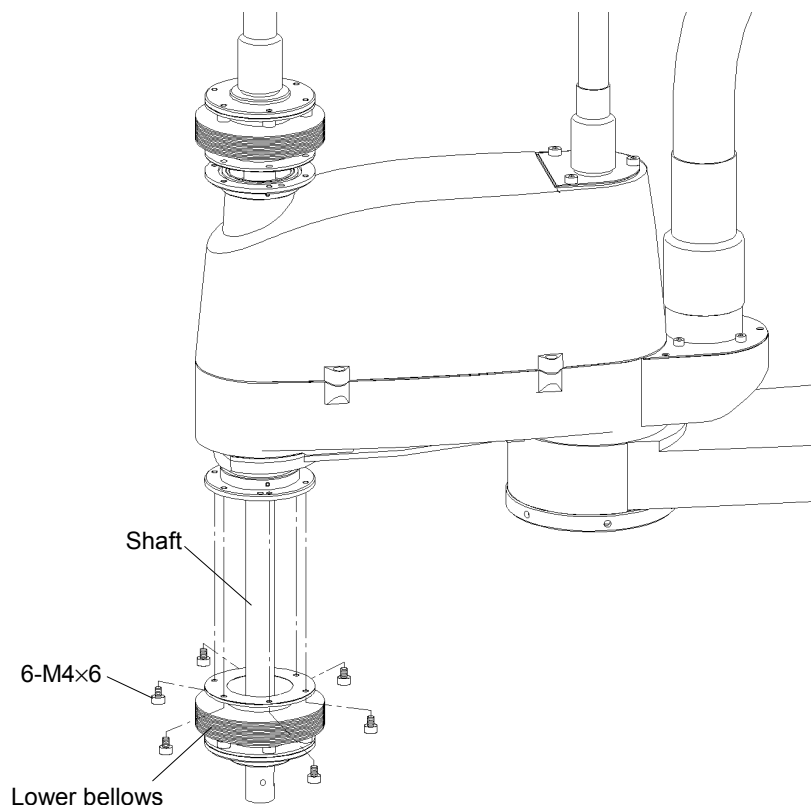
Shaft

6-M4×6

Lower bellows

(7) Fill the groove of the ball screw spline shaft with grease.   Apply it directly by hand. Wipe off excess grease from the shaft.

(8) Move the shaft up and down several times to spread grease all over the shaft while pushing the brake release button.   Wipe off excess grease from the ball screw spline shaft.

(9) After checking that the O-ring fits onto the groove of the flange, fasten the mounting ring on the bottom of the upper bellows and the flange using six bolts (M4×6).

(10) After checking that the O-ring fits onto a groove of the flange, fasten the mounting ring on the top of the lower bellows to the flange using six bolts (M4×6).

13.8 Replacing the Bellows

If the bellows are damaged, follow the steps described below to replace the bellows.
The specifications are the same for the upper and lower bellows.

Removal

Remove the wiring and piping to the end effector and the end effector itself after turning OFF the power.

RC+ **SPEL 95**　(1)　Disengage the motors using the motor <OFF> button while keeping the Drive Unit power ON.

300　(1)　Disengage the motors using the MOTOR OFF command while keeping the Controller power ON.

(2)　Lower the shaft manually to its lower limit while pushing the brake release button.

(3)　Remove the six bolts (M4×6) from the mounting ring on the top of the lower bellows. There is an O-ring between the bellows and flange that is fitted into a groove of the flange.
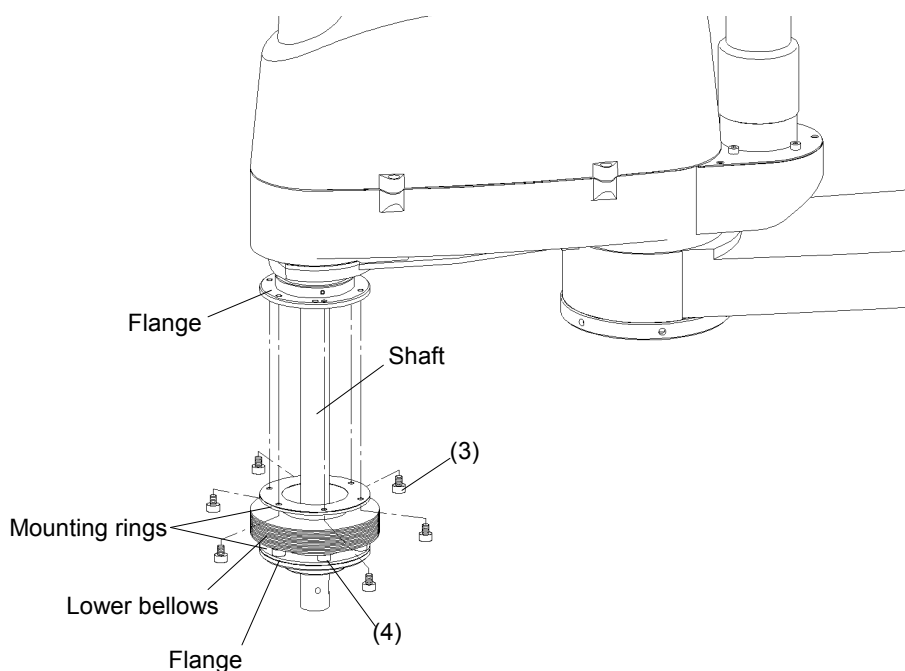
(4)　Remove the six bolts (M4×6) from the mounting ring on the bottom of the lower bellows.　There is an O-ring between the bellows and flange that is fitted into a groove of the flange.

(5) Lift up the lower bellows and loosen the bolt (M4×18) on the upper-limit mechanical stop.   Slide the stop upward about 50 mm.

Upper-limit
mechanical stop

M4×18 bolt
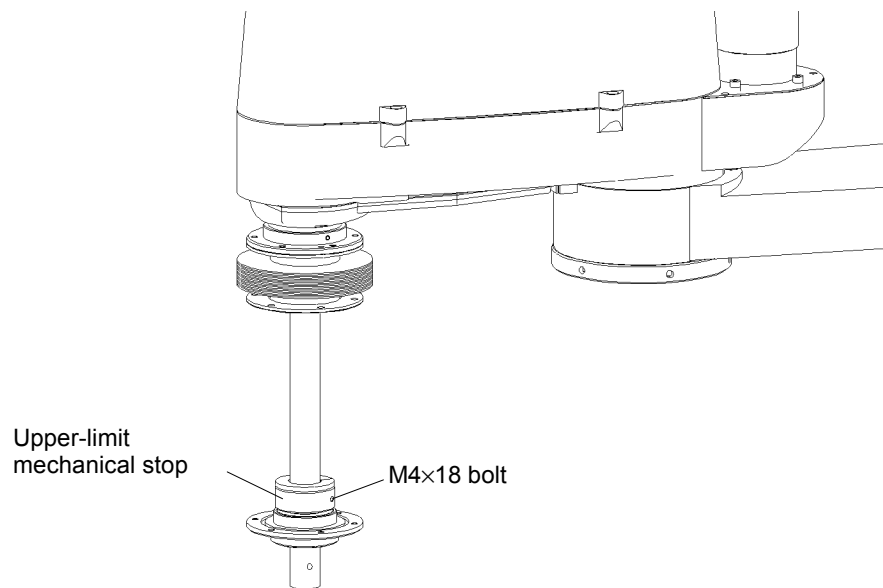
(6) Lift up the flange and loosen the bolt (M6×18) on the set-ring.   Remove the set-ring, flange, O-rings, lower bellows, and mounting rings from the shaft.

Flange

M6×18 bolt

Set-ring

(7) Push the shaft all the way up to the upper limit while pushing the brake release button.

(8)   Remove the six bolts (M4×6) from the mounting ring on the bottom of the upper
      bellows.   There is an O-ring between the bellows and flange that is fitted into a groove
      of the flange.
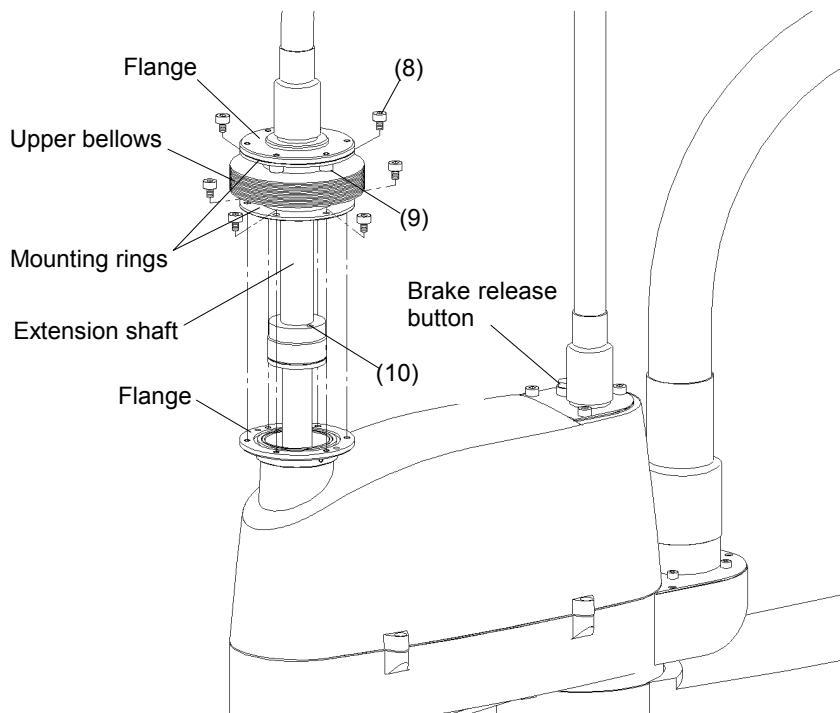
(9)   Remove the six bolts (M4×6) from the mounting ring on the top of the upper bellows.
      There is an O-ring between the bellows and flange that is fitted into a groove of the
      flange.

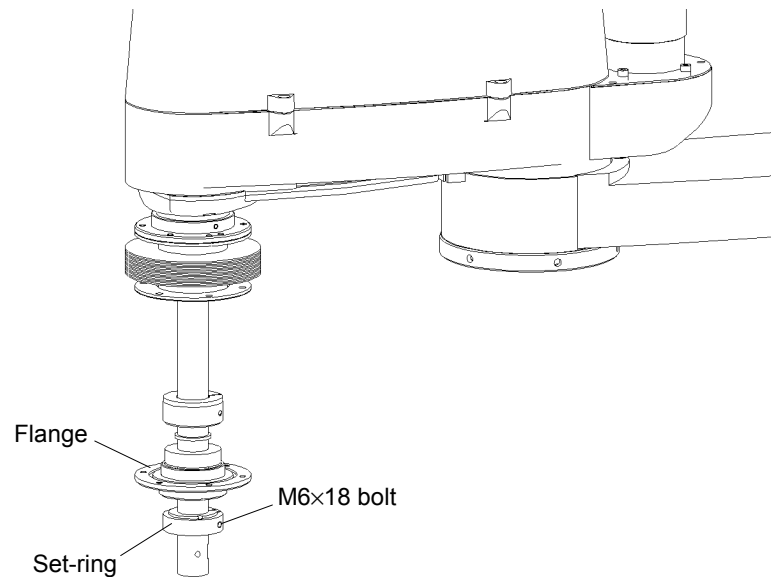(10) Remove the two bolts (M4×15) from the extension shaft.

(11) Pull the cable and tubes out of the shaft.

(12) Remove the upper bellows, mounting rings, and O-rings from the shaft.

(13) Remove the mounting rings from the upper and lower bellows.

Installation

(1) Attach the mounting rings to both ends of the new bellows.

(2) Pass the shaft through the O-ring, bellows, and O-ring.

(3) Pass the wiring and tubes through the shaft. Mount the extension shaft to the main shaft with two bolts (M4×15).
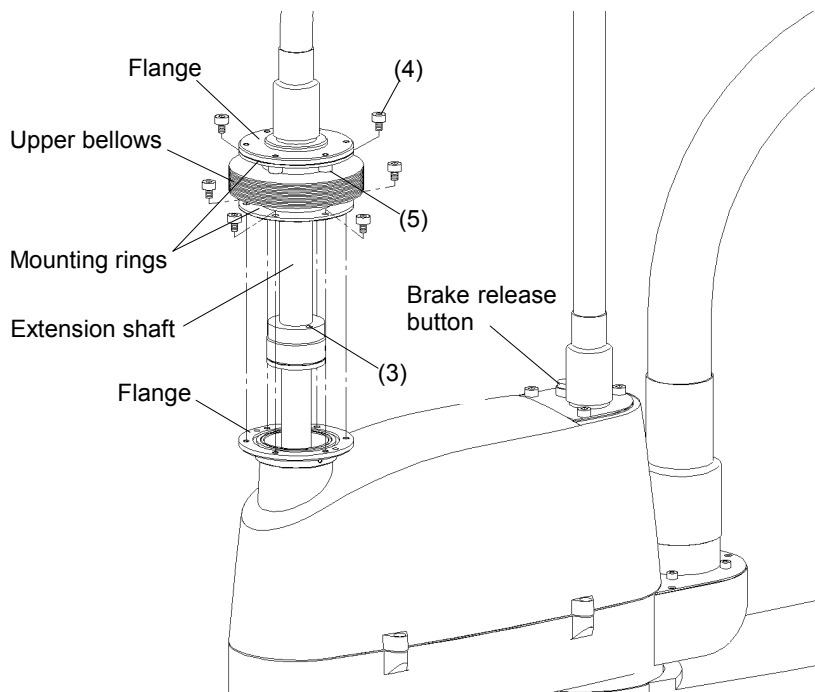
(4) Fit the O-ring into the groove of the flange. Fasten the flange and the mounting ring on the top of the upper bellows with six bolts (M4×6).

(5) Fit the O-ring into the groove of the flange. Fasten the flange and the mounting ring on the bottom of the upper bellows with six bolts (M4×6).

(6) Pass the shaft through the O-ring, bellows, O-ring, flange, and set-ring. Secure the set-ring at the 30 mm apart from the end of the shaft with a bolt (M6×18).
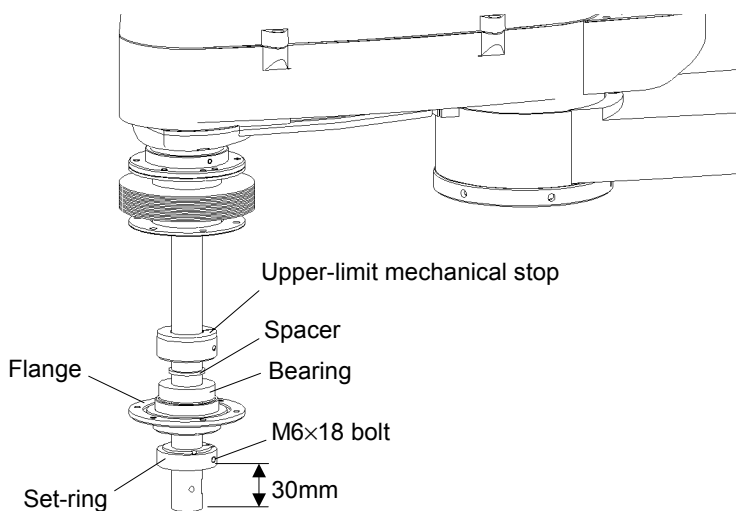
(7) Place the flange on the set-ring.   Lower the bearing, spacer and upper-limit mechanical stop to the bottom.

(8) Secure the upper-limit mechanical stop with a bolt (M4×18).
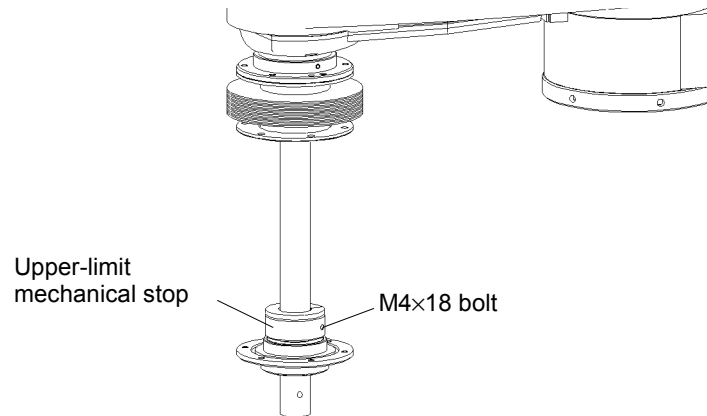
(9) Fit the O-ring into the groove of the flange.   Fasten the flange and the mounting ring on the bottom of the lower bellows with six bolts (M4×6).

(10) Fit the O-ring into the groove of the flange.   Fasten the flange and the mounting ring on the top of the lower bellows with six bolts (M4×6).

(11) To make sure that the bellows can expand and contract smoothly without excessive force, raise and lower manually Joint #3 while pushing the brake release button and move Joint #4.

(12) Turn OFF the power to attach the end effector and connect the wiring and piping to the end effector.

13.9 Replacing the Signal Relay Board

For basic information, refer to chapter *10. Replacing the Signal Relay Board*.

NOTE
☞

Before turning OFF the power for the replacement, keep the power of the manipulator ON for more than 30 minutes.   It is necessary for the super-capacitor of each motor to retain the position data.

The charged motor can retain position data for about 2 hours when its cable is disconnected. (Motor whose serial number start with "0" can retain the data for about 2 days.)

The position data cannot be retained beyond the time duration mentioned above after which it will be lost.   If this happens, Error 5016/195 will occur when the power is turned ON. In this case, all the joints need to be calibrated again.   (Refer to chapter *11. Calibration*.)

Removal

(1)   Disconnect cables from the base connector plate on the back of the manipulator and remove the base connector plate. (Refer to chapter *2. Opening the Covers*.)   If the base connector plate does not come out easily because of the liquid gasket, use a flat screwdriver to remove the base connector plate from the manipulator base.

(2)   Remove all connectors from the signal relay board (X10, X20, X30, X40, X50, X1, and user connector).   Open up the top and bottom clips and pull off connector X10, X20, X30, and X40.

(3)   Remove the four screws (M3×6) on the signal relay board and remove the board.

Installation

(1)   Install a new signal relay board with four screws (M3×6).

(2)   Securely connect the connectors (X10, X20, X30, X40, X50, X1, and user connector).

⚠ CAUTION
■ Be sure to connect the signal connectors securely.   Do not bend the cables sharply or damage them in any way.   Abnormal signals may cause the malfunction of the robot.

(3)   Mount the base connector plate on the back of the manipulator. (Refer to chapter *2. Opening the Covers*.)

(4)   Seal the base connector plate and manipulator base with liquid gasket. (Refer to the section *Sealing the Manipulator* in this chapter.)

(5)   Connect the cables to the base connector plate.

(6)   Turn ON the Controller power and test it with a few teach points to make sure that the teach positions have not been offset.   When you have confirmed that the position data has been retained, replacement is completed.   If there is any position found to be offset, calibrate the manipulator by referring to the chapter *11. Calibration*.

14. Maintenance Part Lists

14.1 Maintenance Parts for All Models

(S/N: Serial No.)

Parts Name				New code	Old code	Standard	Note
AC servo motor	ES	Joint #1	S/N: 0****	R13ZA00061400	ZA000614	200W-ABS	Common to Joint #2 of EL
			S/N: 1****	R13ZA00062500	ZA000625		
		Joint #2, 3, 4	S/N: 0****	R13ZA00061300	ZA000613	100W-ABS	Common to Joint #3 and #4 of EL
			S/N: 1****	R13ZA00062400	ZA000624		
	EL	Joint #1	S/N: 0****	R13ZA00061500	ZA000615	400W-ABS	
			S/N: 1****	R13ZA00062600	ZA000626		
		Joint #2	S/N: 0****	R13ZA00061400	ZA000614	200W-ABS	Common to Joint #1 of ES
			S/N: 1****	R13ZA00062500	ZA000625		
		Joint #3, 4	S/N: 0****	R13ZA00061300	ZA000613	100W-ABS	Common to Joint #2, #3, and #4 of ES
			S/N: 1****	R13ZA00062400	ZA000624		
Brake		Joint #3		R13ZA00350100	ZA003501	ERS-135L	
Signal cable				R13ZA00200300	ZA002003	3 m (standard)	
Z belt				R13ZA00321400	ZA003214	264-2GT-6	
U1 belt				R13ZA00321300	ZA003213	240-2GT-9-T434N1	
U2 belt				R13ZA00321200	ZA003212	366-2GT-20-T434N1	
U2 pulley				R13ZA003B0100	ZA003B01		
Grease for ball screw spline shaft				R13ZA00330200	ZA003302	AFB grease	400 g
Grease for reduction gear unit				R13ZA00330100	ZA003301	SK-1A	500 g
Liquid gasket				R13ZA00371000	ZA003710	Single-liquid type of RTV rubber	
Signal relay board				R13ZA00450200	ZA004502	SKP337-ABS	
Lithium battery for signal relay board (Battery unit)				R13ZA00600100	ZA006001		
O-ring		For SHF-20		R13A030700200	–		
		For SHF-25		R13A030700300	–		

14.2 Maintenance Parts for Standard-model

Parts Name		New code	Old code	Standard	Note
Ball screw spline unit	ES**1S	R13ZA00120800	ZA001208	BNS2020A-385B	For 170 mm stroke Only for ES
	ES**3S EL**3S	R13ZA00120900	ZA001209	BNS2020A-535B	For 320 mm stroke
Cable unit	ES45*S ES55*S ES65*S EL65*S	R13ZA00204100	ZA002041	MPI11100100	Common to Clean-model
	EL85*S	R13ZA00204200	ZA002042	MPI11100200	
Power cable		R13ZA00200200	ZA002002	3 m (standard)	
Brake release switch	Joint #3	R13Z702640100	Z7026401	AB2M-M1W	
Reduction gear unit	ES Joint #1	R13ZA00100700	ZA001007	SHF-25-80	Common to Joint #1 of ES / Joint #2 of EL
	ES Joint #2	R13ZA00100800	ZA001008	SHF-20-50	
	EL Joint #1	R13ZA00100600	ZA001006	SHF-32-100	Common to Clean-model
	EL Joint #2	R13ZA00100700	ZA001007	SHF-25-80	

14.3 Maintenance Parts for Clean-model

Parts Name			New code	Old code	Standard	Note
Bellows	Round-type	ES**1C	R13ZA00370400	ZA003704	$\phi\,90 - \phi\,45 \times$ st.150	2 bellows for only ES
		ES**3C EL**3C	R13ZA00370500	ZA003705	$\phi\,90 - \phi\,45 \times$ st.300	2 bellows
Ball screw spline unit		ES**1C	R13ZA00121600	ZA001216	BNS2020A-385B+CL	For 150 mm stroke Only for ES
		ES**3C EL**3C	R13ZA00121700	ZA001217	BNS2020A-535B+CL	For 300 mm stroke
Cable unit		ES45*C ES55*C ES65*C EL65*C	R13ZA00204100	ZA002041	MPI11100100	Common to Standard-model
		EL85*	R13ZA00204200	ZA002042	MPI11100200	
Power cable			R13ZA00200200	ZA002002	3 m (standard)	
Brake release switch		Joint #3	R13Z702640100	Z7026401	AB2M-M1W	
Reduction gear unit	ES	Joint #1	R13ZA00100700	ZA001007	SHF-25-80	Common to Joint #1 of ES / Joint #2 of EL
		Joint #2	R13ZA00100800	ZA001008	SHF-20-50	
	EL	Joint #1	R13ZA00100600	ZA001006	SHF-32-100	Common to Standard-model
		Joint #2	R13ZA00100700	ZA001007	SHF-25-80	

14.4 Maintenance Parts for Protected-model

Name			New code	Old code	Standard	Note
Bellows	Flange-type	ES**1P	R13ZA00371300	ZA003713	φ 90 - φ 45 × st.150	2 bellows
		ES**3P EL**3P	R13ZA00371400	ZA003714	φ 90 - φ 45 × st.300	2 bellows
Reduction gear unit	ES	Joint #1	R13ZA00101300	ZA001013	SHF-25-80+P	Common to Joint #2 of EL
		Joint #2	R13ZA00101400	ZA001014	SHF-20-50+P	
	EL	Joint #1	R13ZA00101200	ZA001012	SHF-32-100+P	
		Joint #2	R13ZA00101300	ZA001013	SHF-25-80+P	Common to Joint #1 of ES
Ball screw splin unit		ES**1P	R13ZA00121800	ZA001218	BNS2020A-385B+P	For 150mm stroke Only for ES
		ES**3P EL**3P	R13ZA00121900	ZA001219	BNS2020A-535B+P	For 300 mm stroke
Cable unit		ES45*P ES55*P ES65*P EL65*P	R13ZA00204800	ZA002048	MPI11100100+P	
		EL85*P	R13ZA00204900	ZA002049	MPI11100200+P	
User cable unit		ES**1P	R13ZA00206200	ZA002062		
		ES**3P	R13ZA00206300	ZA002063		
		EL**3P	R13ZA00206400	ZA002064		
Power cable			R13ZA00205000	ZA002050	3 m (Wash down)	
			R13ZA00205100	ZA002051	5 m (Wash down)	
			R13ZA00205200	ZA002052	10 m (Wash down)	
Brake release switch	IP65		R13ZA00350400	ZA003504	AB2M-M1PW	
Seal unit	ES		R13ZA00371500	ZA003715	ESP_SEAL	
	EL		R13ZA00371600	ZA003716	ELP_SEAL	
Liquid gasket			R13ZA00370300	ZA003703	1212	

The bellows used in the following Manipulators have the same structure as that in the Clean-model.

Use the bellows (round-type), R13ZA00370400.

    ·ES451P   S/N 00540 (EPSON OKAYA)

    ·ES651P   S/N 00419 (EDG)