FANUC Robot M-410*i*B/450

MECHANICAL UNIT

OPERATOR'S MANUAL

B-81924EN/01

- **Original Instructions**

Thank you very much for purchasing FANUC Robot.
Before using the Robot, be sure to read the "FANUC Robot series SAFETY HANDBOOK (B-80687EN)" and understand the content.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.
Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume. It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to enable the safe use of the robot. Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
For safe use of FANUC robots, you must read and follow the instructions in “FANUC Robot series SAFETY HANDBOOK (**B-80687EN)**”.

1 PERSONNEL

Personnel can be classified as follows.

Operator:
- Turns the robot controller power ON/OFF
- Starts the robot program from operator panel

Programmer or Teaching operator:
- Operates the robot
- Teaches the robot inside the safeguarded space

Maintenance technician:
- Operates the robot
- Teaches the robot inside the safeguarded space
- Performs maintenance (repair, adjustment, replacement)

- The operator is not allowed to work in the safeguarded space.
- The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Works carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.
- To work inside the safeguarded space, the person must be trained on proper robot operation.

Table 1 (a) lists the work outside the safeguarded space. In this table, the symbol “O” means the work allowed to be carried out by the specified personnel.

Table 1 (a) List of work outside the Safeguarded Space

	Operator	Programmer or Teaching operator	Maintenance technician
Turn power ON/OFF to Robot controller	O	O	O
Select operating mode (AUTO/T1/T2)		O	O
Select remote/local mode		O	O
Select robot program with teach pendant		O	O
Select robot program with external device		O	O
Start robot program with operator’s panel	O	O	O
Start robot program with teach pendant		O	O
Reset alarm with operator’s panel		O	O
Reset alarm with teach pendant		O	O
Set data on teach pendant		O	O

	Operator	Programmer or Teaching operator	Maintenance technician
Teaching with teach pendant		○	○
Emergency stop with operator's panel	○	○	○
Emergency stop with teach pendant	○	○	○
Operator's panel maintenance			○
Teach pendant maintenance			○

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance technician take care of their safety using at least the following safety protectors.

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

2 DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Read the contents of each **"WARNING**", "**CAUTION**" and "**NOTE**" before using the robot.

Symbol	Definitions
⚠**WARNING**	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
⚠**CAUTION**	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
NOTE	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

3 PROCEDURE TO MOVE ARM WITHOUT DRIVE POWER IN EMERGENCY OR ABNORMAL SITUATIONS

(1) For emergency or abnormal situations (e.g. persons trapped in or pinched by the robot), brake release unit can be used to move the robot axes without drive power. Please order following unit and cable.

Name	Specification
Brake release unit	A05B-2450-J350 (Input voltage AC100-115V single phase) A05B-2450-J351 (Input voltage AC200-240V single phase)
Robot connection cable	A05B-2450-J360 (5m) ,(except A cabinet integrated type controller) A05B-2450-J361 (10m),(except A cabinet integrated type controller) A05B-2525-J045 (5m) ,(A cabinet integrated type controller) A05B-2525-J046 (10m) ,(A cabinet integrated type controller)
Power cable	A05B-2525-J010 (5m) (AC100-115V Power plug) (*) A05B-2525-J011 (10m) (AC100-115V Power plug) (*) A05B-2450-J364 (5m) (AC100-115V or AC200-240V No power plug) A05B-2450-J365 (10m) (AC100-115V or AC200-240V No power plug)

(2) Please make sure that adequate numbers of brake release units are available and readily accessible for robot system before installation.
(3) Regarding how to use brake release unit, please refer to Robot controller maintenance manual.

⚠ CAUTION
Robot systems installed without adequate number of brake release units or similar means are not in compliance with EN ISO 10218-1 nor with the Machinery Directive and therefore cannot bear the CE marking.

⚠ WARNING
Robot arm would fall down by releasing its brake because of gravity. Especially because spring balancer is used for J2-axis, it is hard to predict J2-arm movement by the condition of Robot posture and end effector. Therefore it is strongly recommended to take adequate measures such as hanging Robot arm by a crane before releasing a brake.

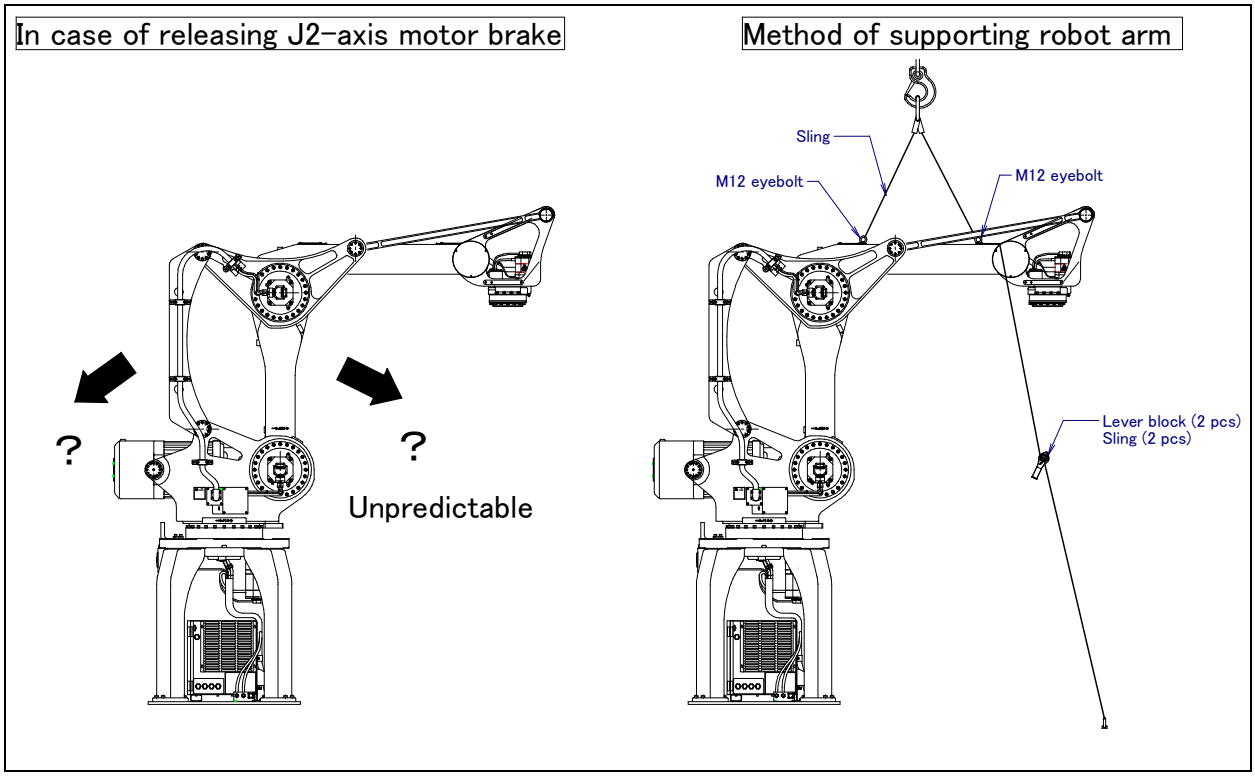


Fig. 3 (a) Arm operation by the release of J2-axis motor brake and measure

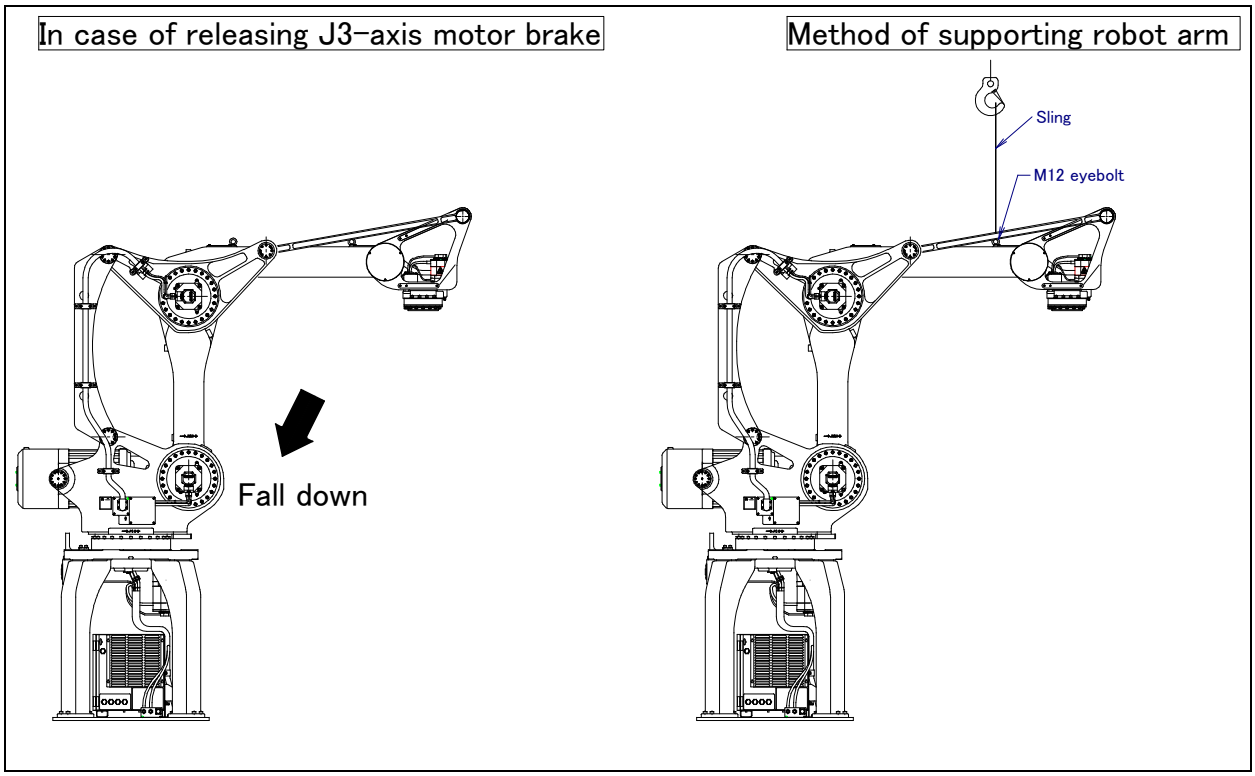


Fig. 3 (b) Arm operation by the release of J3-axis motor brake and measure

4 WARNING & CAUTION LABEL

(1) Greasing and degreasing label

Fig. 4 (a) Greasing and degreasing label

Description

When greasing and degreasing, observe the instructions indicated on this label.

1) When greasing, be sure to keep the grease outlet open.
2) Use a manual pump to grease.
3) Be sure to use a specified grease.

> ⚠ **CAUTION**
> See Subsection 2.2.3 Replacing Grease for explanations about specified grease, the grease amount, and the locations of grease and degrease outlets for individual models.

(2) Disassembly prohibitive label

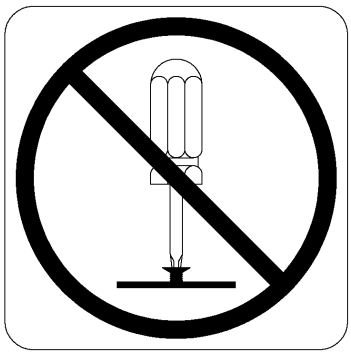


Fig. 4 (b) Disassembly prohibitive label

Description

Do not disassemble the balance unit. It is very dangerous because a spring is loaded in it.

(3) Step-on prohibitive label

Fig. 4 (c) Step-on prohibitive label

Description

Do not step on or climb the robot or controller as it may adversely affect the robot or controller and you may get hurt if you lose your footing as well.

(4) High-temperature warning label

Fig. 4 (d) High-temperature warning label

Description

Be cautious about a section where this label is affixed, as the section generates heat. If you have to inevitably touch such a section when it is hot, use a protective tool such as heat-resistant gloves.

(5) Transportation label

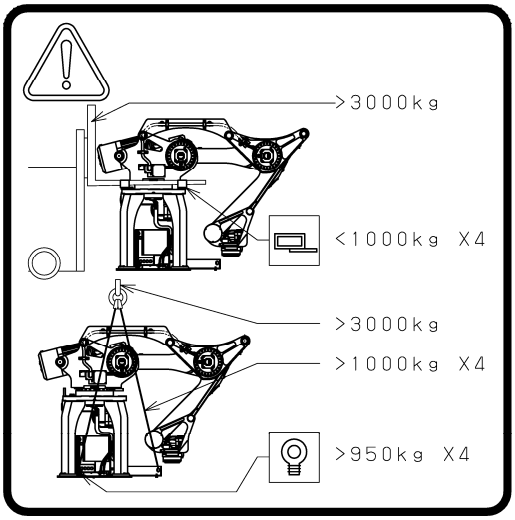


Fig. 4 (e) Transportation label

Description

When transporting the robot, observe the instructions indicated on this label.

1) Using a forklift
   - Use a forklift having a load capacity of 3000 kg or greater.
   - Keep the total weight of the robot to be transported to within 4000 kg, because the withstand load of the forklift bracket (option) is 9800 N (1000 kgf).
2) Using a crane
   - Use a crane having a load capacity of 3,000 kg or greater.
   - Use at least four slings each having a withstand load of 9800 N (1000 kgf) or greater.
   - Use at least four eyebolts each having a withstand load of 9310 N (950 kgf) or greater.

> ⚠ **CAUTION**
> See section 9.1 TRANSPORTATION for explanations about the posture a specific model should take when it is transported.

(6) Balancer replacement label

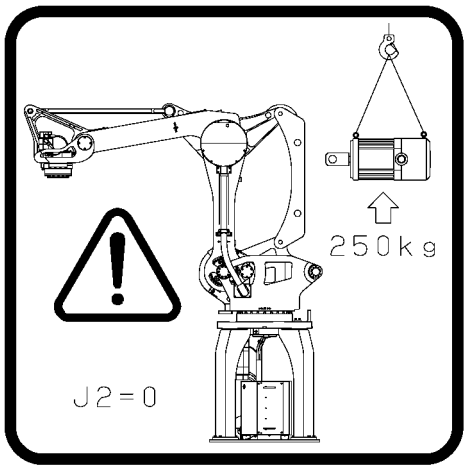


Fig. 4 (f) Balancer replacement label

Description

When replacing the balancer, observe the instructions indicated on this label.

- When replacing the balancer, keep the J2 axis at 0°.
- Balancer weight is 250 kg.

(7) Transportation prohibitive label

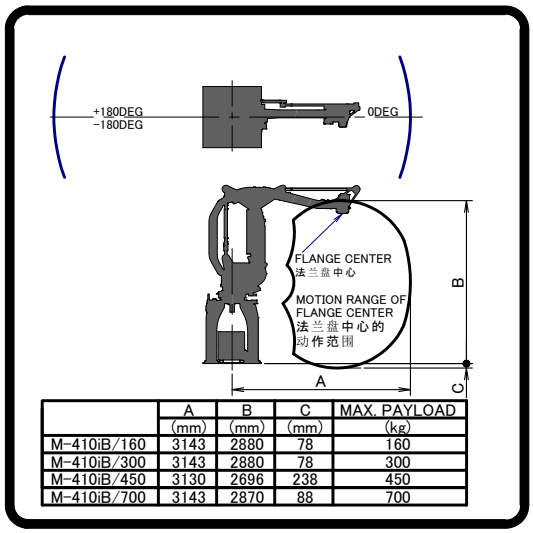
Fig. 4 (g) Transportation prohibitive label

Description

Keep the following in mind when transporting the robot.
Do not pull eyebolts sideways

(8) Operating space and payload mark label

Below label is added when CE specification is specified.



	A (mm)	B (mm)	C (mm)	MAX. PAYLOAD (kg)
M-410iB/160	3143	2880	78	160
M-410iB/300	3143	2880	78	300
M-410iB/450	3130	2696	238	450
M-410iB/700	3143	2870	88	700

Fig. 4 (h) Operating space and payload mark label

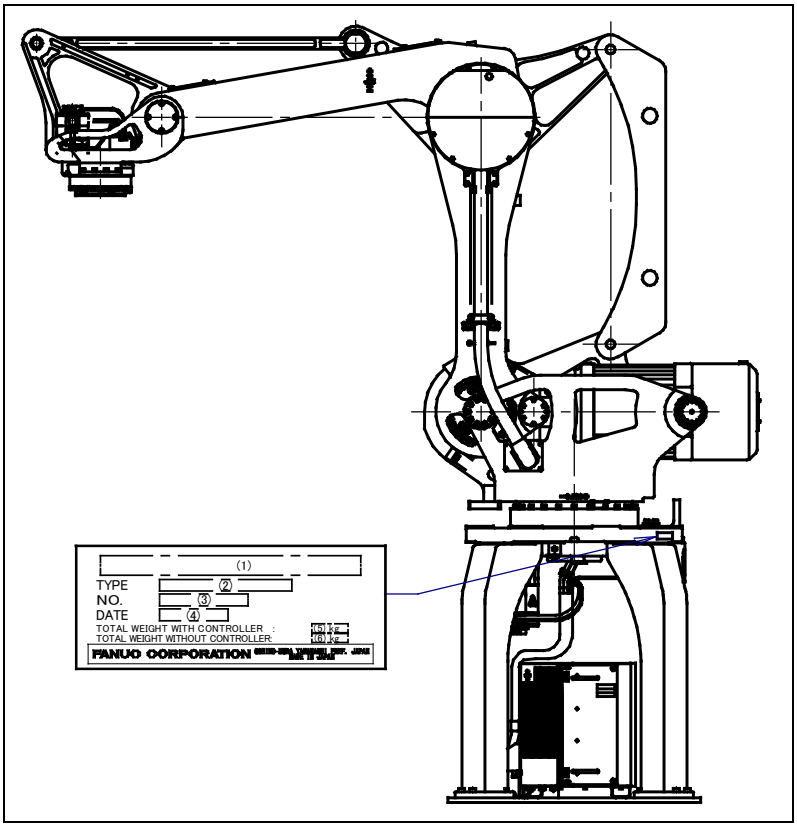
PREFACE

This manual explains the operation procedures for the mechanical units of the following robots:

Model name	Mechanical unit specification No.	Maximum load	Controller
FANUC Robot M-410*i*B/450	A05B-1039-B221	450kg	R-J3*i*B
FANUC Robot M-410*i*B/450	A05B-1039-B231	450kg	R-30*i*A/R-30*i*B

⚠ CAUTION
Note that the models for the R-J3*i*B controller and those for the R-30*i*A/R-30*i*B controller partly differ in the specifications of mechanical unit cables.

The label stating the mechanical unit specification number is affixed in the position shown below. Before reading this manual, verify the specification number of the mechanical unit.



Position of label indicating mechanical unit specification number

	(1)	(2)	(3)	(4)	(5)	(6)
CONTENTS	**MODEL NAME**	**TYPE**	**No.**	**DATE**	**WEIGHT kg (Including controller)**	**WEIGHT kg (Not including controller)**
LETTERS	FANUC Robot M-410*i*B/450	A05B-1039-B221	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	2430	2310
		A05B-1039-B231				

Specifications

ITEM		Specifications
Type		Articulated type
Controlled axes		4 axes (J1, J2, J3, J4)
Installation		Floor mount
Motion range (Maximum speed) (Note 1)	J1-axis	360° (70°/s) 6.28rad (1.12rad/s)
	J2-axis	145° (70°/s) 2.53rad (1.22rad/s)
	J3-axis	135° (70°/s) 2.36rad (1.22rad/s)
	J4-axis	540° (180°/s) 9.42rad (3.14rad/s)
Max. load capacity at wrist (Note 2)		450 kg
Allowable load inertia at wrist		196 kgm^2 (2000kgfcms^2) (Note 3) (∗1)
		294 kgm^2 (3000kgfcms^2) (Note 3) (∗2)
Drive method		Electric servo drive by AC servo motor
Repeatability		±0.5 mm
Mass		Integrated type controller : 2,430 kg (with controller) Remote type controller : 2,310 kg (without controller) : 120 kg (controller)
Acoustic noise		less than 70dB (Note 4)
Installation requirement		Ambient temperature : 0 to 45°C (Note 5) Ambient humidity Normally : 75%RH or less (No dew, nor frost allowed) Short time (within one month) : Max. 95%RH Height : Up to 1000 meters above the sea level requires, no particular provision for posture. Vibration acceleration : 4.9m/s^2 (0.5G) or less Free of corrosive gases (Note 6)

NOTE

1 During short distance motions, the axis speed may not reach the maximum value stated.
2 In case of M-410*i*B, avoid keeping J3 arm horizontally with max payload for a long time to prevent occurrence of the overheat alarm.
3 The allowable value in the standard inertia mode is indicated on the (∗1) and that in the high inertia mode is indicated on the (∗2). For details, see Section 8.3 in the connection manual.
4 This value is equivalent continuous A-weighted sound pressure level which applied with ISO11201 (EN31201). This value is measured with the following conditions.
- Maximum load and speed
- Operating mode is AUTO

5 When the robot is used in a low temperature environment that is near to 0ºC, or not operated for a long time in the environment that is less than 0ºC (during a holiday or during the night), a collision detection alarm (SRVO-050) etc. may occur since the resistance of the drive mechanism could be high immediately after starting the operation. In this case, we recommend performing the warm up operation for several minutes.
6 Contact the service representative, if the robot is to be used in an environment or a place subjected to severe vibrations, heavy dust, cutting oil splash and or other foreign substances.

RELATED MANUALS

For the FANUC Robot series, the following manuals are available:

Safety handbook B-80687EN All persons who use the FANUC Robot and system designer must read and understand thoroughly this handbook		Intended readers : Operator, system designer Topics : Safety items for robot system design, operation, maintenance
R-J3*i*B controller	Setup and Operations manual HANDLING TOOL B-81464EN-2	Intended readers : Operator, programmer, maintenance technician, system designer Topics : Robot functions, operations, programming, setup, interfaces, alarms Use : Robot operation, teaching, system design
	Maintenance manual B-81465EN B-81465EN-1 (European specification)	Intended readers : Maintenance technician, system designer Topics : Installation, start-up, connection, maintenance Use : Installation, start-up, connection, maintenance
R-30*i*A controller	Setup and Operations manual HANDLING TOOL B-83124EN-2 ALARM CODE LIST B-83124EN-6	Intended readers : Operator, programmer, maintenance technician, system designer Topics : Robot functions, operations, programming, setup, interfaces, alarms Use : Robot operation, teaching, system design
	Maintenance manual B-82595EN B-82595EN-1 (For Europe) B-82595EN-2 (For RIA)	Intended readers : Maintenance technician, system designer Topics : Installation, start-up, connection, maintenance Use : Installation, start-up, connection, maintenance
R-30*i*B controller	Operations manual (Basic Operation) B-83284EN (Alarm Code List) B-83284EN-1 OPTIONAL FUNCTION B-83284EN-2	Intended readers : Operator, programmer, maintenance technician, system designer Topics : Robot functions, operations, programming, setup, interfaces, alarms Use : Robot operation, teaching, system design
	Maintenance manual B-83195EN	Intended readers : Maintenance technician, system designer Topics : Installation, start-up, connection, maintenance Use : Installation, start-up, connection, maintenance

This manual uses following terms.

Name	Terms in this manual
Connection cable between robot and controller	Robot connection cable
Robot mechanical unit	Mechanical unit

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1 CONFIGURATION

The configuration of the mechanical unit is shown in Fig. 1 (a) and (b).

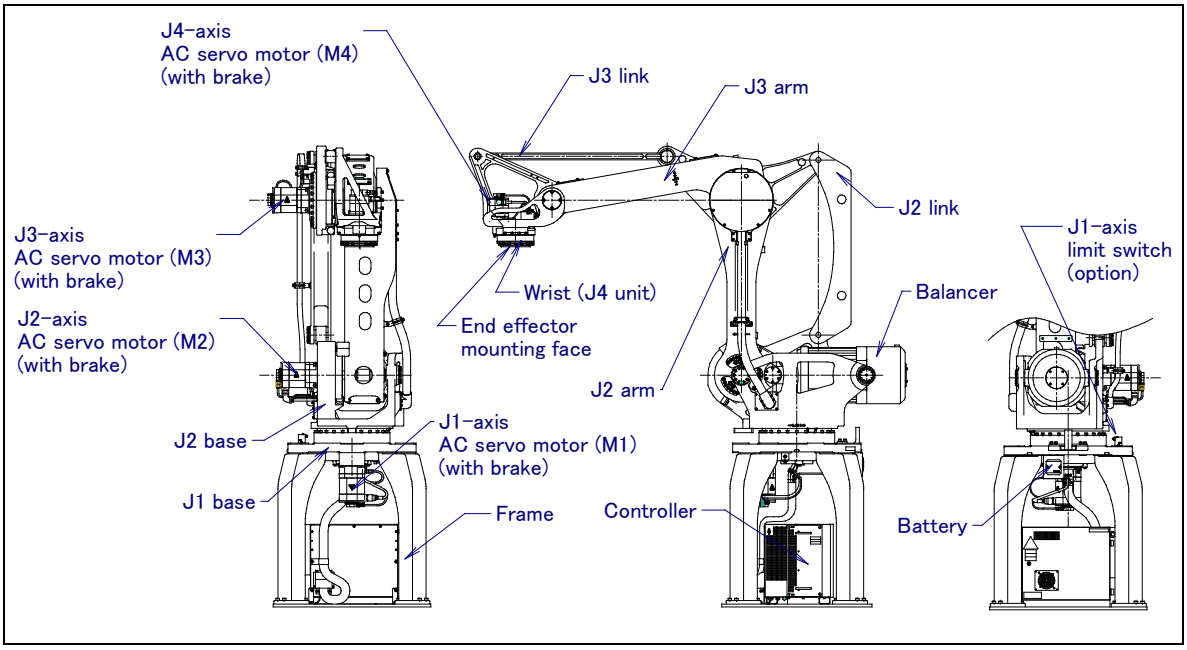


Fig. 1 (a) Mechanical unit configuration (Integrated type controller)

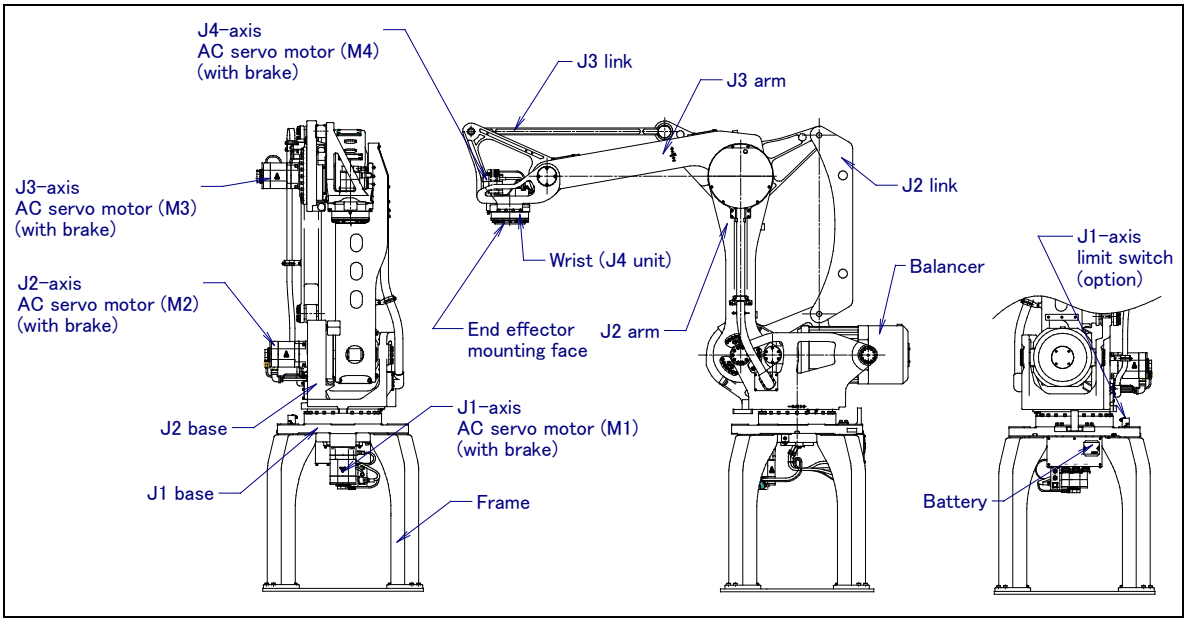


Fig. 1 (b) Mechanical unit configuration (Remote type controller)

2 CHECKS AND MAINTENANCE

Optimum performance of the robot can be maintained for a long time by performing the periodic maintenance procedures presented in this chapter. (Refer to the Appendix A.)

NOTE
The periodic maintenance procedures described in this chapter assume that the FANUC robot is used for up to 3840 hours a year. In cases where robot use exceeds 3840 hours/year, adjust the given maintenance frequencies accordingly. The ratio of actual operating time/year vs. the 3840 hours/year should be used to calculate the new (higher) frequencies. For example, when using the robot 7680 hours a year, the maintenance frequency should be doubled – i.e. the interval should be divided by 2.

2.1 DAILY CHECKS

Clean each part, and visually check component parts for damage before daily system operation. Check the following items as the occasion demands.

1) Before turning on power

Item	Check items	Check points
1	Oil seepage	Check there is oil seepage on sealed part of each joint parts.(Note 1)

Note 1) About oil seepage

Check items

- Check there is oil seepage on sealed part of each joint parts. Oil seepage may be attached (Slightly a loot oil stick) to outside of lip depend on the movement condition or environment of the circumference. If this oil contents change to a state of dew, it may fail depend on the movement. You can prevent oil spot from falling down by wiping the oil contents which is accumulated to under part of oil seal before operation.
- Also, motors may become the high temperature and the internal pressure of grease bath or oil bath may rise by frequent repetition movement and use in the high temperature environment. In these cases, you can return internal pressure by releasing grease out let or oil outlet just after operation of robot. (When opening grease outlet or oil outlet, refer to Section 3.1 and pay attention grease or oil is not scattered.)

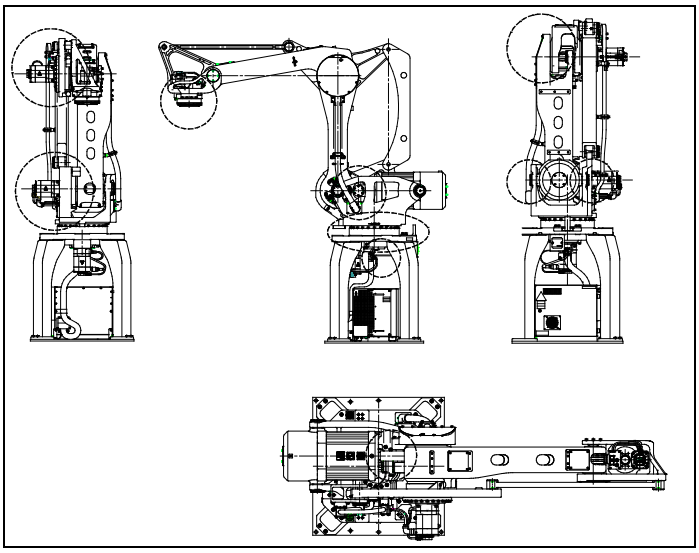


Fig. 2.1 (a) Check parts of oil seepage

Check method

Wipe off the oil contents of each joint part which has oil seal.

When air control set is combined

Item	Check items	Check points
1	Air pressure	Check air pressure using the pressure gauge on the air regulator as shown in Fig.2.1 (b). If it does not meet the specified pressure of 0.49 to 0.69 MPa (5-7 kgf/cm^2), adjust it using the regulator pressure setting handle.
2	Lubricator oil mist quantity	Check the drop quantity during wrist or hand motion. If it does not meet the specified value (1 drop/10-20 sec), adjust it using the lubricator control knob. Under normal usage the lubricator becomes empty in about 10 to 20 days under normal operation.
3	Lubricator oil level	Check to see that the lubricator level is within the specified level.
4	Leakage from hose	Check the joints, tubes, etc. for leaks. Repair leaks, or replace parts, as required.
5	Drain	Check drain and release it. When quantity of the drain is remarkable, examine the setting of the air dryer to the air supply side.

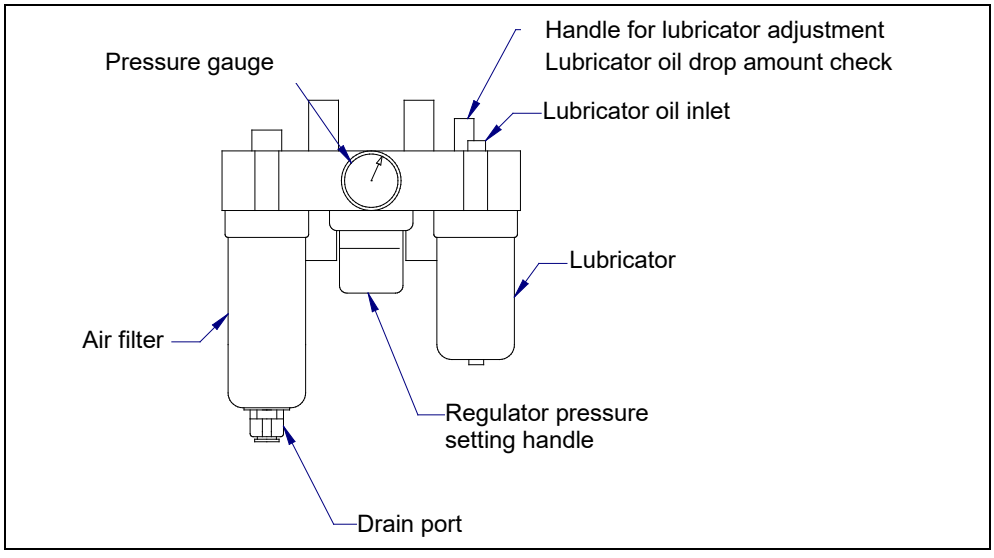


Fig. 2.1 (b) Air control set (option)

2) After automatic operation

Item	Check items	Check points
1	Vibration, abnormal noises, and motor heating	Check whether the robot moves along and about the axes smoothly without unusual vibration or sounds. Also, check whether the temperature of the motors is excessively high.
2	Changing repeatability	Check to see that the stop positions of the robot have not deviated from the previous stop positions.
3	Peripheral devices for proper operation	Check whether the peripheral devices operate properly according to commands from the robot.
4	Brakes for each axis	Check that the end effector drops within 0.5 mm when the power is cut.

2.2 FIRST 1-MONTH (320 HOURS) CHECKS

Check the following items once every one-month (320 hours). Additional inspection areas and times should be added to the table according to the robot's working conditions, environment, etc. Then every 3 months (960 hours) thereafter. (See the Section 2.4.)

Item	Check items	Check points
1	Ventilation portion of controller	If the ventilation portion of the controller is dusty, turn off power and clean the unit.

2.3 FIRST 3-MONTH (960 HOURS) CHECKS

Check the following items at the first quarterly inspection, then every year thereafter. (See the Section 2.5.)

Item	Check items	Check points
1	Cables used in mechanical unit	Check whether the jackets of the mechanical unit cables are damaged. Also check whether the cables are excessively bent or unevenly twisted. Check that the connectors of the motors and connector panels are securely engaged. (NOTE1)
2	Retightening external main bolts	Retighten the end effector mounting bolts and external main bolts.(NOTE2)
3	Check the mechanical stopper and adjustable mechanical stopper	Check the tightness of mounting bolts of mechanical stopper and adjustable mechanical stopper. Particular, check swing stopper of J1-axis rotates smoothly (NOTE3)
4	Cleaning and checking each part	Clean each part (remove chips, etc.) and check component parts for cracks and flaws. (NOTE4)
5	Check the end effector (hand) cable	Confirm whether there is wound in the cable.
6	Check the teach pendant cable, operation box connecting cable and robot connecting cable	Check whether the cable connected to the teach pendant and robot is unevenly twisted.

NOTE 1 Inspection points and check items of the mechanical unit cables and connectors

Inspection points of the mechanical unit cables

Movable parts of J1, the upper side and lower side of link for wrist posture maintenance of rear side of J2 arm, movable part in uniting part of J2 to J3 and J3 to J4 and fixed department cable who interferes easily in peripherals

For the J2/J3 connection part, remove the side cover. Then check cables from side.

Check items

For cables with a cable cover, open the cover before making the check.
Check the cables for a sheath break and wear.
If wires of the cable appear, replace it.

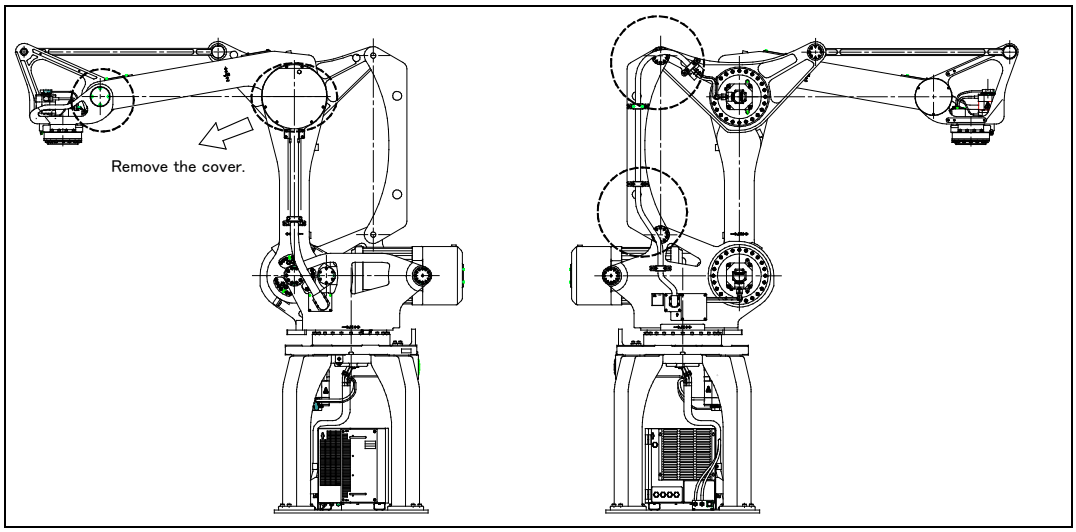


Fig 2.3 (a) Check items of Mechanical unit cable

Inspection points of the connectors

- Power/brake connectors of the motor exposed externally.
- Robot connection cables, user cables and earth terminal.

Check items

- Circular connector: Check the connector for looseness by turning it manually.
- Square connector: Check the connector for disengagement of its lever.
- Earth terminal: Check the connector for looseness.

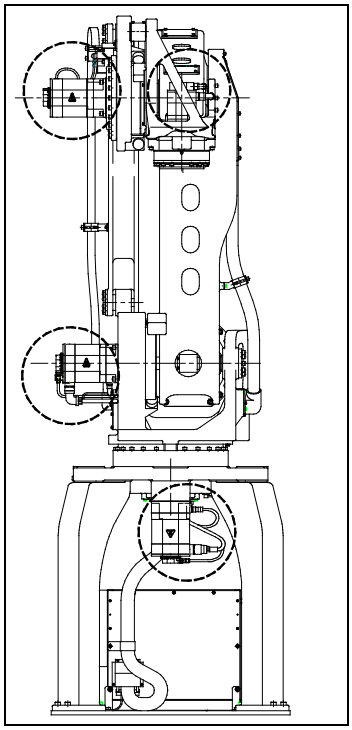


Fig 2.3 (b) Check items of connector

NOTE 2 Points to be retightened

- The end effector mounting bolts, robot installation bolts, and bolts to be removed for inspection need to be retightened.
- The bolts exposed to the outside of the robot need to be retightened.
  For the tightening torque, see the recommended bolt tightening torque shown in the Appendix.
  A loose prevention agent (adhesive) is applied to some bolts. If the bolts are tightened with greater than the recommended torque, the loose prevention agent may be removed. So, follow the recommended tightening torque when retightening them.

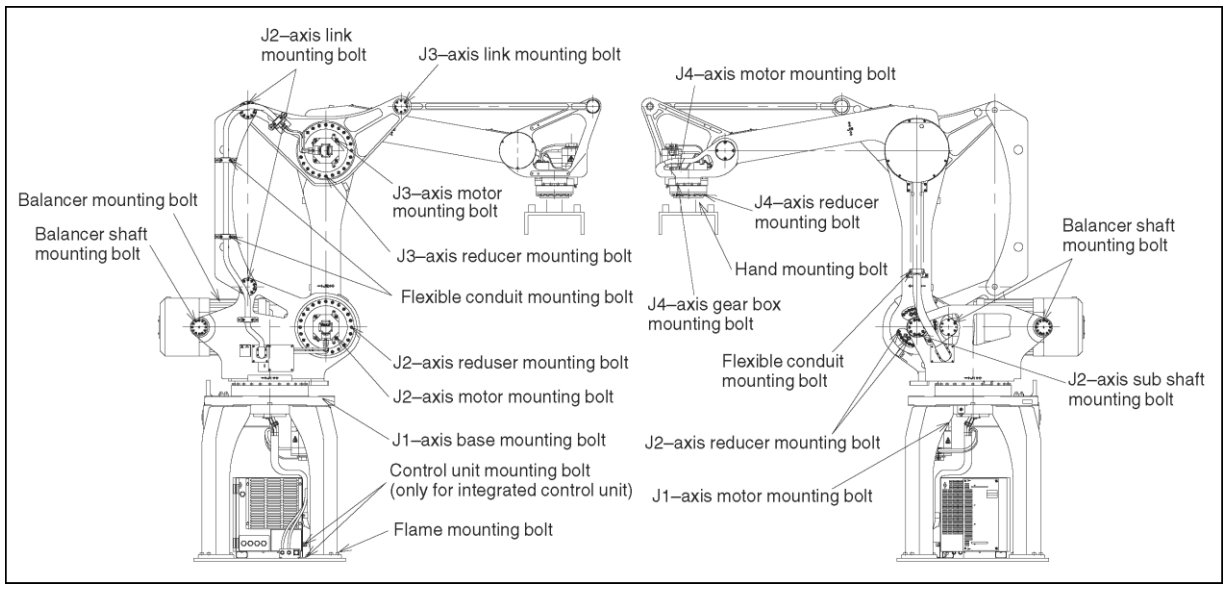


Fig. 2.3 (c) Retighten of the major bolts

NOTE 3 Check of mechanical stopper and adjustable mechanical stopper.

- Check the looseness of stopper mounting bolts. If they are loose, they are needed to be retightened. Especially, check the tightness of mounting bolts of J1-axis swing stopper.
- Check that J1-axis swing stopper rotates smoothly.

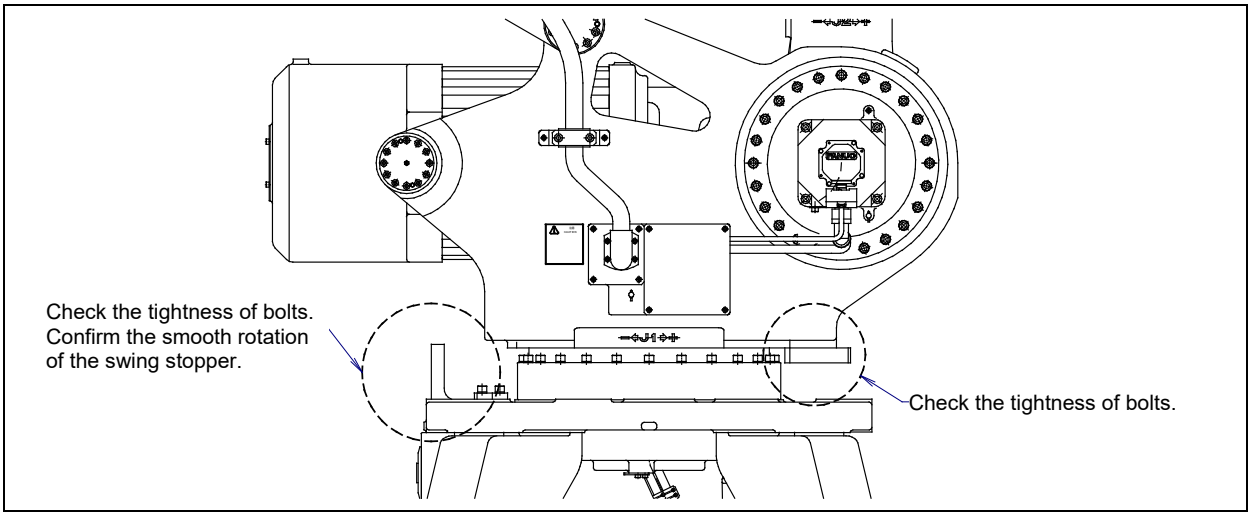


Fig.2.3 (d) Check of mechanical stopper and adjustable mechanical stopper.

NOTE 4 Cleaning

- Necessary cleaning points, dust on the flat part, spatter depositions

Clean sediments periodically.

In particular, clean the following points carefully.

1) Vicinity of the balancer rod and shaft
   → If chippings or spatters are attached to the bushing, abnormal wear may be caused.
2) Vicinity of the wrist axis and oil seal
   → If chippings or spatters are attached to the oil seal, an oil seepage may be occurred.

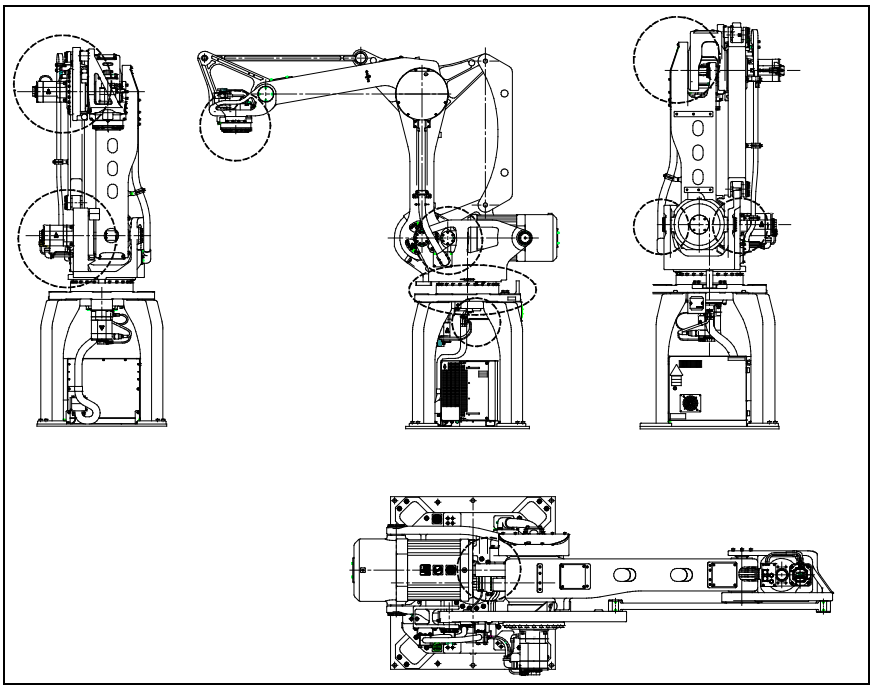


Fig 2.3 (e) Cleaning part

- Check if the vicinity of the necessary inspection points, wrist part, and J3 arm significantly wears due to rubbing against the welding cable or hand cable.
- Check if there is a trace of a collision around the hand.
- Check the reducer or grease bath for an oil seepage.

→ If oil can be found a day after wiping oil, an oil seepage may be

2.4 3-MONTH (960 HOURS) CHECKS

Check the following item at the intervals based on 3 months or 960 hours, whichever comes first, then every 3-month thereafter.

Item	Check items	Check points
1	Ventilation portion of controller	(See Section 2.2.)

2.5 1-YEAR CHECKS (3840 HOURS)

Check the following item at the intervals based on 1 year or 3840 hours, whichever comes first.

Item	Check items	Check points
1	Cables used in mechanical unit	(See Section 2.3)
2	Retightening external main bolts	(See Section 2.3)
3	Check the mechanical stopper and adjustable mechanical stopper	(See Section 2.3)
4	Cleaning and checking each part	(See Section 2.3)
5	Check the end effector (hand) cable	(See Section 2.3)
6	Grease of balancer bush	Supply grease to balancer bush. (See Section 3.2.)
7	Tightness of major external bolts	(See Section 2.3)

2.6 1.5-YEAR CHECKS (5760 HOURS)

Check the following item at the intervals based on 1.5 year or 5760 hours, whichever comes first.

Item	Check items	Check points
1	Battery	Replace battery in the mechanical unit. (See Section 3.3.)

2.7 3-YEAR CHECKS (11520 HOURS)

Check the following item at the intervals based on 3 years or 11520 hours, whichever comes first.

Item	Check items	Check points
1	Grease of each axis reducer	Replace grease of each axis reducer. (See Section 3.1.)
2	Grease of J3/J4-axis cross roller bearing	Supply grease to J3/J4-axis cross roller bearing. (See Section 3.2.)

2.8 4-YEAR CHECKS (15360 HOURS)

Check the following item at the intervals based on 4 years or 15360 hours, whichever comes first.

Item	Check items	Check points
1	Replace the mechanical unit cable	Replace mechanical unit cable. Contact your local FANUC representative for information regarding replacing the cable.

3 PERIODIC MAINTENANCE

3.1 REPLACING GREASE (3 YEARS CHECK (11520 HOURS) PERIODIC MAINTENANCE)

Replace the grease in the J1-, J2-, J3-, and J4-axis reducers every three years or after 11520 operating hours, whichever occurs sooner, by following the procedure explained below.

Table 3.1 (a) shows the required grease type and quantity.

Fig. 3.1 (a) shows the greasing posture.

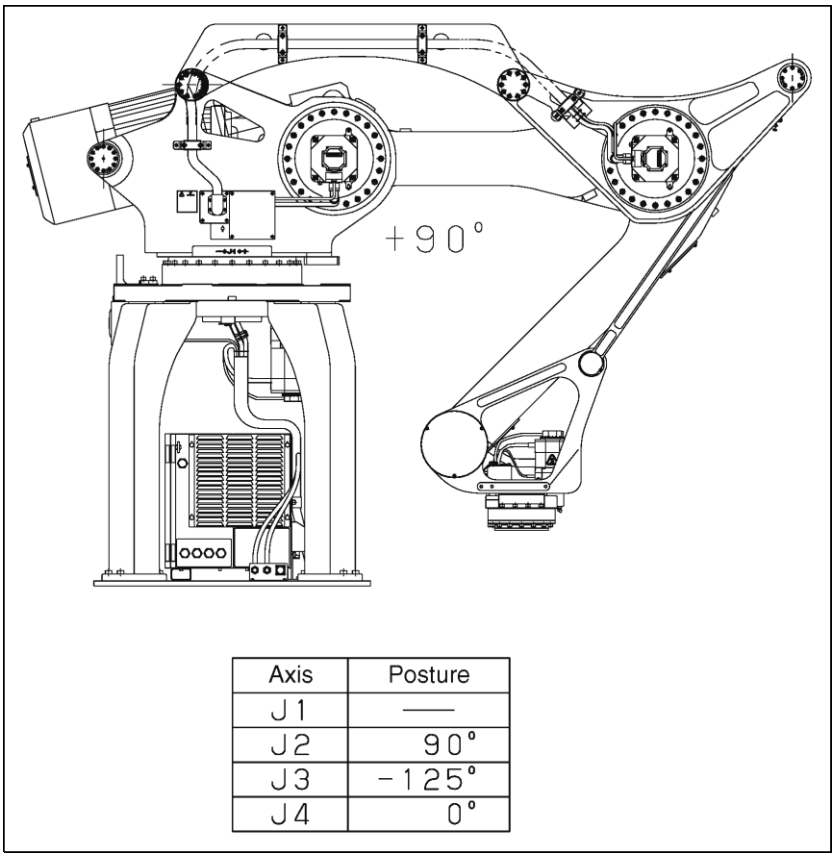
Figs. 3.1 (b) through (d) show the grease inlets and outlets of each reducer.

Table 3.1 (a) Grease for 3-year periodical replacement

Supply position	Grease name	Quantity	Gun tip pressure
J1-axis reducer	Spec.: A98L-0040-0174	10800ml	0.15 MPa or less (NOTE)
J2-axis reducer		2300ml	
J3-axis reducer		2300ml	
J4-axis reducer		1600ml	

NOTE
When a manual pump is used for greasing, the standard rate is two pumping cycles per three seconds.

⚠ WARNING
Hot grease might eject suddenly when you open the grease outlet. Attach bags for collecting grease, and use appropriate protective equipment such as heat-resistant gloves, protective glasses, a face shield, or a body suit if necessary.



Axis	Posture
J1	——
J2	90°
J3	−125°
J4	0°

Fig. 3.1 (a) Greasing posture

1) To replace on the reducer
   1 Turn off the controller power.
   2 Remove the grease outlet plug.
   3 Apply new grease as described Table 3.1 from the grease inlet until it comes out from the grease outlet.
   4 After applying grease, release the remaining pressure within the grease bath as described in the procedure in Subsection 3.1.1.

⚠ CAUTION

If greasing is performed incorrectly, the internal pressure of the grease bath may suddenly increase, possibly causing damage to the seal, which would in turn lead to grease leakage and abnormal operation.
When performing greasing, therefore, observe the following cautions.

1 Before starting to grease, open the grease outlet (remove the plug or bolt from the grease outlet) to allow the grease to come out.
2 Supply grease slowly without applying excessive force, using a manual pump.
3 Whenever possible, avoid using a compressed-air pump, powered by the factory air supply. Even when using a compressed-air pump unavoidably, set the gun tip pressure (see Table 3.1 (a)) to 0.1 5MPa or less during application of grease.
4 Use grease only of the specified type. Grease of a type other than that specified may damage the reducer or lead to other problems.
5 After applying grease, release the remaining pressure within the grease bath as described in the procedure in Subsection 3.1.1.
6 To prevent slipping accidents and catching fire, completely remove all any excess grease from the floor or robot.

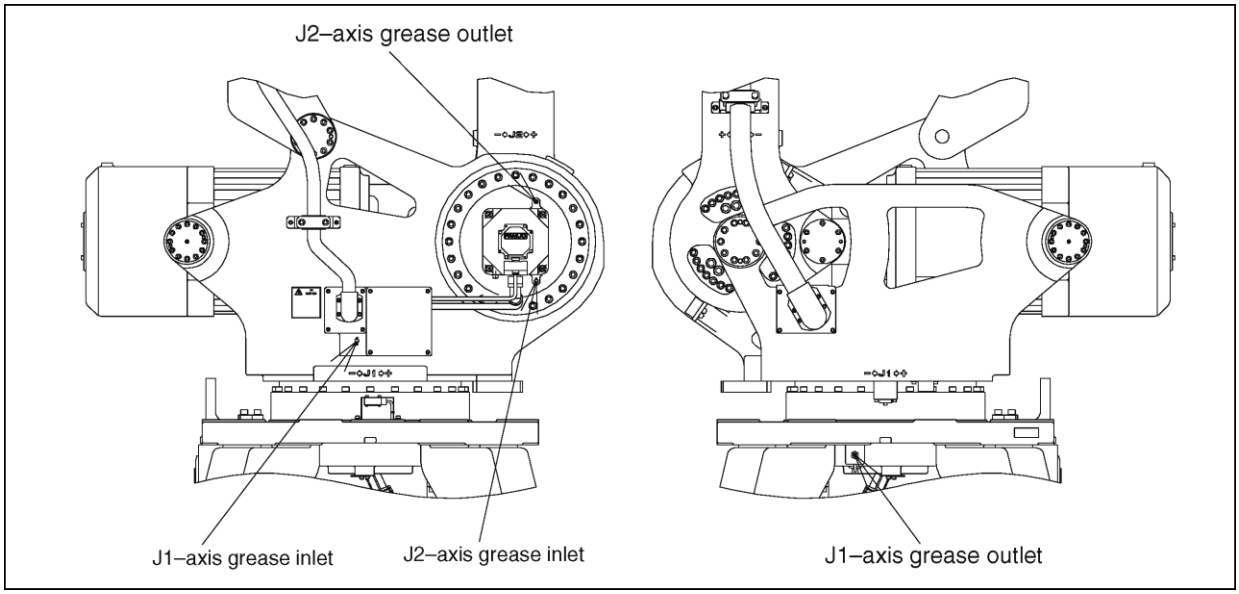


Fig. 3.1 (b) Replacing the grease of the J1-axis/J2-axis reducers

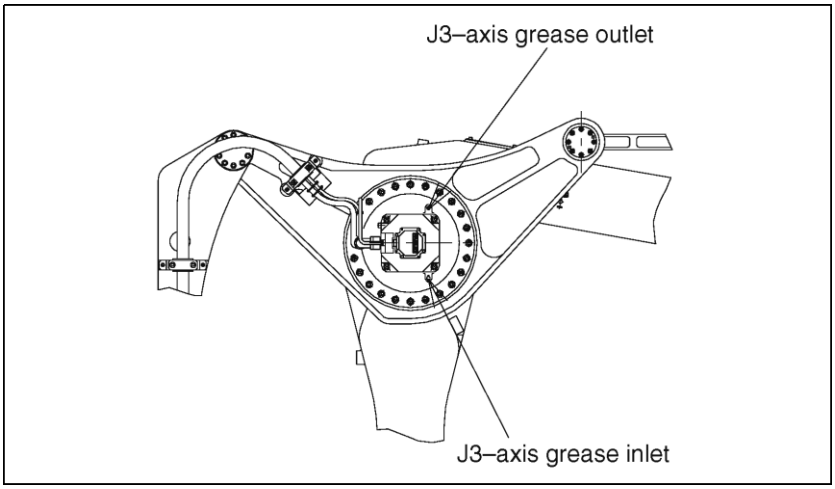


Fig. 3.1 (c) Replacing the grease of the J3-axis reducer

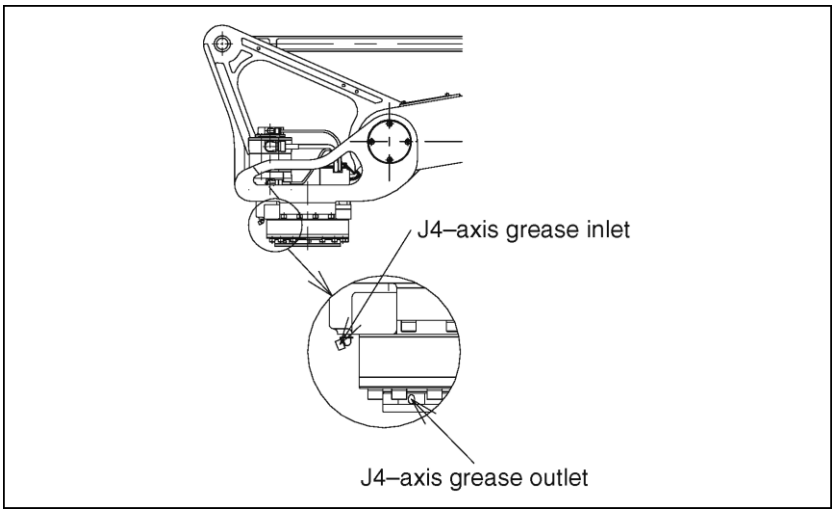


Fig. 3.1 (d) Replacing grease of J4-axis reducer

3.1.1 Procedure for Releasing Remaining Pressure within the Grease Bath

To release the remaining pressure in the grease bath after applying grease, operate the robot for 40 minutes or more for J1 and J2-axis and for 20 minutes or more for J3 and J4-axis as described in the table below with the grease nipple of the grease inlet and the plug of the grease outlet left open for the J1-axis reducer and J4-axis reducer, and the plug of the grease outlet left open for the J2-axis reducer and J3-axis reducer. Attach the reclaim bags under the grease inlet and grease outlet to prevent spilled grease from splattering.

<table>
<tr><th>Operating axis / Grease replacement part</th><th>J1-axis</th><th>J2-axis</th><th>J3-axis</th><th>J4-axis</th></tr>
<tr><td>J1-axis reducer</td><td>Axis angle of 80° or more
OVR 50%</td><td colspan="3">Arbitrary</td></tr>
<tr><td>J2-axis reducer</td><td>Arbitrary</td><td>Axis angle of 90° or more
OVR 50%</td><td colspan="2">Arbitrary</td></tr>
<tr><td>J3-axis reducer</td><td colspan="2">Arbitrary</td><td>Axis angle of 60° or more
OVR 50%</td><td>Arbitrary</td></tr>
<tr><td>J4-axis gearbox</td><td colspan="3">Arbitrary</td><td>Axis angle of 60° or more
OVR 100%</td></tr>
</table>

If the above operation cannot be performed due to the environment, adjust the operating time according to the operating angle. (When the maximum allowable axis angle is 30°, operate the robot for twice minute of a specified length.) If you grease multiple axes, you can exercise multiple axes at the same time.
After the above operation is performed, attach the grease nipple to the grease inlet and the seal bolt to the grease outlet. When the seal bolt or grease nipple is reused, be sure to seal it with seal tape.

3.2 GREASING (3 YEARS CHECK (11520 HOURS) PERIODIC MAINTENANCE)

Supply grease to the parts periodically (after the prescribed number of operating hours or every specified interval, whichever comes earlier). If the robot is installed in a severe environment, apply grease whenever necessary. If water splashes on the robot, apply grease immediately. Table 3.2 (a) and Fig. 3.2 show greasing points. Table 3.2 (b) shows substitute greases. When performing greasing, observe the cautions listed in Section 3.1.

NOTE
When the robot is used under high-duty conditions that, for example, require a cooling unit (fan), perform greasing at half of the standard interval.

Table 3.2 (a) Greasing points

Positions	Grease	Amount	Method	Greasing interval
Balancer connection point bushing (2 positions)	SHELL ALVANIA GREASE S2 (A98L-0004-0602#CTG)	Each $1.0\times1.0^{-5}m^3$ (Each 10 ml)	Supply to the grease nipple	11520 hours (Every 3 years)
J3-axis cross roller bearing		$4.0\times10^{-5}m^3$ (40 ml)	Supply to the grease nipple	
J4-axis cross roller bearing		$2.0\times10^{-5}m^3$ (20 ml)	Supply to the grease nipple	

NOTE

Old grease is expelled from the bearing rotating part after new grease is supplied. Wipe off old grease immediately after supplying grease, and then again after 50 to 100 hours of operation.

Table 3.2 (b) Substitutes for ALVANIA GREASE S2

Maker	Grease name
MOBIL OIL	MOBILACKS EP2
JXTG Nippon Oil & Energy Corporation	MULTINOC 2
JXTG Nippon Oil & Energy Corporation	EPINOC AP-2
IDEMITSU KOHSAN	EPONEX GREASE NO.2
COSMO OIL	DYNAMAX NO.2
Showa Shell Sekiyu K.K.	Shell Gadus S2 V100 2

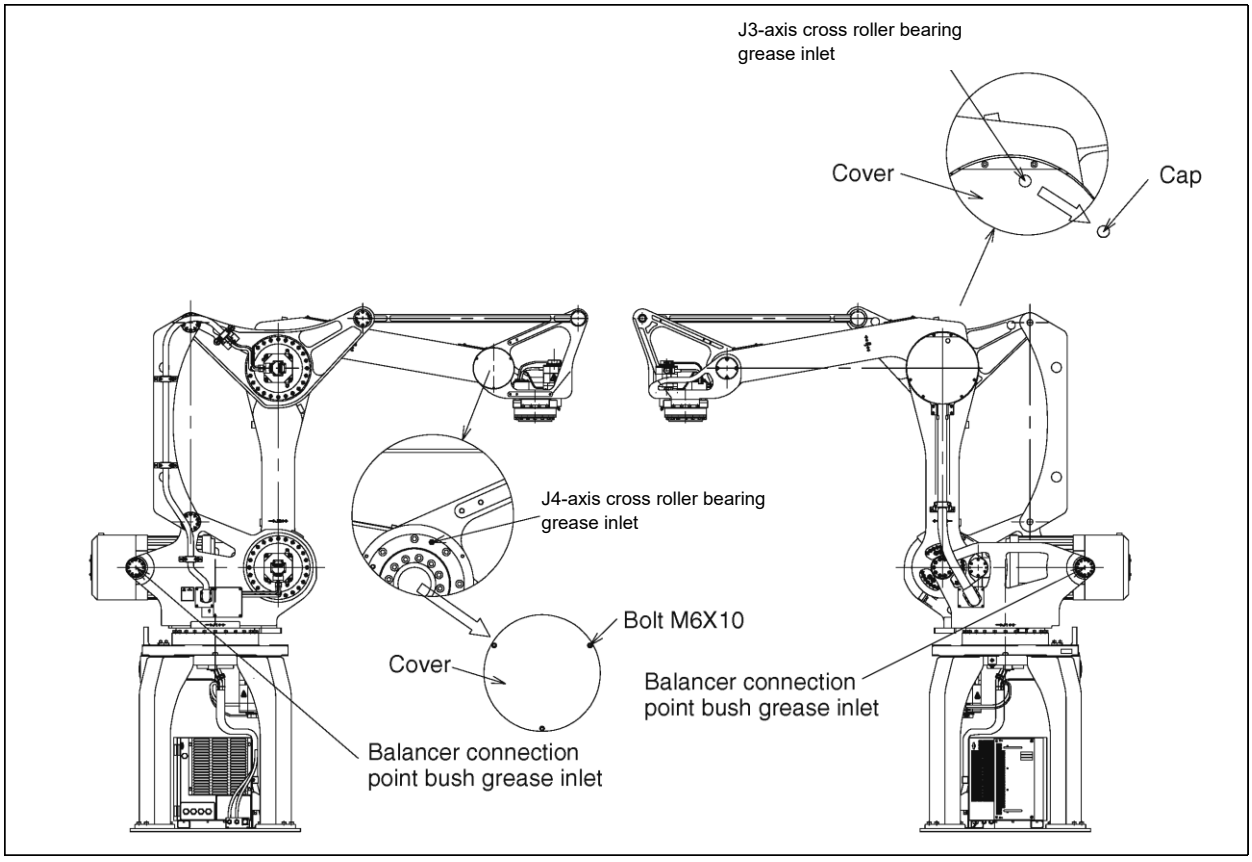


Fig. 3.2 (a) Greasing points

3.3 REPLACING BATTERY (1.5 YEARS CHECK (5760 HOURS) PERIODIC MAINTENANCE)

The position data of each axis is preserved by the backup battery. The battery needs to be periodically replaced at every 1.5 year. Use the following procedure to replace when the backup battery voltage drop alarm occurs. The following shows the replacing procedure.

1 Press the EMERGENCY STOP button to prohibit the robot motion.
2 Remove the battery case cap.
3 Take out the old batteries from the battery case.
4 Insert new batteries into the battery case.
Pay attention to the direction of batteries.
5 Close the battery case cap.

⚠ CAUTION
Be sure to keep the power supply turning on. Replacing the batteries with the power supply turned off causes all current position data to be lost. Therefore, mastering will be required again. (See Sections 5.5.)

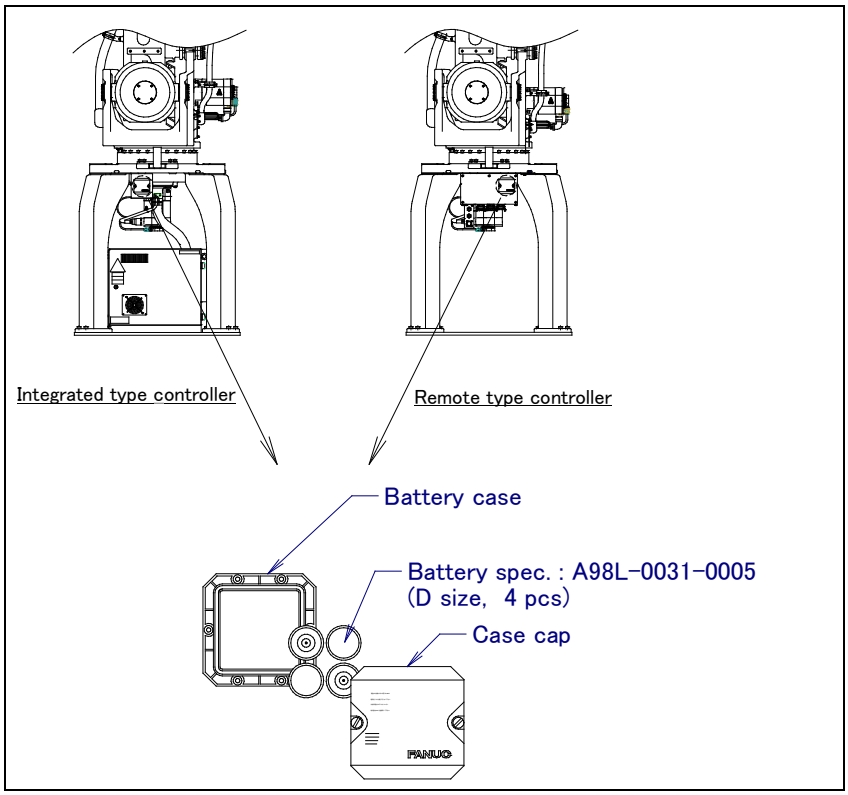


Fig. 3.3 (a) Replacing Battery

4 TROUBLESHOOTING

The source of mechanical unit problems may be difficult to locate because of overlapping causes. Problems may become further complicated, if they are not corrected properly. Therefore, you must keep an accurate record of problems and take proper corrective actions.

4.1 TROUBLESHOOTING

Table 4.1 (a) shows the major troubleshooting that may occur in the mechanical unit and their probable causes. If you cannot pinpoint a failure cause or which measures to take, contact your local FANUC representative.

Table 4.1 (a) Troubleshooting

Symptom	Description	Cause	Measure
Vibration Noise	- The J1 base lifts off the floor plate as the robot operates. - There is a gap between the J1 base and floor plate. - A J1 base retaining bolt is loose.	[J1 base fastening] - It is likely that the robot J1 base is not securely fastened to the floor plate. - Probable causes are a loose bolt, an insufficient degree of surface flatness, or contamination caught between the floor plate and floor plate. - If the robot is not securely fastened to the floor plate, the J1 base lifts the floor plate as the robot operates, allowing the base and floor plates to strike each other which, in turn, leads to vibration.	- If a bolt is loose, apply LOCTITE and tighten it to the appropriate torque. - Adjust the floor plate surface flatness to within the specified tolerance. - If there is any contaminations, remove it.
	- The rack or floor plate vibrates during robot operation.	[Rack or floor] - It is likely that the rack or floor is not rigid enough. - If the rack or floor is not rigid enough,counterforce can deform the rack or floor, and cause vibration.	- Reinforce the rack or floor to make it more rigid. - If reinforcing the rack or floor is impossible, modify the robot control program; doing so might reduce the vibration.
	- Vibration becomes more serious when the robot adopts a specific posture. - If the operating speed of the robot is reduced, vibration stops. - Vibration is most noticeable when the robot is accelerating. - Vibration occurs when two or more axes operate at the same time.	[Overload] - It is likely that the load on the robot is greater than the maximum rating. - It is likely that the robot control program is too demanding for the robot hardware. - It is likely that the acceleration value is excessive.	- Check the maximum load that the robot can handle. If the robot is overloaded, reduce the load, or modify the robot control program. - Vibration can be reduced by modifying the robot teach pendant program ; reducing speed or acceleration while minimizing the effect on the entire cycle time.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- Vibration or noise was first noticed after the robot collided with an object or the robot was overloaded for a long period. - The grease of the vibrating or noise occurring axis has not been replaced for a long period. - Periodic vibration and noise occur.	[Gear, bearing, or reducer] - It is likely that the collision or overload applied an excessive force to the drive system, thus damaged the geartooth surface or rolling surface of a bearing, or reducer. - It is likely that prolonged use of the robot while overloaded caused fretting of the gear tooth surface or rolling surface of a bearing, or reducer due to resulting metal fatigue. - It is likely that contamination caught in a gear, bearing, or within a reducer caused damage on the gear tooth surface or rolling surface of the bearing, or reducer. - It is likely that contamination caught in a gear, bearing, or within a reducer caused vibration. - It is likely that, because the grease has not been replaced for a long period, fretting occurred on the gear tooth surface or rolling surface of a bearing, or reducer due to metal fatigue.	- Operate one axis at a time to determine which axis is vibrating. - Remove the motor, and replace the gear, the bearing, and the reducer. For the spec. of parts and the method of replacement, contact your local FANUC representative. - Using the robot within its maximum rating prevents problems with the drive mechanism. - Supplying the specified grease at the recommended interval will prevent problems.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- The cause of the problem cannot be identified from examination of the floor, rack, or mechanical unit.	[Controller, cable, and motor] - If a failure occurs in a controller circuit, preventing control commands from being supplied to the motor normally, or preventing motor information from being sent to the controller normally, vibration might occur. - Pulsecoder defect may be the cause of the vibration as the motor cannot send the accurate position to the controller. - If the motor becomes defective, vibration might occur because the motor cannot deliver its rated performance. - If a power line in a movable cable of the mechanical unit has an intermittent break, vibration might occur because the motor cannot accurately respond to commands. - If a Pulsecoder wire in a movable part of the mechanical unit has an intermittent break, vibration might occur because commands cannot be sent to the motor accurately. - If a robot connection cable has an intermittent break, vibration might occur. - If the power supply cable is about to be snapped, vibration might occur. - If the power source voltage drops below the rating, vibration might occur. - It may vibrate when an invalid value parameter was set.	- Refer to CONTROLLER MAINTENANCE MANUAL for troubleshooting related to the controller and amplifier. - Replace the motor of the axis that is vibrating, and check whether vibration still occurs. For the method of replacement, contact your local FANUC representative. - If vibration occurs only when the robot assumes a specific posture, it is likely that there is a mechanical problem. - Shake the movable part cable while the robot is at rest, and check whether an alarm occurs. If an alarm or any other abnormality occurs, replace the mechanical unit cable. - Check whether the cable jacket of the robot connection cable is damaged. If so, replace the connection cable, and check whether vibration still occurs. - Check whether the power cable jacket is damaged. If so, replace the power cable, and check whether vibration still occurs. - Check that the robot is supplied with the rated voltage. - Check that the robot control parameter is set to a valid value. If it is set to an invalid value, correct it. Contact your local FANUC representative for further information if necessary.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- There is a relationship between the vibration of the robot and the operation of a machine near the robot.	[Noise from a nearby machine] - If the robot is not grounded properly, electrical noise can be induced on the grounding wire, preventing commands from being transferred accurately, thus leading to vibration. - If the robot is grounded at an unsuitable point, its grounding potential becomes unstable, and noise is likely to be induced on the grounding line, thus causing it to vibrate.	- Connect the grounding wire firmly to ensure a reliable ground potential thereby preventing extraneous electrical noise.
	- There is an unusual sound after replacing grease. - There is an unusual sound after a long time pause. - There is an unusual sound during operation at low speed.	- There may be an unusual sound when using other than the specified grease. - Even for the specified grease, there may be an unusual sound during operation at low speed immediately after replacement or after a long period of time.	- Use the specified grease. - When there is an abnormal noise even when using the specified grease, operate for one or two days as an experiment. Generally, any abnormal noise will disappear.
Rattling	- While the robot is not supplied with power, pushing it by hand wobbles part of the mechanical unit. - There is a gap on the mounting face of the mechanical unit.	[Mechanical unit mounting bolt] - It is likely that overloading or a collision has loosened a mounting bolt in the robot mechanical unit.	- Check the following retaining bolts tightness for each axis. If any of these bolts is loose, apply LOCTITE and bolt down with appropriate torque. - Motor retaining bolt - Reducer retaining bolt - Reducer shaft retaining bolt - Base retaining bolt - Arm retaining bolt - Casing retaining bolt - End effector retaining bolt

Symptom	Description	Cause	Measure
Motor overheating	- The motor overheated due to the temperature in the installation area rose. - After a cover was attached to the motor, the motor overheated. - After changing the Robot control program or the load, the motor overheat.	[Ambient temperature] - It is likely that the motor overheated along with the ambient temperature rose, and could not release heat. [Operating condition] - It is likely that the overcurrent is above the specified permissive average current.	- Reducing the ambient temperature is the most effective means of preventing overheat. - Having the surroundings of the motor well ventilated enables the motor to release heat efficiently, thus preventing overheat. - If there is a source of heat near the motor, it is advisable to install shielding to protect the motor from heat radiation. - Relaxing the robot control program and load condition is an effective way to reduce the average current. Thus, prevent overheat. - The teach pendant can monitor the average current. Check the average current when the robot control program launched.
	- After a robot control parameter (load setting etc.) was changed, the motor overheated.	[Parameter] - If data input for a workpiece is invalid, the robot cannot be accelerate or decelerate normally, so the average current increases, leading to the motor overheating.	- As for load setting, Input an appropriate parameter referring to Section 8.3 of the operator's manual.
	- Symptom other than stated above	[Mechanical section problems] - It is likely that problems occurred in the mechanical unit drive mechanism, thus placing an excessive load on the motor. [Motor problems] - It is likely that a failure of the motor brake resulted in the motor running with the brake applied, thus placing an excessive load on the motor. - It is likely that a failure of the motor prevented it from delivering its rated performance, thus causing an excessive current to flow through the motor.	- Repair the mechanical unit referring to the above descriptions of vibration, noise, and rattling. - Check that, when the servo system is energized, the brake is released. If the brake remains applied to the motor all the time, replace the motor. - Judgment is possible if the average current decreased after replacing the motor, the former motor had been defected.

Symptom	Description	Cause	Measure

Grease leakage	- Grease leaks from the mechanical unit.	[Poor sealing]
		- Probable causes are a crack in the casting, a damaged O-ring, a damaged oil seal or gasket, sealant deterioration or a loose seal bolt.
		- The casting may crack with excessive force caused in collision.
		- An O-ring can be damaged if it is trapped or cut during disassembling or re-assembling.
		- An oil seal may be damaged if dust scratches the lip.
		- A loose seal bolt may allow grease to leak along the threads.
		- Problems with the grease nipple.
			- If the casting cracks, sealant can be used as a quick-fix to prevent further grease leakage. However, the component must be replaced as soon as possible, as the crack will widen.
			- O-rings are used in the locations listed below.
			  - Motor coupling section
			  - Reducer (case and shaft) coupling section
			  - Wrist coupling section
			  - J3 arm coupling section
			  - Inside the wrist
			- Oil seals are used in the locations stated below.
			  - Inside the reducer
			  - Inside the wrist
			- Seal bolts are used in the locations stated below.
			  - Grease outlet
			- Replace the grease nipple.

Dropping axis	- An axis falls because the brake went out.
	- An axis falls while standing still.
		[Brake drive relay and motor]
		- It is likely that brake drive relay contacts are stuck to each other and keep the brake current flowing, thus preventing the brake from operating when the motor is reenergized.
		- It is likely that the brake shoe has worn out or the brake main body is damaged, preventing the brake from operating efficiently.
		- It is likely that oil or grease soak through the motor, causing the brake to slip.
			- Check whether the brake drive relays are stuck to each other or not. If they are found to be stuck, replace the relays.
			- Replace the motor after confirming whether the following symptoms have occurred.
			  - Brake shoe is worn out
			  - Brake main body is damaged
			  - Oil soaked through the motor

Symptom	Description	Cause	Measure
Displacement	- The robot moves to a point other than the taught position. - The repeatability is not within the tolerance.	[Mechanical unit problems] - If the robot is not repeatable, probable causes are a failure in the drive mechanism or a loose bolt. - If the robot is repeatable, it is likely that a collision caused slip on the sting surface of each axis arm, and reducer. - It is likely that the Pulsecoder is faulty.	- If the robot is not repeatable, repair the mechanical unit by referring to the above descriptions of vibration, noise, and rattling. - If the robot is repeatable, correct the taught program. The problem will not reoccur unless another collision occurs. - If the Pulsecoder is faulty, replace the motor.
	- Displacement occurs only in specific peripheral equipment.	[Peripheral equipment displacement] - It is likely that an external force was applied to the peripheral equipment, thus shifting its position relative to the robot.	- Correct the peripheral equipment position. - Correct the taught program.
	- Displacement occurred after a parameter was changed.	[Parameter] - It is likely that the mastering data was overwritten moving the robot's origin.	- Re-enter the previous optimal mastering data. - If correct mastering data is unavailable, perform mastering again.
BZAL alarm displayed	- BZAL is displayed on the teach pendant screen	- It is likely that the voltage of the memory backup battery is low. - It is likely that the Pulsecoder cable is defective.	- Replace the battery. - Replace the cable.

Table 4.1 (b) Allowable drop of brake

At Power-Off stop	0.5mm

NOTE
The value is the drop value from the end effector mounting face.

5 ADJUSTMENTS

Each part of the mechanical unit is carefully adjusted at the factory before shipment. Therefore it is usually unnecessary for the customer to make adjustments at the time of delivery. However, after for a long period of use or after parts are replaced, adjustments may be required.

5.1 ADJUSTING LIMIT SWITCHES AND DOGS (OPTION)

1) Zero point position and motion limit

Zero point and motion limits are provided for each controlled axis. Reaching the operation limit of controlled axis is called over travel (OT). Over travel is detected at J1-axis only (option). Over travel detection function is not prepared at J2-axis to J4 axis.

The robot cannot exceed the motion range unless there is a failure of the system causing loss of the zero point position, or there is a system error.

Fig. 5.1 (a) shows the zero point, motion limit OT detection point and point of mechanical stopper of J1-axis.

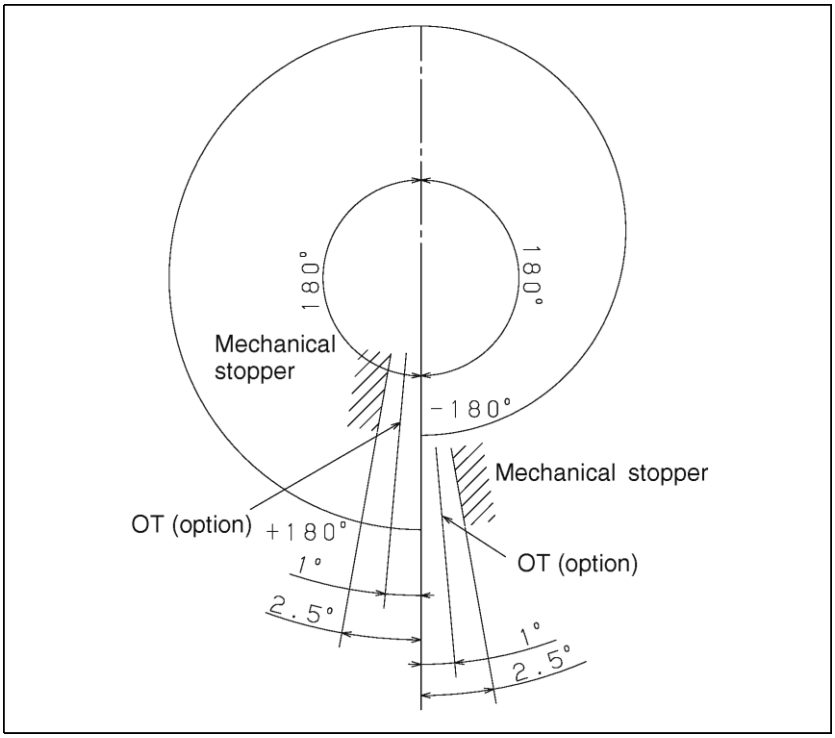


Fig. 5.1 (a) Zero point and motion limit of J1-axis

2) How to adjust the J1-axis
   1 Set the $MOR_GRP.$CAL_DONE system parameter to FALSE. This disables the stroke end specified by the software. As a result, the operator can rotate the robot around the J1-axis by a jog feed which goes beyond the stroke end.
   2 Loosen the two M6 x 12 bolts and the two M4 x 25 bolts that secure the J1-axis limit switch.
   3 Adjust the switch position so that the robot activates the limit switch when approximately 1.0 degree from each stroke end. When the dog is pressed, only one side of the pushing width indication lines on the end of the switch must be hidden.
   4 When the limit switch operates and detects over travel (OT), the robot stops, and an error message, "OVERTRAVEL", is displayed. To restart the robot, hold on the [SHIFT] key and press the [RESET] key. Then, while holding on the [SHIFT] key, release the J1 axis from the limit by JOG feed.
   5 Check that the robot also activates the limit switch when the robot is approx. 1.0 degree from the opposite stroke end in the same way as above. If the limit switch does not operate at the position, adjust the position of the switch again.
   6 Set the $MOR_GRP.$CAL_DONE system parameter to TRUE.
   7 Cycle power of the controller.

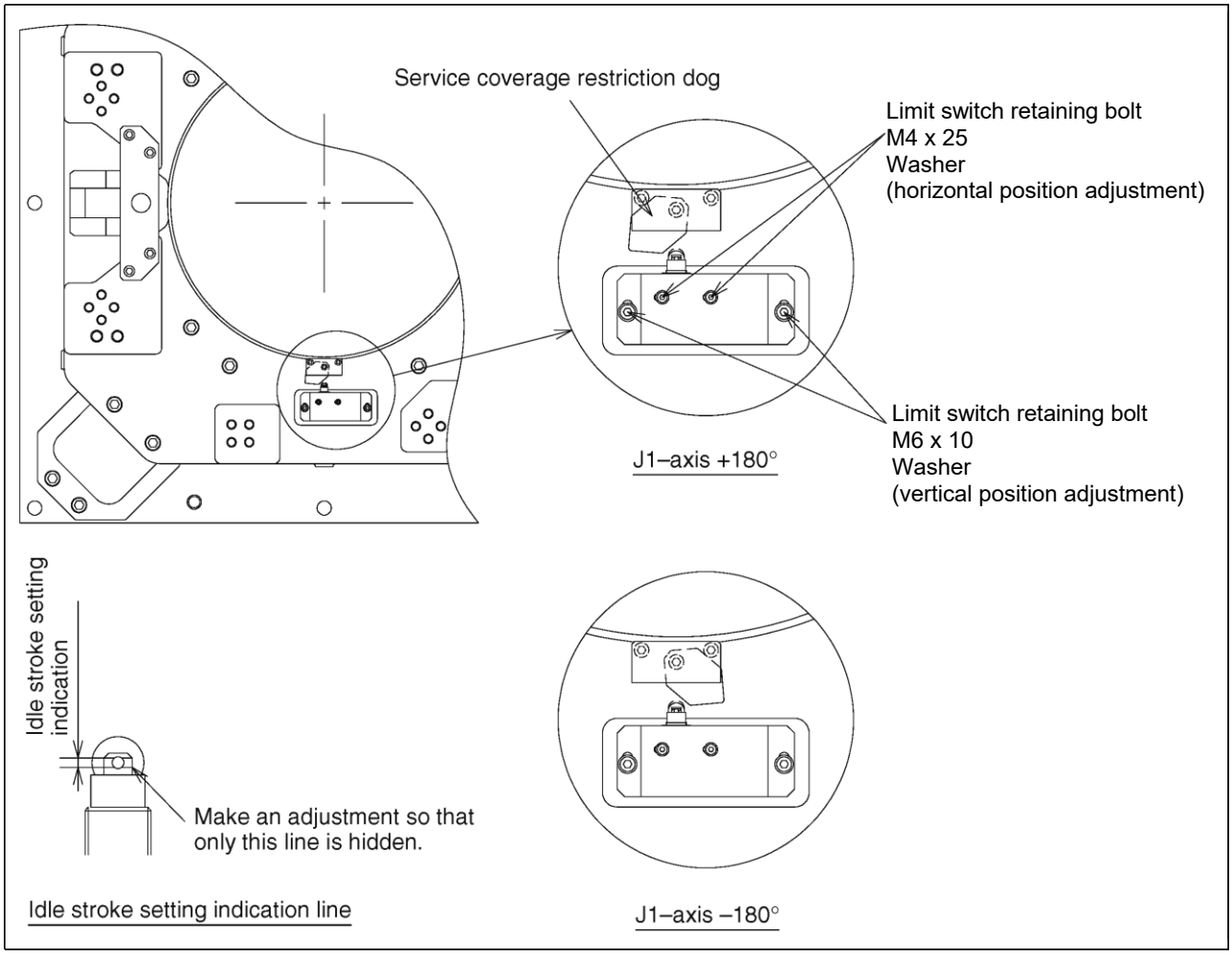


Fig. 5.1 (b) Adjusting J1-axis OT (option)

5.2 ZERO POINT POSITION AND MOTION LIMIT OF J2-AXIS TO J4-AXIS

Fig. 5.2 (a) to (c) show zero point position and motion area and mechanical stopper of each axis.

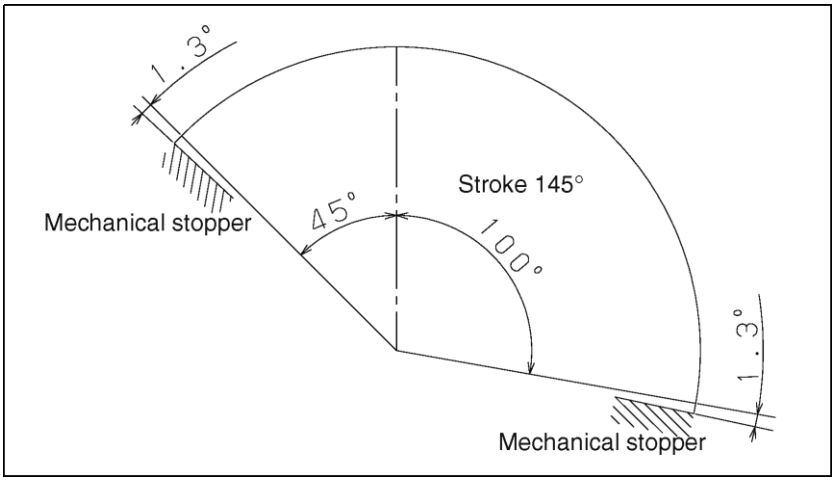


Fig. 5.2 (a) J2-axis

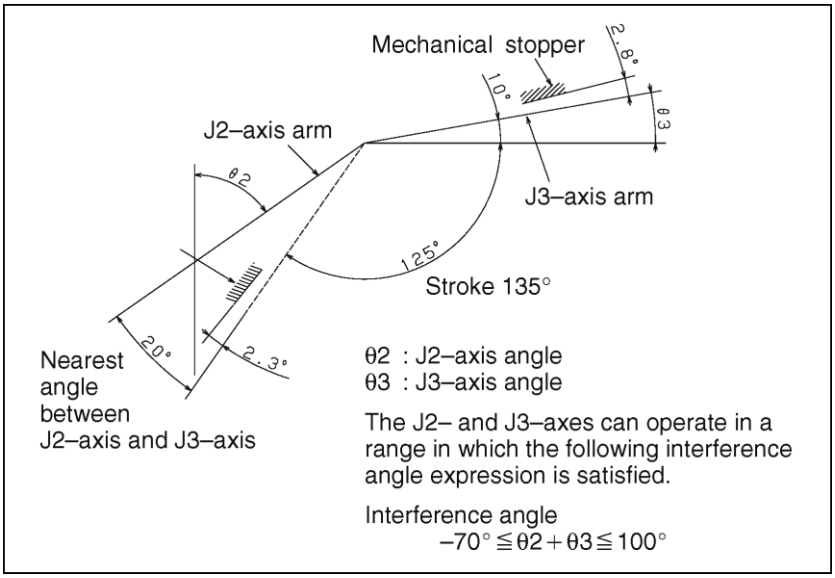


Fig. 5.2 (b) J3-axis

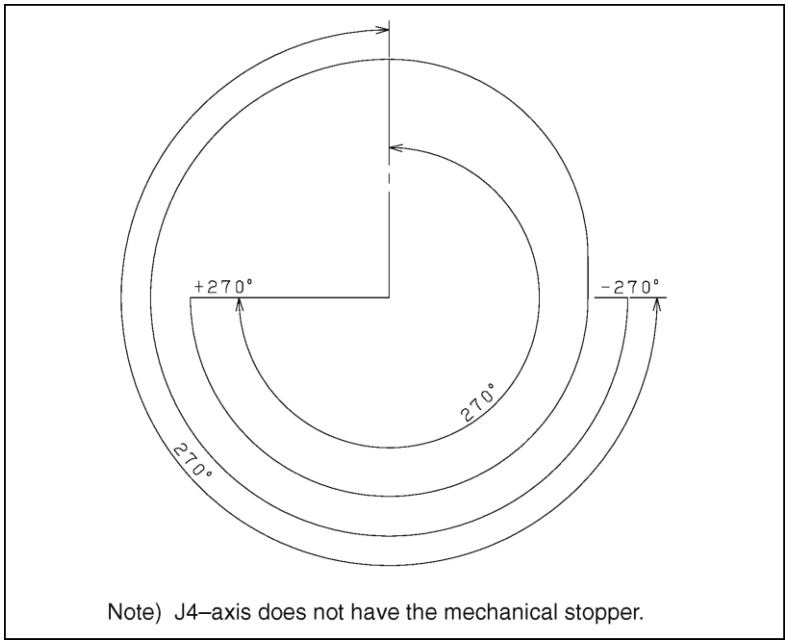


Fig. 5.2 (c) J4-axis

5.3 J1-AXIS STROKE MODIFICATION (OPTION)

The J1-axis stroke can be limited depending on the operating environment of the robot. The stroke can be changed by changing the locations of the dog and mechanical stopper and the settings of the parameters using the following procedure. (Fig. 5.3 (a) to (b) and Table 5.3 (a))
The stroke can be changed every 45 degrees in the upper limit of +45 degrees to + 180 degrees and the lower limit of -180 degrees to -45 degrees.

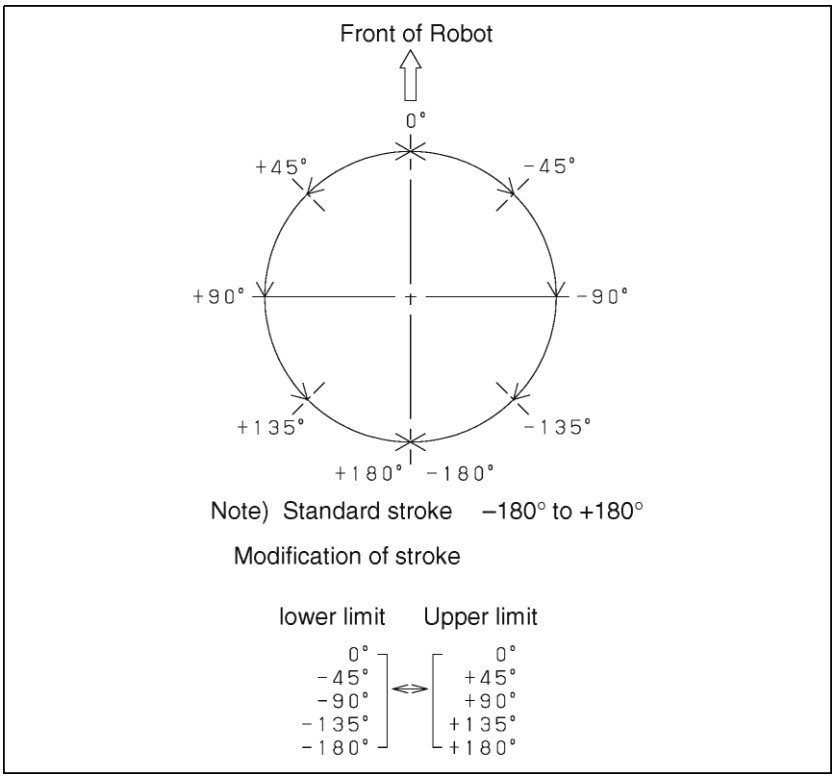


Fig. 5.3 (a) Modifying J1-axis stroke (option)

(a) Changing the mechanical stopper and the dog (option) position.
Change the mechanical position and the dog position as shown in Fig. 5.3 (b).

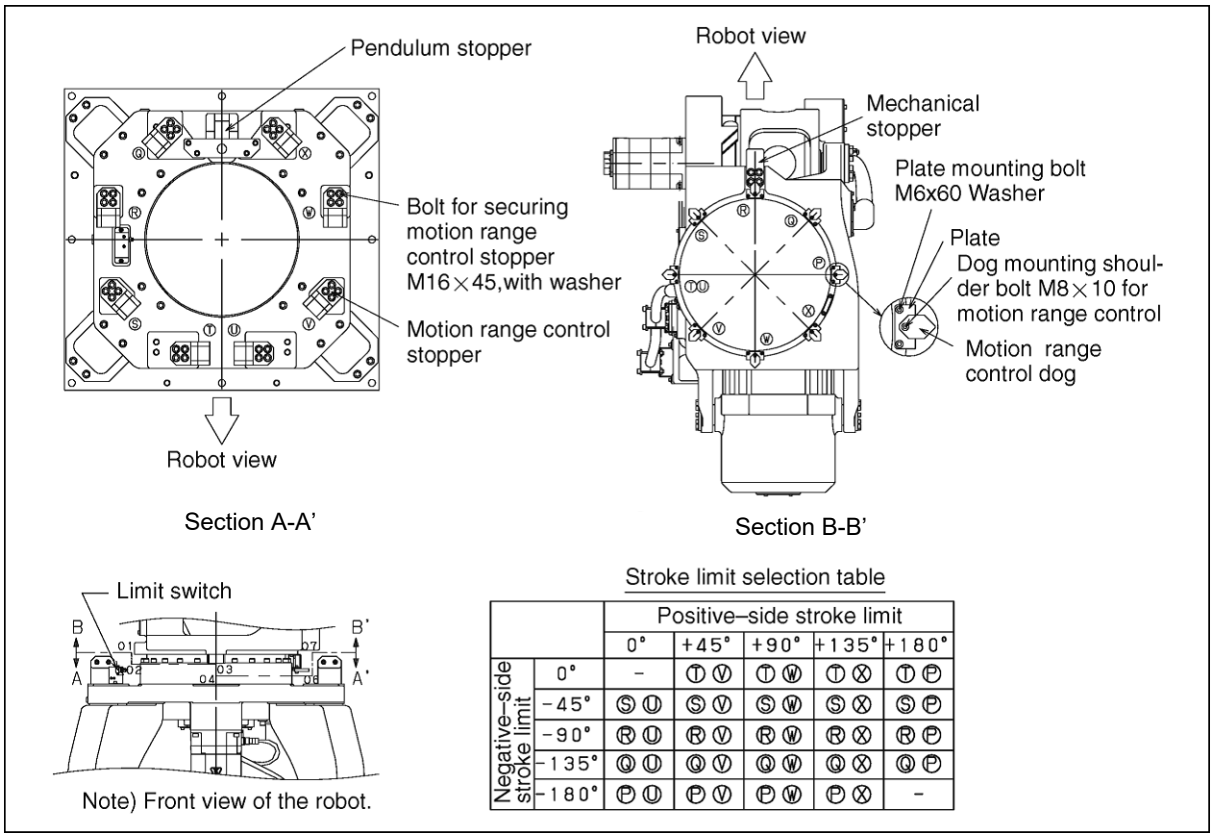


Fig. 5.3 (b) Modification of J1-axis stroke (option)

(b) Changing system variables
When changing the dog and mechanical stopper, also be sure to change the following system variables according to the required strokes.
After changing system variables, turn the power off then back on again. (The stroke setting described above can be made also by selecting "SYSTEM" using the [MENU] key, then selecting "Axis limit" menu using F1 (TYPE). Refer to the controller Operator's Manual for details.

> **⚠ WARNING**
> After changing system variables, be sure to run the robot at a low speed and make sure that the robot stops at the ends of the stroke.

Table 5.3 (a) Modification of system variable

Positions	System variable	
	Lower stroke limit $PARAM_GROUP $LOWERLIMS[1]	Upper stroke limit $PARAM_GROUP. $UPPERLIMS[1]
-180°	-180	–
-135°	-135	–
-90°	-90	–
-45°	-45	–
0°	0	0
+45°	–	45
+90°	–	90
+135°	–	135
+180°	–	180

⚠ WARNING
1 If a collision should occur, the J1 axis stopper becomes deformed to absorb energy, so that the robot can stop safely. If the stopper is deformed by mistake, replace it.
2 Do not add threaded holes to the frame, or do not use a self-made stopper to control the J1 stroke at any angle other than the one specified; otherwise, robot operation may be dangerous.

5.4 SOFTWARE SETTING

Axis limit software settings are upper and lower motion degree limitations. The limits can be set for all robot axes and will stop robot motion if the robot is calibrated.

Procedure Setting up Axis Limits

1 Press the [MENU] key to display the screen menu.
2 Select SYSTEM. Press [0 NEXT] and select [6 SYSTEM]
3 Press F1, [TYPE].
4 Select [Axis Limits]. The following screen will be displayed.

System Axis Limits JOINT 100%
Group1 1/16

AXIS	GROUP	LOWER	UPPER	
1	1	-150.00	150.00	deg
2	1	-40.00	100.00	deg
3	1	-110.00	10.00	deg
4	1	-240.00	240.00	deg
5	1	0.00	0.00	deg
6	1	0.00	0.00	deg
7	1	0.00	0.00	mm
8	1	0.00	0.00	mm
9	1	0.00	0.00	mm

[TYPE]

⚠ WARNING
1 The setting value 0.00 indicates that the robot does not have the axis.
2 Do not depend on J1 -axis limit software settings to control the motion range of your robot. Use the axis limit switches or adjustable mechanical stopper also; otherwise injury to personnel or damage to equipment could occur.

5 Move the cursor to the desired axis range and type the new value using the numeric keys on the teach pendant.

System Axis Limits 2/16

AXIS	GROUP	LOWER	UPPER	
2	1	-40.00	100.00	deg

[TYPE]

6 Perform the setting for all axes.
7 Cycle the power of the controller in the cold start mode so the new settings are enabled.

> ⚠ **WARNING**
> You must cycle the power of the controller to enable the new setting. If you fail to do so, the robot does not work normally and it may injure personnel or damage the equipment.

5.5 MASTERING

Mastering is an operation performed to associate the angle of each robot axis with the pulse count value supplied from the absolute Pulsecoder connected to the corresponding axis motor. To be specific, mastering is an operation for obtaining the pulse count value corresponding to the zero position.

5.5.1 Overview

The current position of the robot is determined according to the pulse count value supplied from the Pulsecoder on each axis.
Mastering is factory-performed. It is unnecessary to perform mastering in daily operations. However, mastering becomes necessary after:

- Motor replacement.
- Pulsecoder replacement.
- Reducer replacement.
- Cable replacement.
- Batteries for pulse count backup in the mechanical unit have gone dead.

> ⚠ **CAUTION**
> Robot data (including mastering data) and Pulsecoder data are backed up by their respective backup batteries. Data will be lost if the batteries go dead. Replace the batteries in the controller and mechanical units periodically. An alarm will be issued to warn the user of a low battery voltage.

Mastering Method

There are following five methods of mastering.

Table 5.5.1 (a) Types of Mastering

Fixture position mastering	This is performed using a mastering fixture before the machine is shipped from the factory.
Zero-position mastering (witness mark mastering)	This is performed with all axes set at the 0-degree position. A zero-position mark (witness mark) is attached to each robot axis. This mastering is performed with all axes aligned to their respective witness marks.
Quick mastering	This is performed at a user-specified position. The corresponding count value is obtained from the rotation count of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the fact that the absolute value of a rotation angle within one rotation will not be lost. (All axes at the same time)
Quick mastering for single axis	This is performed at a user-specified position for one axis. The corresponding count value is obtained from the rotation count of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the fact that the absolute value of a rotation angle within one rotation will not be lost.
Single-axis mastering	This is performed for one axis at a time. The mastering position for each axis can be specified by the user. This is useful in performing mastering on a specific axis.
Mastering data entry	Mastering data is entered directly.

Once mastering is performed, it is necessary to carry out positioning, or calibration. Positioning is an operation in which the controller reads the current pulse count value to sense the current position of the robot.

This section describes zero-position mastering, quick mastering, quick mastering for single axis, single-axis mastering, and mastering data entry. For more accurate mastering (fixture position mastering), contact your local FANUC representative.

⚠ CAUTION
1 If mastering is performed incorrectly, the robot may behave unexpectedly. This is very dangerous. For this reason, the Master/Cal screen is designed to appear only when the $MASTER_ENB system variable is 1 or 2. After performing positioning, press F5, ([DONE]) on the Master/Cal screen. The $MASTER_ENB system variable is then reset to 0 automatically, and the Master/Cal screen will disappear.
2 Before performing mastering, it is recommended that you back up the current mastering data.

5.5.2 Resetting Alarms and Preparing for Mastering

Before performing mastering because a motor is replaced, you must release the relevant alarm and display the positioning menu.

Alarm displayed

"SRVO-062 BZAL" or "SRVO-075 Pulse not established"

Procedure

1 Display the positioning menu by following steps 1 to 6.
   1 Press the [MENU] key.
   2 Press [0 NEXT] and Select [6 SYSTEM].
   3 Press F1 [TYPE], and select [SYSTEM Variable] from the menu.
   4 Place the cursor on $MASTER_ENB, then key in "1" and press the [ENTER] key.
   5 Press F1 [TYPE], and select[Master/Cal] from the menu.
   6 Select the desired mastering type from the [Master/Cal] menu.

2 To reset the "SRVO-062 BZAL" alarm, follow steps 1 to 5.
   1 Press the [MENU] key.
   2 Select [0 NEXT] and select [6 SYSTEM].
   3 Press F1 [TYPE], and select [SYSTEM Variable] from the menu.
   4 Place the cursor on F3 RES_PCA, then press F4 [YES]. The message " TRUE" appears and disappears immediately.
   5 Turn off the controller power and on again

3 To reset the "SRVO-075 Pulse not established" alarm, follow steps 1 to 2.
   1 When the controller power is turned on again, the message "SRVO-075 Pulse not established" appears again.
   2 Move the axis for which the message mentioned above has appeared till alarm disappears when press [FAULT RESET] in either direction.

5.5.3 Zero Degree Mastering

Zero-position mastering (witness mark mastering) is performed with all axes set at the 0-degree position. A zero-position mark (witness mark) is attached to each robot axis (Fig. 5.5.3 (a)). This mastering is performed with all axes set at the 0-degree position using their respective witness marks.

Zero-position mastering involves a visual check, and might not be highly accurate. It should be used only as a quick-fix method.

Zero-position Mastering Procedure

1 Press the [MENU] key to display the screen menu.
2 Select [0 NEXT] and press [6 SYSTEM].
3 Press F1 [TYPE].
4 Select [Master/Cal].

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA                DONE
```

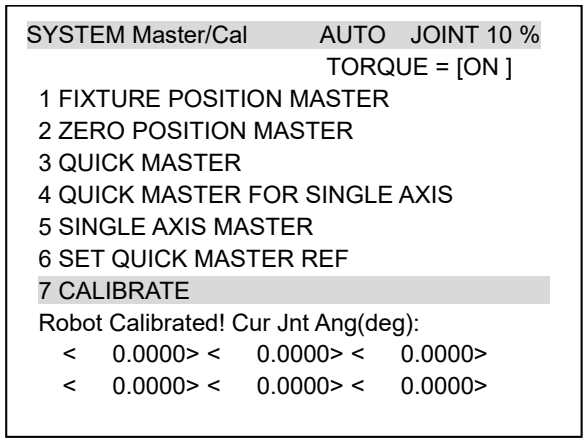
5 Release brake control, and jog the robot into a posture for mastering.

NOTE
Brake control can be released by setting the system variables as follows:
$PARAM_GROUP.SV_OFF_ALL : FALSE
$PARAM_GROUP.SV_OFF_ENB[*] : FALSE (for all axes)
After changing the system variables, cycle power of the controller.

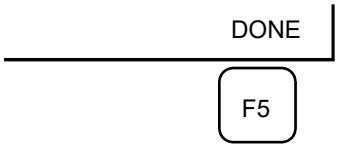
6 Select [2 Zero Position Master]. Press F4 [YES].

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
 Robot Mastered! Mastering Data:
    <0> <11808249> <38767856>
    <9873638> <12200039> <2000319>
 [ TYPE ]   LOAD   RES_PCA                DONE
```

7 Select [7 CALIBRATE] and press F4 [YES]. Mastering will be performed automatically. Alternatively, turn off the controller power and on again. Turning on the power always causes positioning to be performed.



8 After positioning is completed, press F5 [DONE].



9 Return brake control to original setting, and cycle power of the controller.

Table 5.5.3 (a) Posture with position marks aligned

Axis	Position
	M-410*i*B/450
J1-axis	0 deg
J2-axis	0 deg
J3-axis	0 deg
J4-axis	0 deg

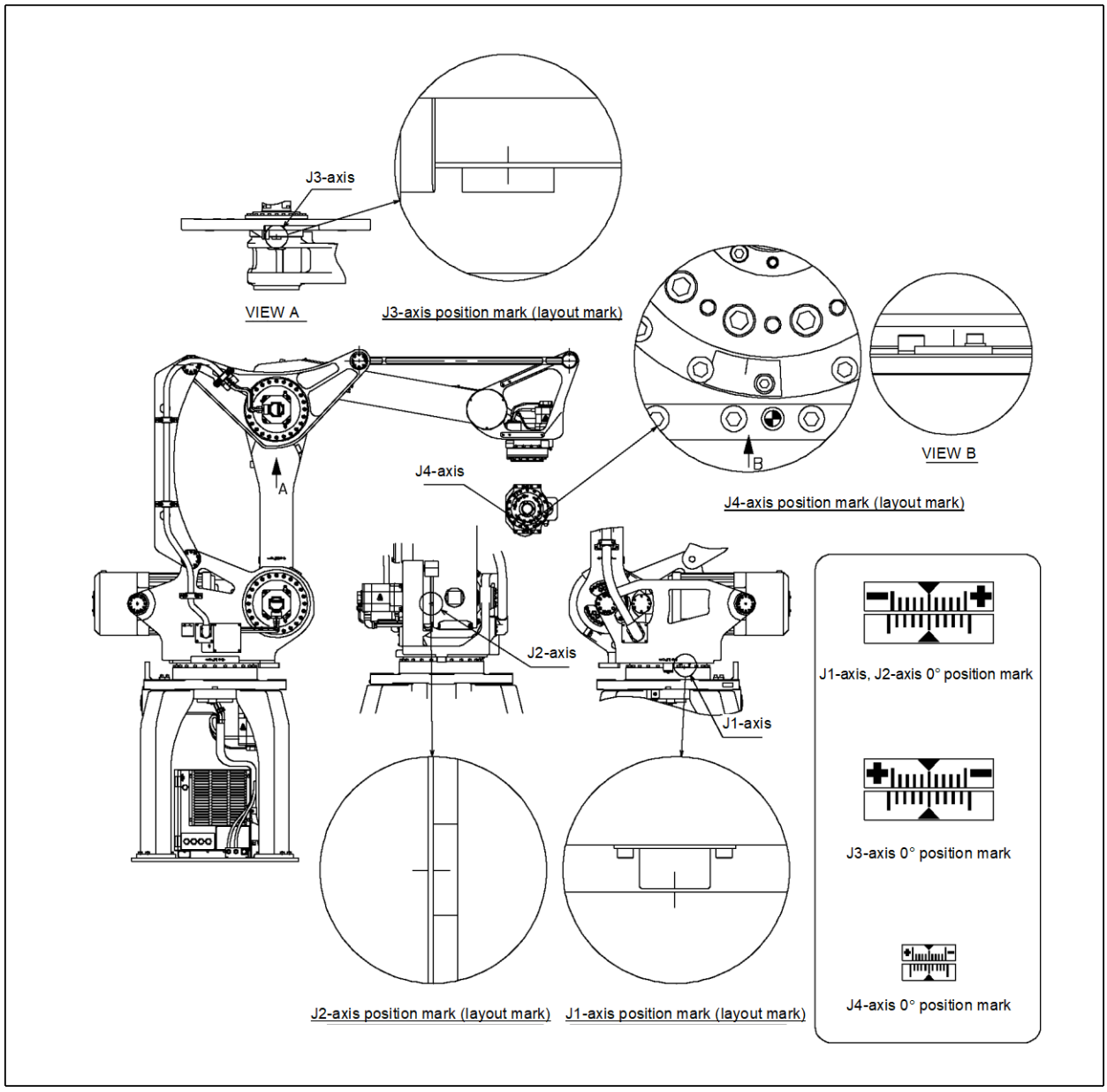


Fig. 5.5.3 (a) Posture with position marks aligned

5.5.4 Quick Mastering

Quick mastering is performed at a user-specified position for one axis. The pulse count value is obtained from the rotation times of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the character that the absolute value of a rotation angle within one rotation will not be lost.

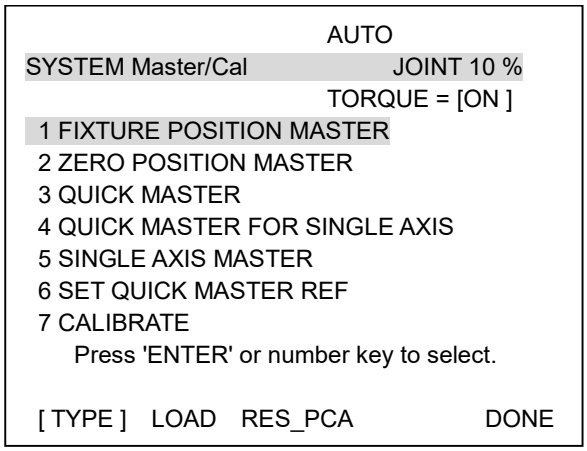
Quick mastering is factory-performed at the position indicated in Table 5.5.4. If possible, do not change the setting.

If setting the robot at the position mentioned above is impossible, you must re-set the quick mastering reference position using the following method. (It would be convenient to set up a marker that can work in place of the witness mark.)

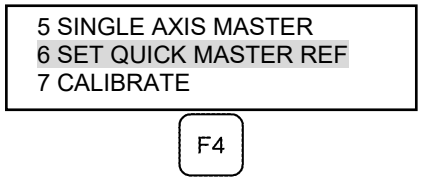
> **⚠ CAUTION**
> 1 Quick mastering can be used, if the pulse count value is lost, for example, because a low voltage has been detected on the backup battery for the pulse counter.
> 2 Quick mastering cannot be used, after the Pulsecoder is replaced or after the mastering data is lost from the robot controller.

Procedure Recording the Quick Mastering Reference Position

1 Select [6 SYSTEM].
2 Select [Master/Cal]. The positioning screen will be displayed.



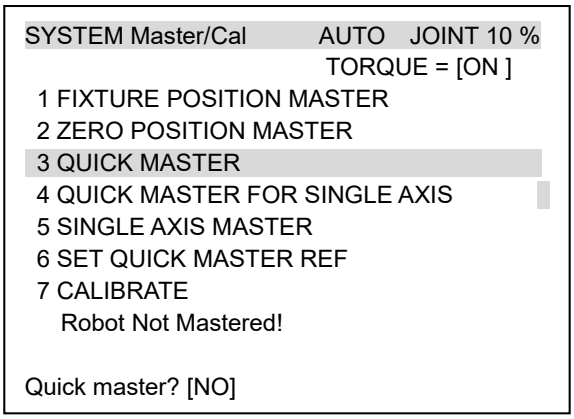
3 Release brake control, and jog the robot to the quick mastering reference position.
4 Select [6 SET QUICK MASTER REF] and press F4 [YES]. Quick mastering reference position will be set.



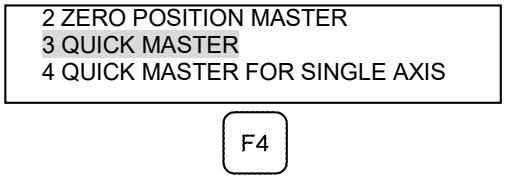
> **⚠ CAUTION**
> If the robot has lost mastering data due to mechanical disassembly or repair, you cannot perform this procedure. In this case, perform Fixture position mastering or Zero position mastering to restore mastering data.

Procedure of Quick Mastering

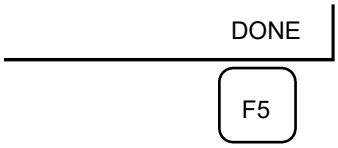
1 Display the Master/Cal screen.



2 Release brake control, and jog the robot to the quick mastering reference position.
3 Select [3 QUICK MASTER] and press F4 [YES]. Quick mastering reference position will be set.



4 Select [7 CALIBRATE] and press [ENTER] key. Calibration is executed. Calibration is executed by cycling power.
5 After completing the calibration, press F5 [Done].



6 Return brake control to original setting, and cycle power of the controller.

5.5.5 QUICK MASTERING FOR SINGLE AXIS

Quick mastering is performed at a user-specified position for one axis. The pulse count value is obtained from the rotation times of the Pulsecoder connected to the relevant motor and the rotation angle within one rotation. Quick mastering uses the character that the absolute value of a rotation angle within one rotation will not be lost.

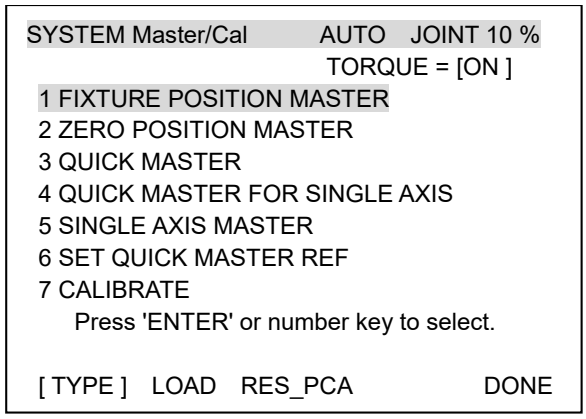
Quick mastering is factory-performed at the position indicated in Table 5.5.3 (a). Do not change the setting unless there is any problem.

If setting the robot at the position mentioned above is impossible, you must re-set the quick mastering reference position using the following method. (It would be convenient to set up a marker that can work in place of the witness mark.)

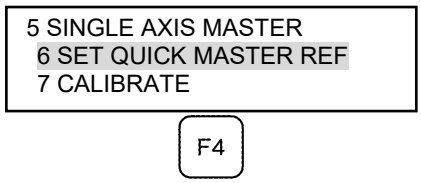
⚠ CAUTION
1 Quick mastering can be used, if the pulse count value is lost, for example, because a low voltage has been detected on the backup battery for the pulse counter.
2 Quick mastering cannot be used, after the Pulsecoder is replaced or after the mastering data is lost from the robot controller.

Procedure Recording the Quick Mastering Reference Position

1 Select [6 SYSTEM].
2 Select [Master/Cal]. The positioning screen will be displayed.



3 Release brake control, and jog the robot to the quick mastering reference position.
4 Select [6 SET QUICK MASTER REF] and press F4 [YES]. Quick mastering reference position will be set.



⚠ CAUTION
If the robot has lost mastering data due to mechanical disassembly or repair, you cannot perform this procedure. In this case, perform Fixture position mastering or zero –position mastering is required to restore mastering data.

Procedure of Quick Mastering for single axis

1 Display the Master/Cal screen.

```
SYSTEM Master/Cal          AUTO   JOINT 10 %
                                  TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]   LOAD   RES_PCA                DONE
```

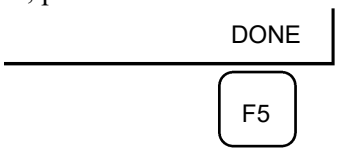
2 Select [4 QUICK MASTER FOR SINGLE AXIS]. The quick master for single axis screen will be displayed.

```
                                   AUTO JOINT 1%
QUICK MASTER FOR SINGLE AXIS
                                                  1/9
    ACTUAL   POS     (MSTR POS)     (SEL)    [ST]
J1          0.000   (      0.000)   (0)      [2]
J2          0.000   (      0.000)   (0)      [2]
J3          0.000   (      0.000)   (0)      [2]
J4          0.000   (      0.000)   (0)      [2]
J5          0.000   (      0.000)   (0)      [2]
J6          0.000   (      0.000)   (0)      [0]
E1          0.000   (      0.000)   (0)      [0]
E2          0.000   (      0.000)   (0)      [0]
E3          0.000   (      0.000)   (0)      [0]

                                                 EXEC
```

3 Move the cursor to the [SEL] column for the unmastered axis and press the numeric key [1]. Setting of [SEL] is available for one or more axes.

```
                                   AUTO JOIN 1%
QUICK MASTER FOR SINGLE AXIS
                                                  1/9
    ACTUAL   POS     (MSTR POS)     (SEL)    [ST]
J5          0.000   (      0.000)   (1)      [2]
J6          0.000   (      0.000)   (1)      [2]

                                                 EXEC
```

4 Turn off brake control, then jog the robot to the quick mastering reference position.
5 Press F5 [EXEC]. Mastering is performed. So, [SEL] is reset to 0, and [ST] is re-set to 2.
6 Select [7 CALIBRATE] and press [ENTER] key. Calibration is executed. Calibration is executed by cycling power.
7 After completing the calibration, press F5 Done.



8 Return brake control to original setting, and cycle power of the controller.

5.5.6 Single Axis Mastering

Single axis mastering is performed for one axis at a time. The mastering position for each axis can be specified by the user.
Single axis mastering can be used, if mastering data for a specific axis is lost, for example, because a low voltage has been detected on the pulse counter backup battery or because the Pulsecoder has been replaced.

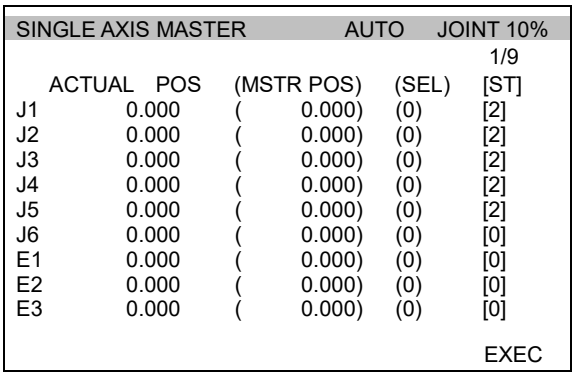
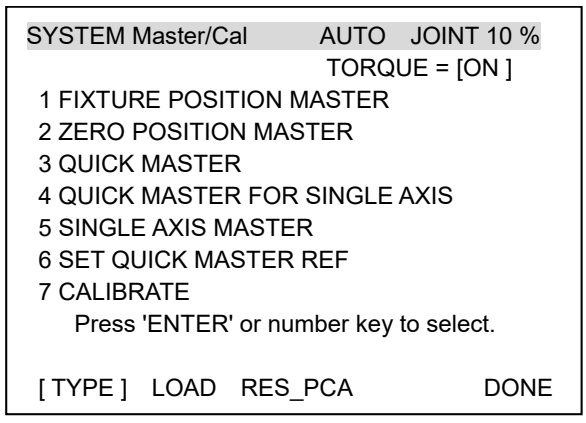


Table 5.5.6 (a) Items set in single axis mastering

Item	Description
Current position (ACTUAL AXIS)	The current position of the robot is displayed for each axis in degree units.
Mastering position (MSTR POS)	A mastering position is specified for an axis to be subjected to single axis mastering. It would be convenient if it is set to 0 degree position.
SEL	This item is set to 1 for an axis to be subjected to single axis mastering. Usually, it is 0.
ST	This item indicates whether single axis mastering has been completed for the corresponding axis. It cannot be changed directly by the user. The value of the item is reflected in $EACHMST_DON (1 to 9). 0 : Mastering data has been lost. Single axis mastering is necessary. 1 : Mastering data has been lost. (Mastering has been performed only for the other interactive axes.) Single axis mastering is necessary. 2 : Mastering has been completed.

Procedure of Single axis mastering

1 Select [6 SYSTEM].
2 Select [Master/Cal]. The positioning screen will be displayed.



3 Select [5 SINGLE AXIS MASTER]. The following screen will be displayed.

```
SINGLE AXIS MASTER          AUTO    JOINT 10%
                                          1/9
   ACTUAL   POS    (MSTR POS)    (SEL)   [ST]
J1          0.000  (      0.000)  (0)     [2]
J2          0.000  (      0.000)  (0)     [2]
J3          0.000  (      0.000)  (0)     [2]
J4          0.000  (      0.000)  (0)     [2]
J5          0.000  (      0.000)  (0)     [2]
J6          0.000  (      0.000)  (0)     [0]
E1          0.000  (      0.000)  (0)     [0]
E2          0.000  (      0.000)  (0)     [0]
E3          0.000  (      0.000)  (0)     [0]

                                          EXEC
```

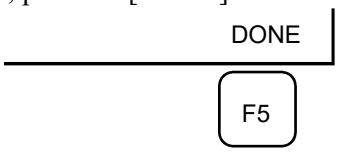
4 For the axis to which to perform single axis mastering, set (SEL) to "1." Setting of [SEL] is available for one or more axes.
5 Turn off brake control, then jog the robot to the mastering position.
6 Enter axis data for the mastering position.
7 Press F5 [EXEC]. Mastering is performed. So, [SEL] is reset to 0, and [ST] is re-set to 2 or 1.

```
SINGLE AXIS MASTER          AUTO    JOINT 10%
                                          1/9
   ACTUAL   POS    (MSTR POS)    (SEL)   [ST]
J1          0.000  (      0.000)  (0)     [2]
J2          0.000  (      0.000)  (0)     [2]
J3          0.000  (      0.000)  (0)     [2]
J4          0.000  (      0.000)  (0)     [2]
J5          0.000  (      0.000)  (0)     [2]
J6          0.000  (      0.000)  (0)     [0]
E1          0.000  (      0.000)  (0)     [0]
E2          0.000  (      0.000)  (0)     [0]
E3          0.000  (      0.000)  (0)     [0]

                                          EXEC
```

8 When single axis mastering is completed, press the [PREV] key to resume the previous screen.

```
                              AUTO
SYSTEM Master/Cal             JOINT 10 %
                              TORQUE = [ON ]
 1 FIXTURE POSITION MASTER
 2 ZERO POSITION MASTER
 3 QUICK MASTER
 4 QUICK MASTER FOR SINGLE AXIS
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
     Press 'ENTER' or number key to select.

 [ TYPE ]  LOAD  RES_PCA              DONE
```

9 Select [7 CALIBRATE], then press F4 [YES]. Positioning is performed. Alternatively, turn off the controller power and on again. Positioning is performed.
10 After positioning is completed, press F5 [DONE].



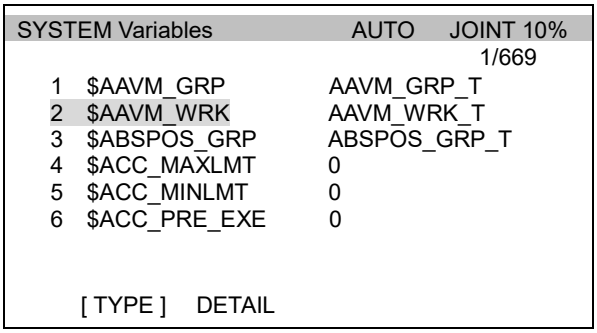
11 Return brake control to original setting, and cycle power of the controller.

5.5.7 Mastering Data Entry

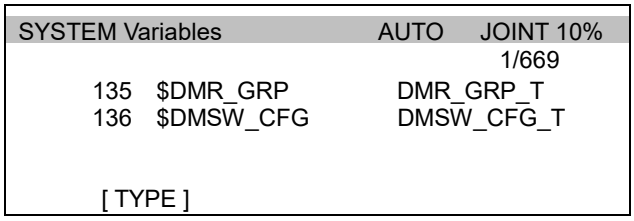
This function enables mastering data values to be assigned directly to a system variable. It can be used if mastering data has been lost but the pulse count is preserved.

Mastering data entry method

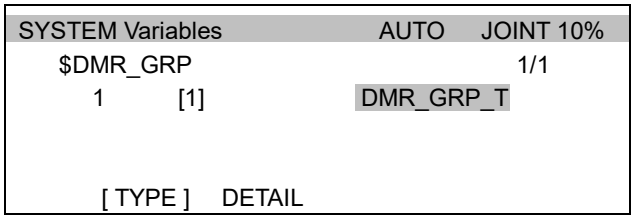
1 Press the [MENU] key, then press [0 NEXT] and select [6 SYSTEM].
2 Press F1 [TYPE]. Select [Variables]. The system variable screen will be displayed.

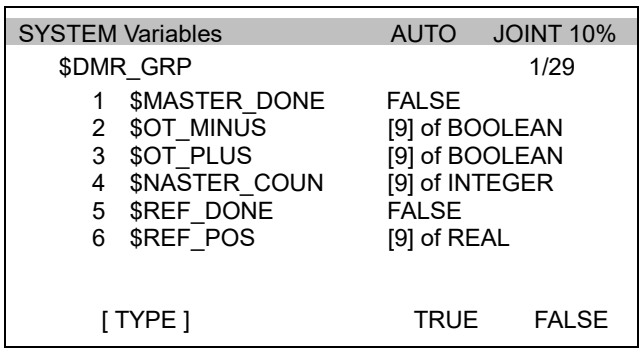


3 Change the mastering data. The mastering data is saved to the $DMR_GRP.$MASTER_COUN system variable.

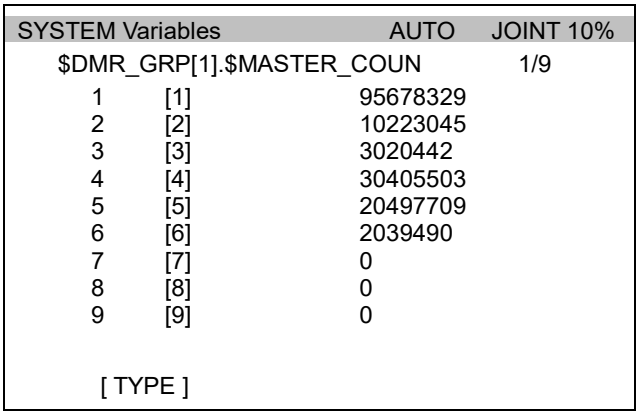


4 Select $DMR_GRP.

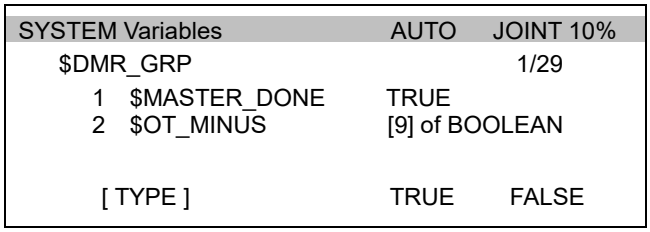




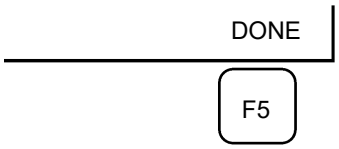
5 Select $MASTER_COUN, and enter the mastering data you have recorded.



6 Press [PREV] key.
7 Set $MASTER_DONE to TRUE.



8 Display the positioning screen, and select [7 CALIBRATE], then press F4 [YES].
9 After completing positioning, press F5 [DONE].



5.6 VERIFYING MASTERING

1 How to verify that the robot is mastered properly:

Usually, positioning is performed automatically at power-on. To check whether mastering has been made correctly, note whether the displayed current position agrees with the actual robot position. Use the procedure described below:

(1) Reproduce a particular point in a program. Check whether the point agrees with the specified position.
(2) Set all axes of the robot to their 0-degree (0 rad) positions. Check that the zero-degree position marks indicated in Subsection 5.5.3 are aligned. There is no need to use any visual aid.
(3) Using fixtures, set the robot to the mastering position in the same way as when performing mastering. Check that the displayed current position agrees with the actual mastering position.

If the displayed and actual positions do not match, the counter value for a Pulsecoder may have been invalidated as a result of an alarm described below 2 in this section. Alternatively, the mastering data in system variable $DMR_GRP.$MASTER_COUN may have been overwritten as a result of an operation error or some other reason.
Compare the data with the values indicated on the supplied data sheet. This system variable is overwritten whenever mastering is performed. Whenever mastering is performed, record the value of the system variable on the data sheet.

2 Alarms that may be output during mastering and remedy for it

(1) BZAL alarm
This alarm is output if the voltage of the Pulsecoder's backup battery falls to 0 V while the power to the controller is disconnected. Also, if Pulsecoder connector is removed for replacing cables etc. this alarm is output because voltage becomes to 0. To clear the alarm, fit a new battery, execute the pulse reset (See Subsection 5.5.2.), then turn the power off then on again and confirm alarm is not output.
Battery might be weak if you can’t reset alarm, then replace battery to new one , perform pulse reset , turn off and on the controller power. Note that, if this alarm occurs, all data originally held by the Pulsecoder will have been lost. Mastering must be performed again.

(2) BLAL alarm
This alarm is output if the voltage of the Pulsecoder's backup battery has fallen to a level where backup is no longer possible. If this alarm is output, fit a new battery immediately while keeping the power turned on. Check whether the current position data is valid, using the procedure described in 1 in this section.

(3) CKAL, RCAL, PHAL, CSAL, DTERR, CRCERR, STBERR, and SPHAL, alarms
Contact the FANUC because the Pulsecoder may be defective.

6 PIPING AND WIRING

Fig. 6 (a), (b) show the wiring diagram in the mechanical unit.

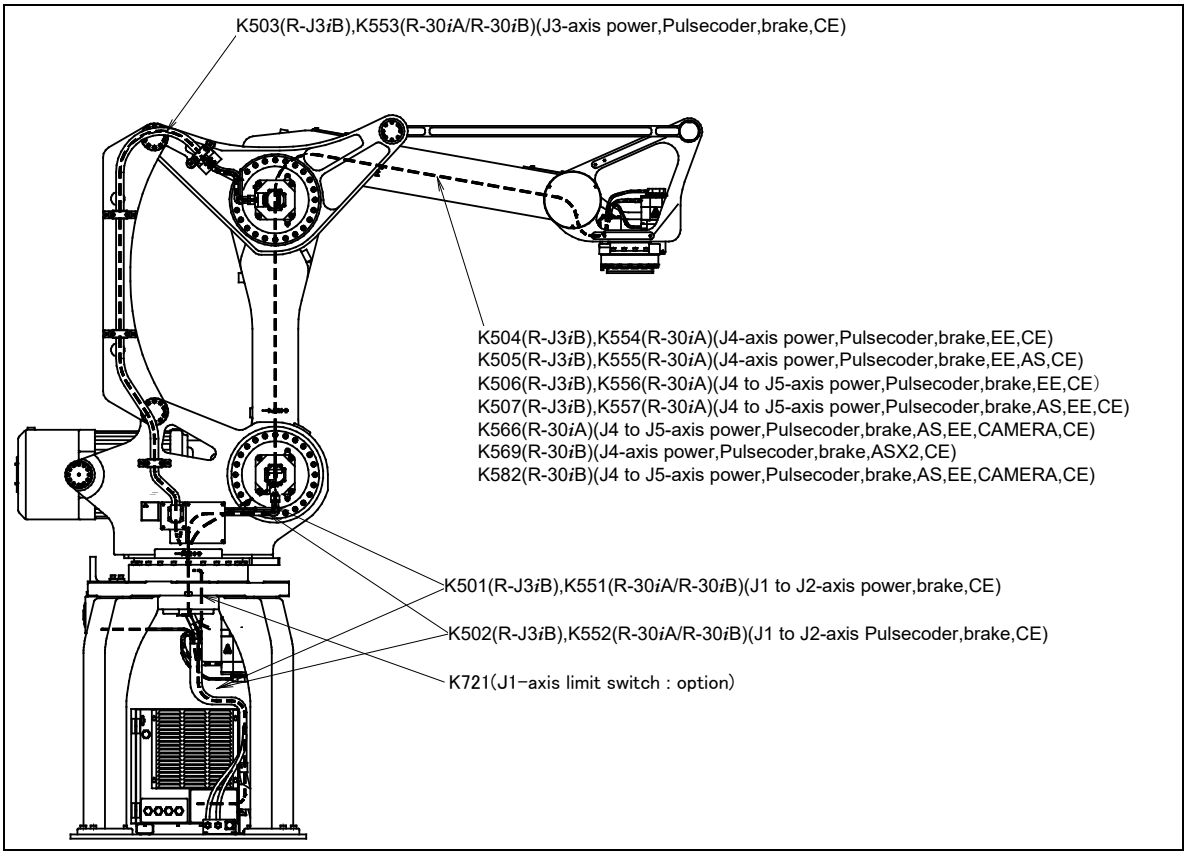


Fig. 6 (a) Wiring diagram in the mechanical unit (Integrated type controller)

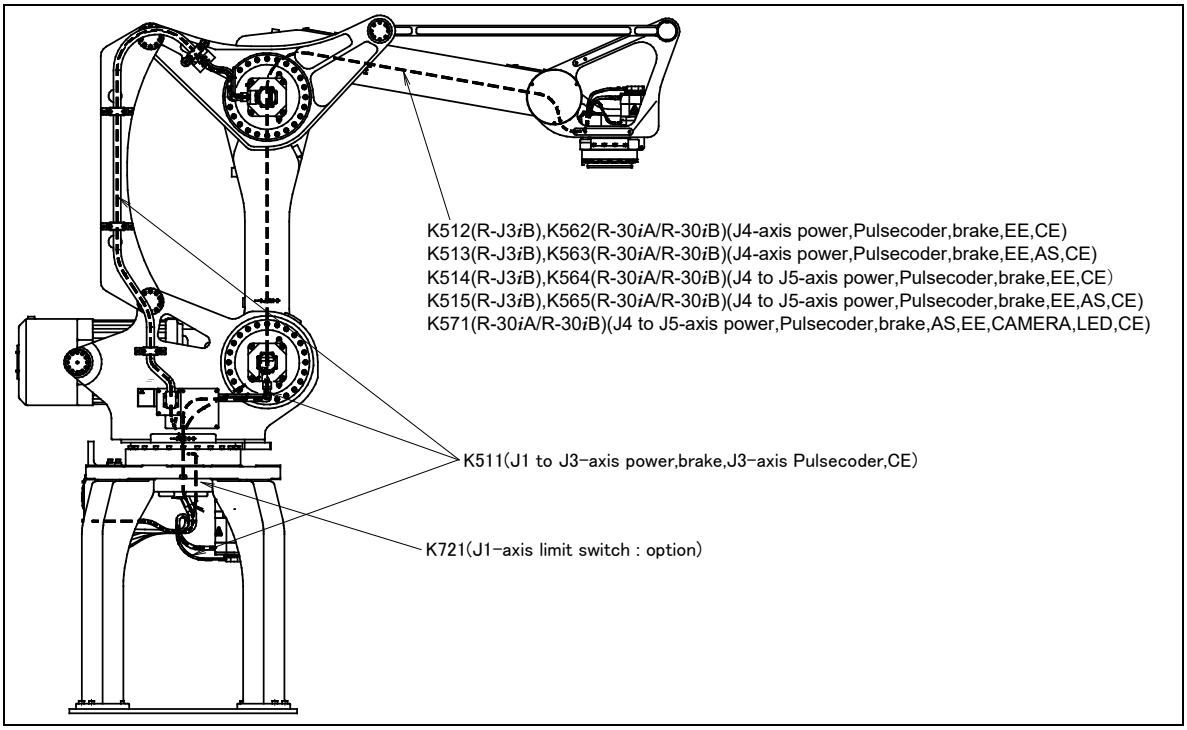


Fig. 6 (b) Wiring diagram in the mechanical unit (Remote type controller)

7 ROBOT INTERFERENCE AREA

Fig. 7 (a) shows the external dimensions of the robot. When installing peripheral equipment, be careful to clear away any objects that are in the robot's motion path in normal operation.

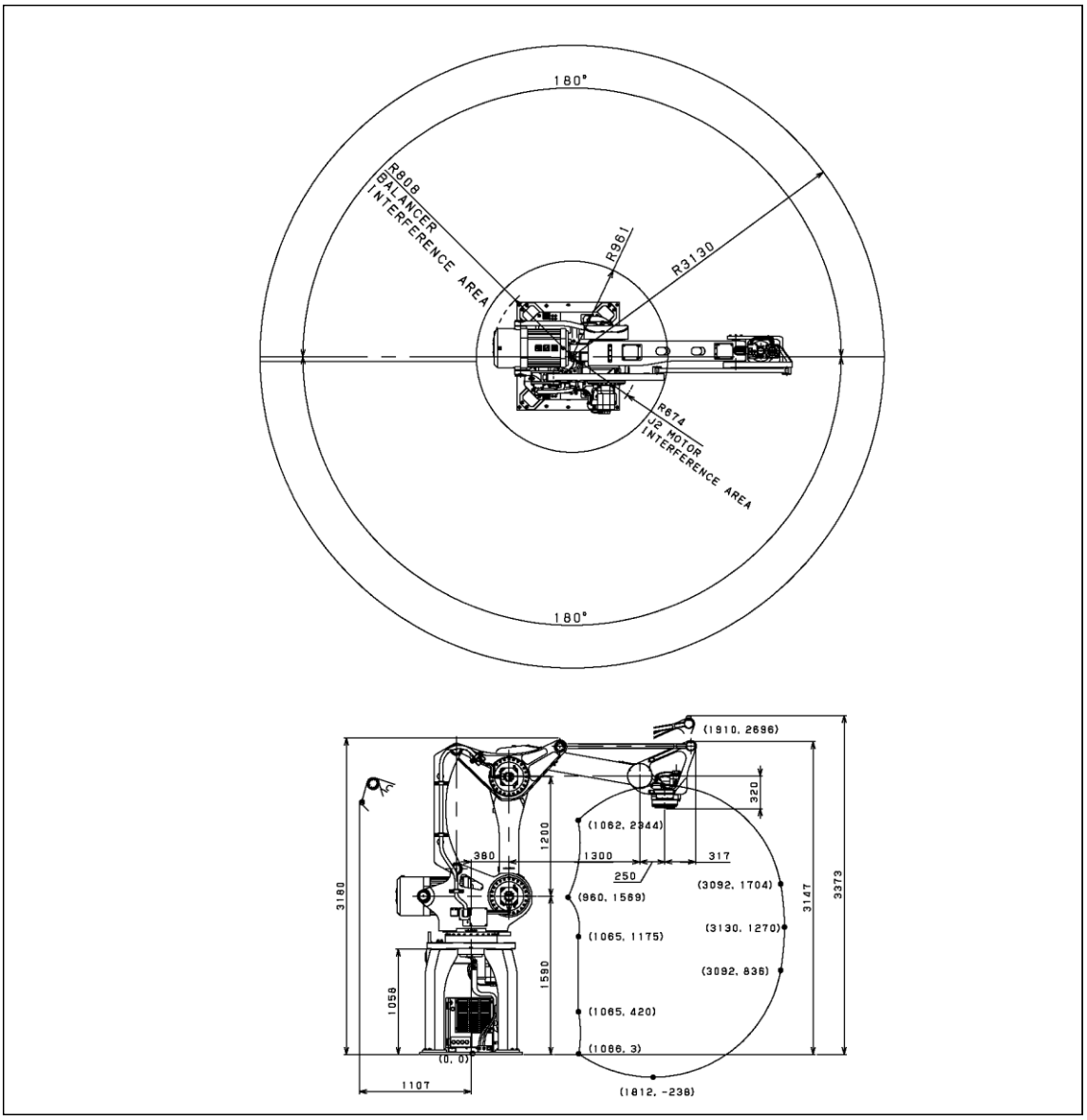


Fig. 7 (a) External dimensions

8 EQUIPMENT INSTALLATION TO THE ROBOT

8.1 LOAD CONDITION AT WRIST

Fig. 8.1 (a)(b) shows the relationships between the horizontal offset of the center of gravity of the wrist load and the permissible load inertia. See Fig. 8.1 (c) to check whether the center of gravity of the load is inside or outside of the wrist.

Fig. 8.1 (d) shows the relationships between the vertical offset of the center of gravity of the wrist load and permissible load weight. See Fig. 8.1 (e) for explanations about the vertical offset of the center of gravity of the wrist load.

The wrist load must fall within the corresponding ranges in Fig. 8.1 (a),(b) and 8.1 (d) and the allowable wrist moment and allowable wrist inertia conditions must be satisfied.
Refer to Specification table of "PREFACE" about he allowable wrist moment and allowable wrist inertia.

See Fig. 8.1 (f) for explanations about how to calculate the load inertial.

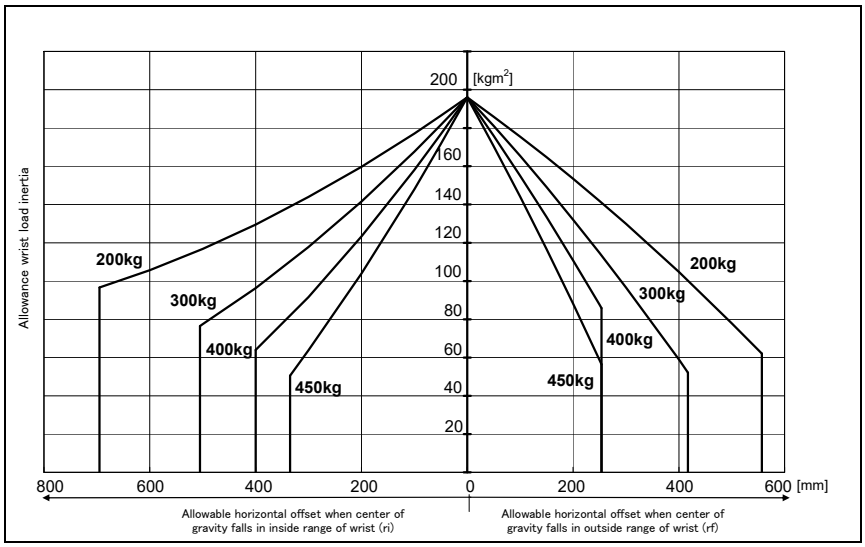


Fig. 8.1 (a) Line chart of the permissible load for the wrist section (horizontal offset / Standard Inertia)

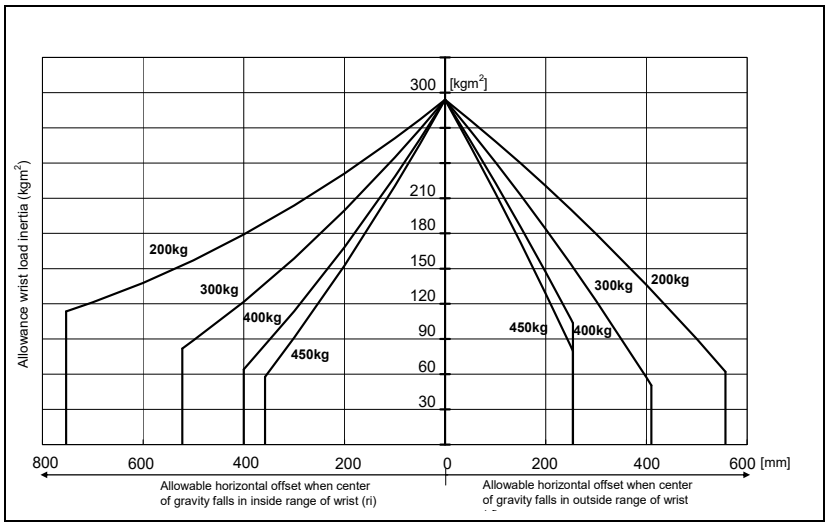


Fig. 8.1 (b) Line chart of the permissible load for the wrist section (horizontal offset/ High Inertia)

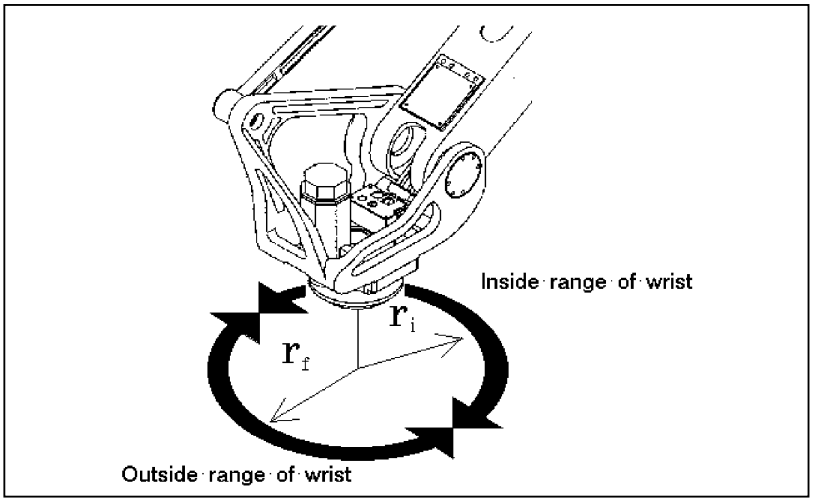


Fig. 8.1 (c) Allowable wrist load condition

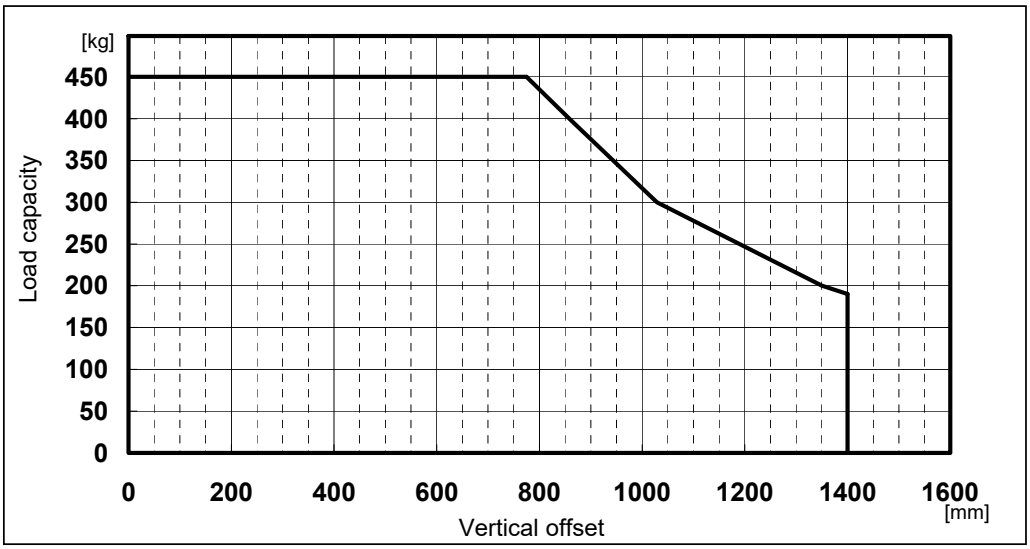


Fig. 8.1 (d) Line chart of the permissible load for the wrist section (vertical offset)

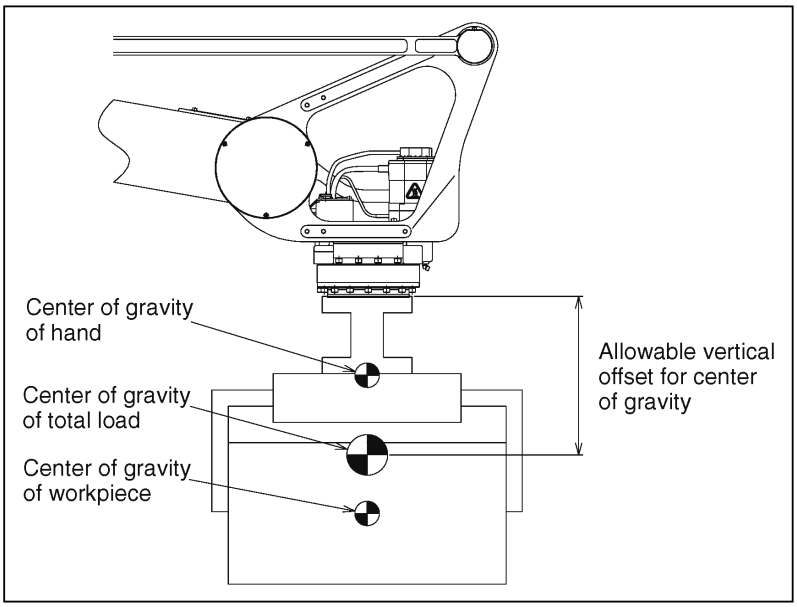


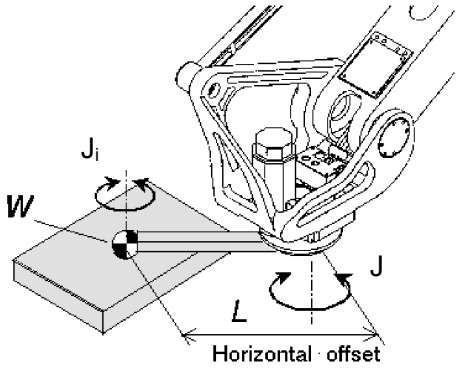
Fig. 8.1 (e) Allowable wrist load condition

The total inertia around the wrist (J4) axis is the sum of the horizontal offset inertia of a workpiece and the geometric inertia around the center of gravity of the workpiece. It can be calculated as shown below.

$$J = J_i + WL^2$$

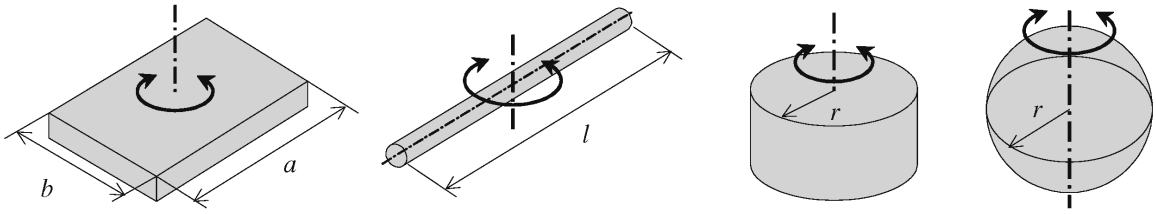
Total inertia — Geometric inertia around center of gravity — Offset inertia

W	: Mass	(kg)
L, l, a, b, r	: Length	(m)
J	: Inertia	(kgm^2)



Note) If a hand or workpiece has a complicated shape, divide it into simple shapes as shown below. Calculate the geometric inertia and offset inertia of each shape, then obtain their sum.

Expressions for calculating inertia around the center of gravity (geometric inertia)



$$J_i = W\frac{a^2 + b^2}{12} \qquad J_i = W\frac{l^2}{12} \qquad J_i = W\frac{r^2}{2} \qquad J_i = W\frac{2r^2}{5}$$

Fig. 8.1 (f) Calculating inertia

8.2 END EFFECTOR INSTALLATION TO WRIST

Fig. 8.2 (a) shows the end effector mounting surface at the end of the wrist.

Choose bolts and positioning pins, considering the depth of the corresponding holes. In this case, use steel bolts (Tensile strength 1200N/mm^2 or more), which should be tightened to a torque of 46 to 66 Nm (470 to 670 kgfcm).

> ⚠ **CAUTION**
> Notice the tooling coupling depth to wrist flange should be shorter than the flange coupling length.

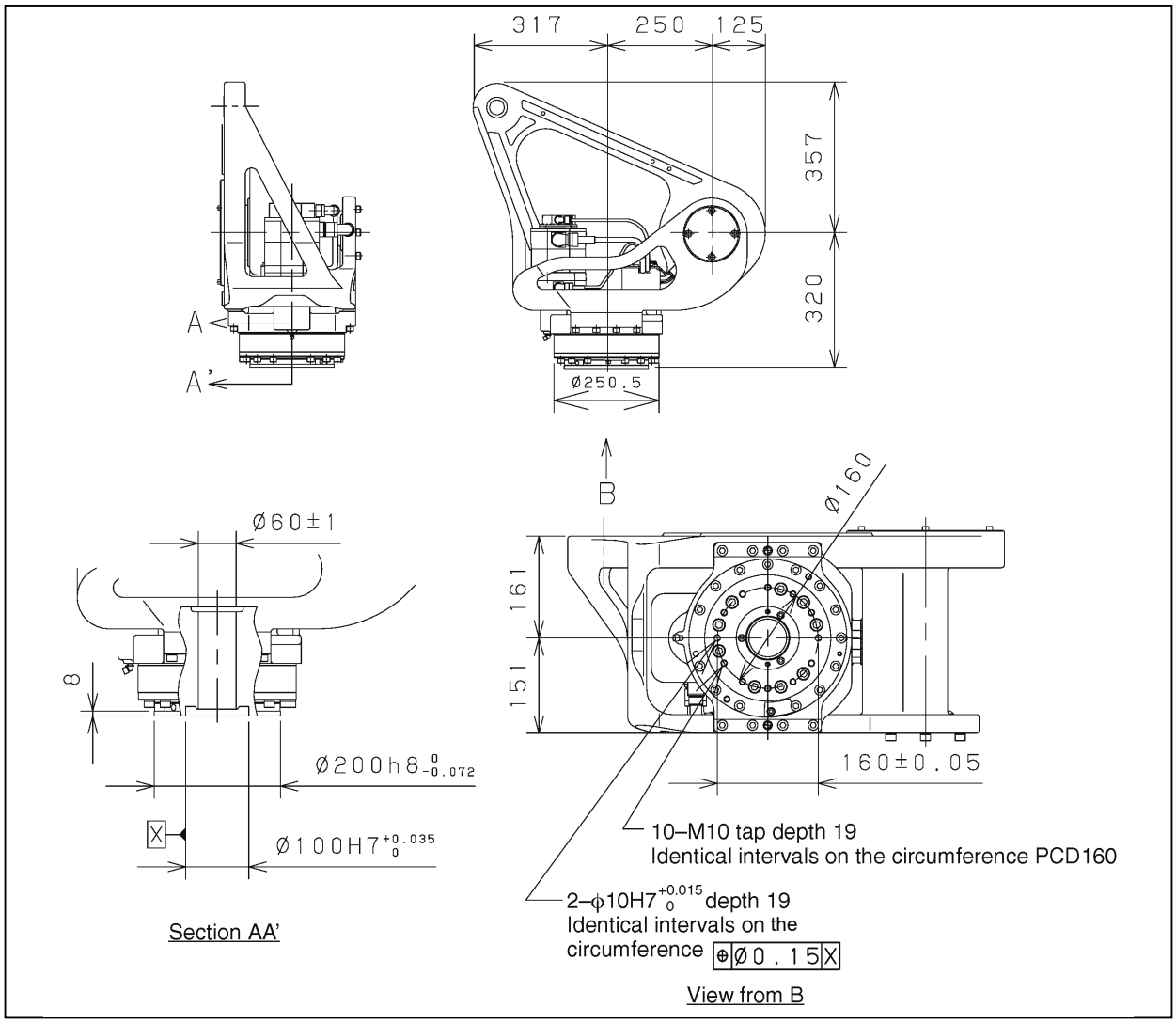


Fig. 8.2 (a) End the effector mounting face

8.3 LOAD SETTING

> ⚠ **CAUTION**
> Set load condition parameter before robot runs. Do not operate the robot in over payload. Don't exceed allowable payload including connection cables and its swing. Operation in over payload may occur troubles such as reducer life reduction.

The motion performance screens include the MOTION PERFORMANCE screen, MOTION PAYLOAD SET screen, and MOTION ARMLOAD SET screen. These screens are used to specify payload information and equipment information on the robot.

1 Press the [MENU] key to display the screen menu.
2 Select "6 SYSTEM" on the next page,
3 Press the F1 ([TYPE]) key to display the screen switch menu.
4 Select "MOTION." The MOTION PERFORMANCE screen will be displayed.

```
MOTION PERFORMANCE                    JOINT 10%
   Group1
No.  PAYLOAD[kg]          Comment
 1            450.00  [                ]
 2            450.00  [                ]
 3            450.00  [                ]
 4            450.00  [                ]
 5            450.00  [                ]
 6            450.00  [                ]
 7            450.00  [                ]
 8            450.00  [                ]
 9            450.00  [                ]
10            450.00  [                ]

 Active PAYLOAD number =0
[ TYPE]  GROUP  DETAIL  ARMLOAD  SETING >
         IDENT                         >
```

5 Ten different pieces of payload information can be set using condition No.1 to No.10 on this screen. Place the cursor on one of the numbers, and press F3 (DETAIL). The MOTION PAYLOAD SET screen will be displayed.

```
MOTION PAYLOAD SET              JOINT  100%

  Group 1
  Schedule No[   1]:[Comment          ]
1 PAYLOAD             [kg]        450.00
2 PAYLOAD CENTER  X   [cm]          0.00
3 PAYLOAD CENTER  Y   [cm]          0.00
4 PAYLOAD CENTER  Z   [cm]          0.49
5 PAYLOAD INERTIA X   [kgfcms^2]  100.00
6 PAYLOAD INERTIA Y   [kgfcms^2]  100.00
7 PAYLOAD INERTIA Z   [kgfcms^2]    0.05

 [TYPE]  GROUP  NUMBER  DEFAULT  HELP
```

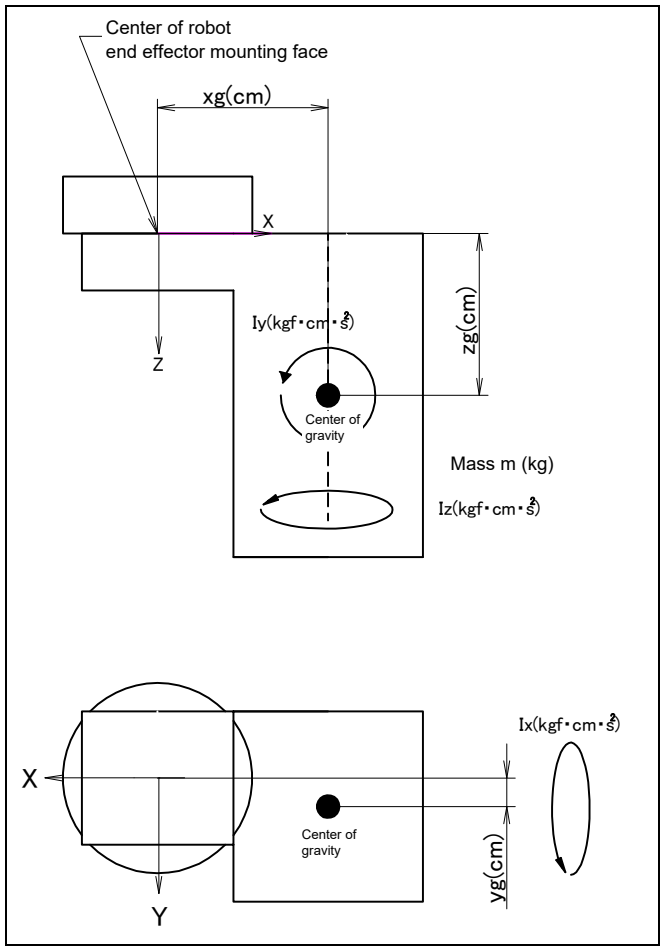


Fig. 8.3 (a) Standard tool coordinate

6 Set the payload, gravity center position, and inertia around the gravity center on the MOTION PAYLOAD SET screen. The X, Y, and Z directions displayed on this screen correspond to the respective standard tool coordinates (with no tool coordinate system set up). When values are entered, the following message appears: “Path and Cycle time will change. Set it?” Select F4 ([YES]) or F5 ([NO]).

7 Pressing F3 ([NUMBER]) will bring you to the MOTION PAYLOAD SET screen for another condition number. For a multigroup system, pressing F2 ([GROUP]) will bring you to the MOTION PAYLOAD SET screen for another group

8 Press the [PREV] key to return to the MOTION PERFORMANCE screen. Press F5 ([SETIND]), and enter the desired payload setting condition number.

8.3.1 Switching between Modes

There are two different parameter settings for the M-410*i*B/450 to support different load inertia magnitudes. (Before shipment, the parameter setting in the standard inertia mode is made.)

	Standard inertia mode	High inertia mode
Allowable load inertia at wrist	196kg·m^2 (2000kgf·cm·s^2)	294kg·m^2 (3000kgf·cm·s^2)

Be sure to make appropriate parameter settings according to the load, as described below. (Before shipment, the parameter setting in the standard inertia mode is made.)

> ⚠ **CAUTION**
> If a workpiece with an inertia exceeding the allowable inertia in the standard inertia mode is used in the mode, parts of the mechanical unit may degrade earlier.

To set parameters, execute setting program, which was stored before shipment. Since this program sets parameters for the high inertia mode, if parameters for the standard inertia mode need to be set, execute the program to reset this program.

Setting method

Specify and execute the program of Table 8.3.1 (a) directly on the program selection screen or create another program and call the program within it.

When the program is completely executed, message "SRVO-333 Power off to reset SRVO -333 TURN OFF THE CONTROLLER, THEN TURN IT ON AGAIN." appears, prompting you to turn off and back on the power. If the power is turned off and back on again, switching of parameters is completed.

[Example of program] (In the case of R-30*i*A/R-30*i*B controller)

```
1:  CALL J4UPM44C (i)
```

Set input parameter i for setting program to the group number of the robot. When input parameter i is omitted, the parameter settings for all M-410*i*B/450's in the controller are changed for the high inertia mode.

Table 8.3.1 (a) Programs to change a mode

	R-J3*i*B controller	R-30*i*A/R-30*i*B controller
Program for setting	J4UPSPC.PC	J4UPM44C.PC
Program for resetting	J4STD.PC	J4STM44C.PC

Checking the setting contents (only R-J3*i*B controller)

When the setting program is executed, the settings made are displayed on the user screen. To display the user screen, press the MENU key and then select "9 USER."

[Information displayed on the user screen]

For standard inertia load settings: Standard payload set (GP: X)
Please power off

For high inertia load settings: High payload set (GP: X)
Please power off

X represents the group number set in the parameter.

In the following cases, exception processing is applied, parameters are not changed, and a message describing the exception processing appears on the user screen.

(1) When the group set in input parameter i for setting program is not present
[Information displayed on the user screen]
Incorrect group number
When this message appears, specify a correct group number

(2) When the group set in input parameter i for setting program is not M-410*i*B/450.
[Information displayed on the user screen]
This group is not M-410*i*B/450
When this message appears, specify a correct group number

8.4 EQUIPMENT MOUNTING SURFACE

Fig. 8.4 (a) shows the positions of holes for mounting the equipment.
Those bolts, for which no tightening torque is specified, tighten as the table of Appendix B.

⚠ CAUTION
1 Never perform additional machining operations such as drilling or tapping on the robot body. This can seriously affect the safety and functions of the robot.
2 Note that the use of a tapped hole not shown in the following figure is not assured. Please do not tighten both with the tightening bolts used for mechanical unit.
3 Equipment should be installed so that mechanical unit cable does not interfere. If equipment interferes, the mechanical unit cable might be disconnected, and unexpected troubles might occur.

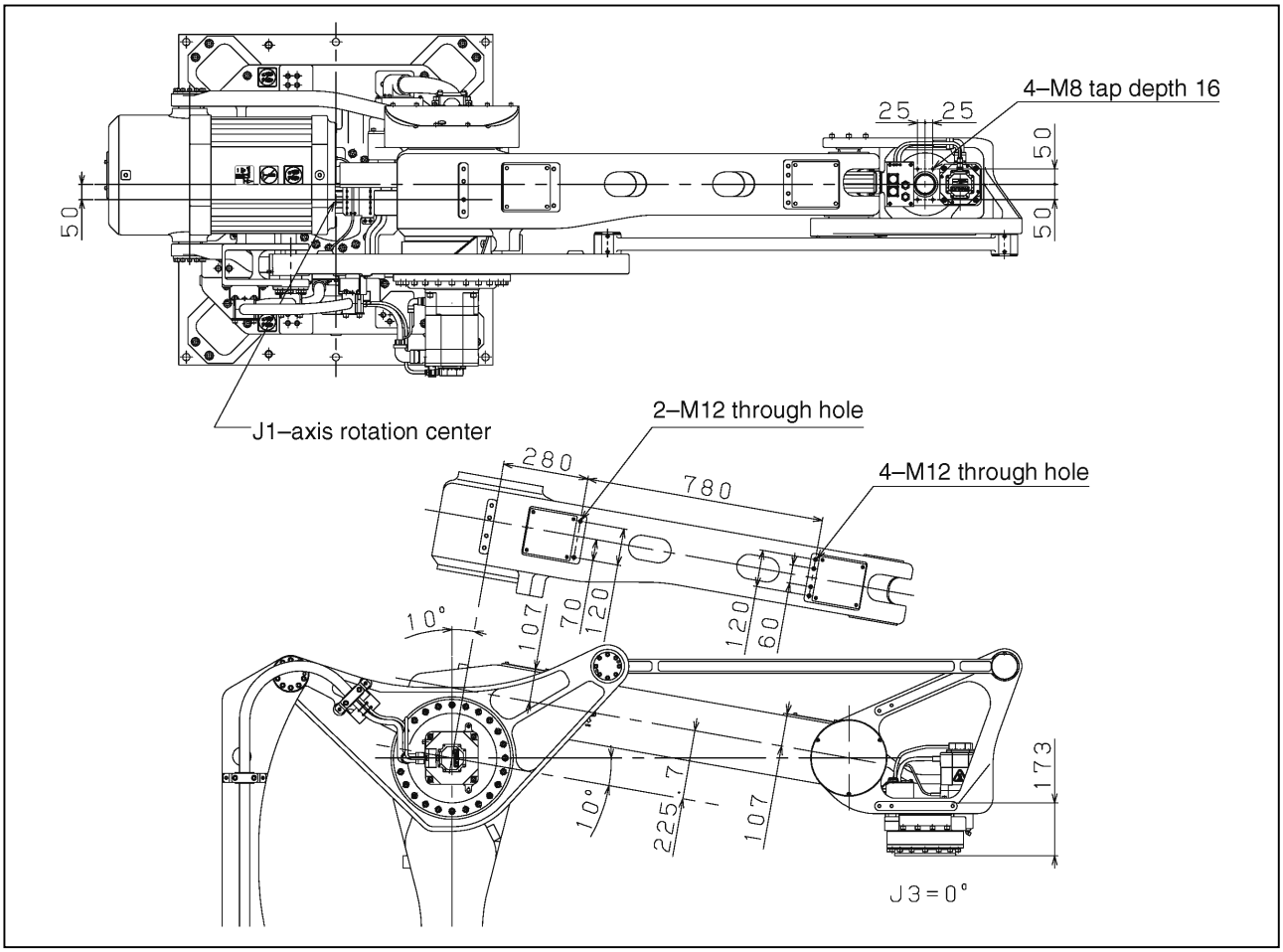


Fig. 8.4 (a) Dimensions of the equipment mounting surface

8.5 AIR SUPPLY

There are air inlets and air outlets on both side of the pedestal as shown in Fig. 8.5 (a) and (b). The connector is an R 3/8 female. As couplings are not supplied, it will be necessary to prepare couplings that suit to the hose size.

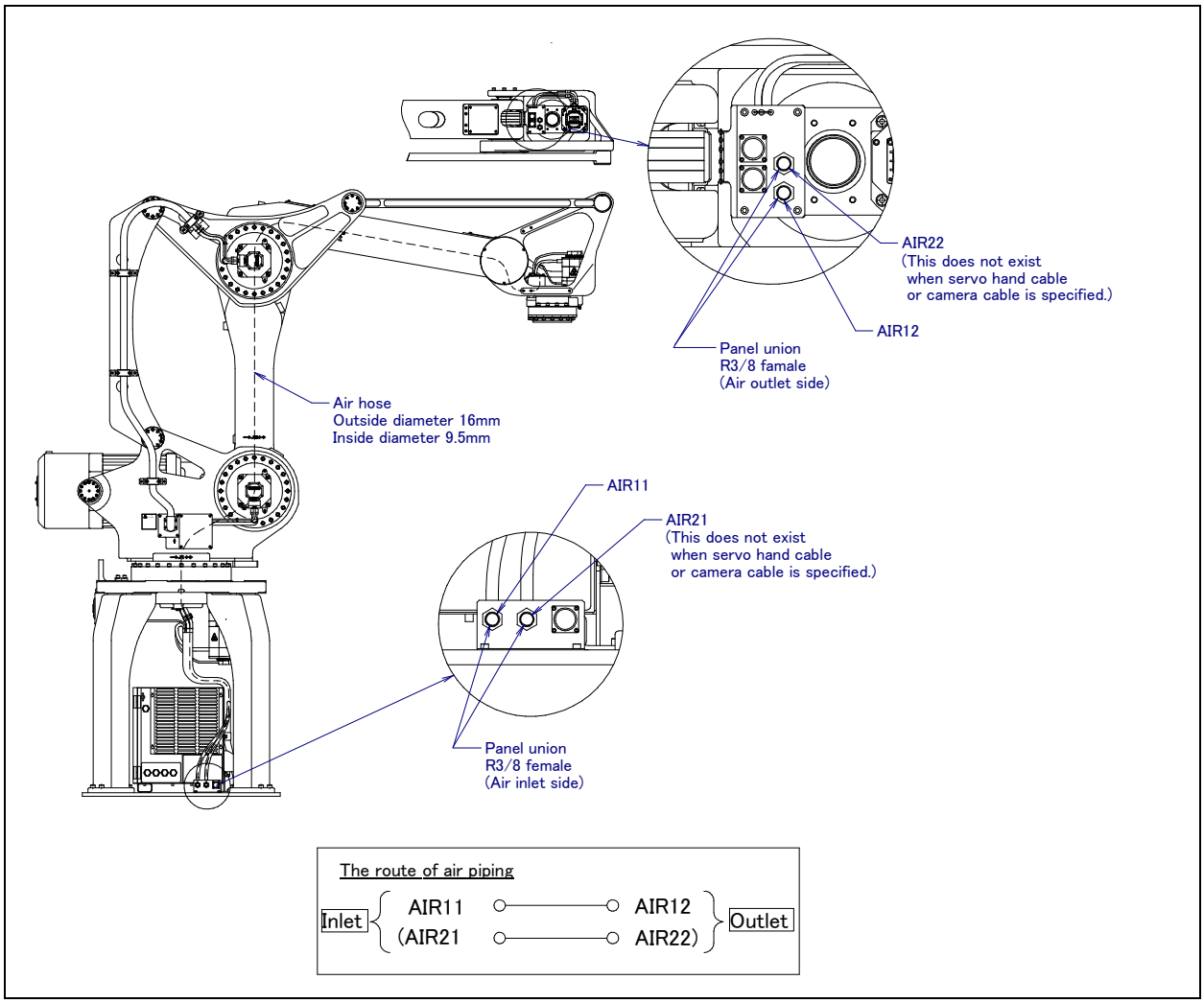


Fig. 8.5 (a) Air-pressure supply connection (Integrated controller)

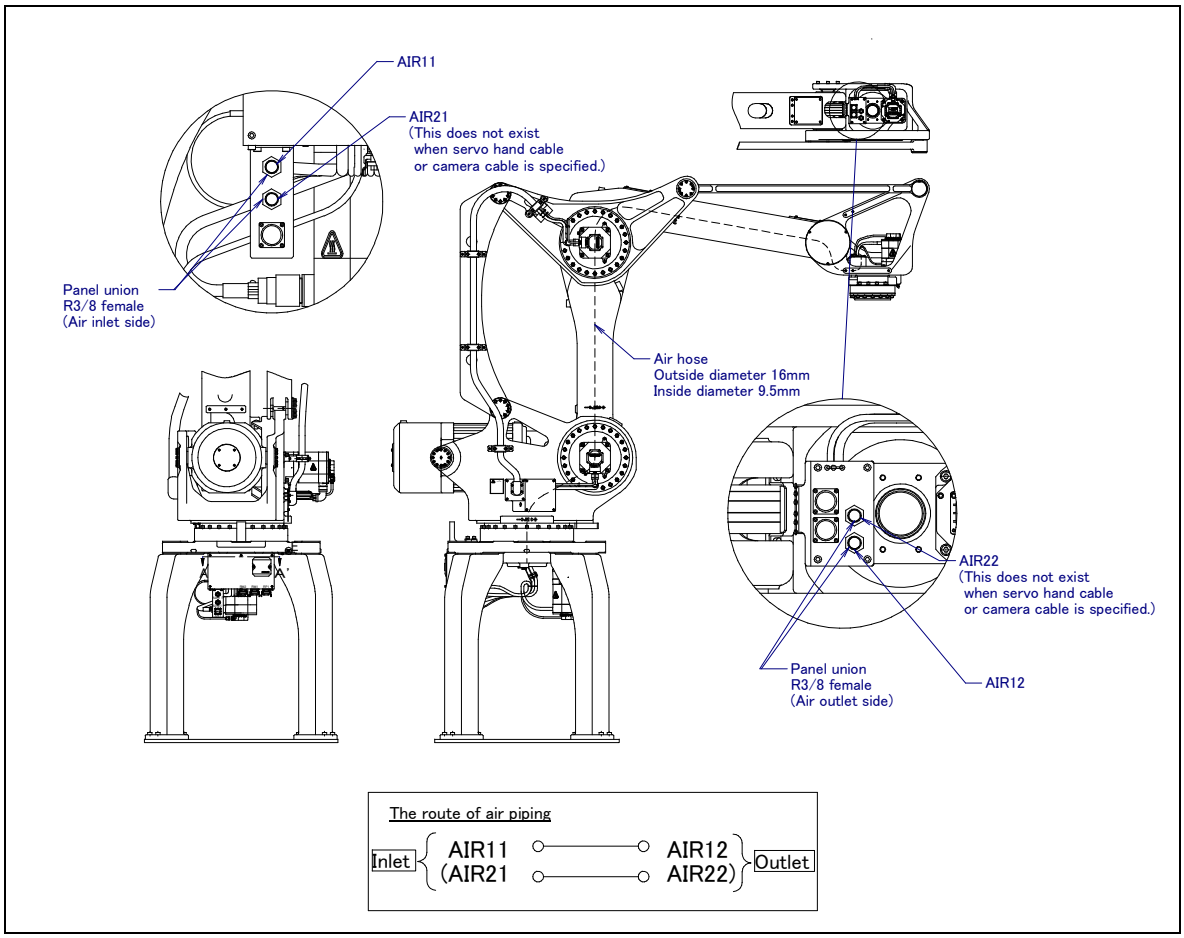


Fig. 8.5 (b) Air-pressure supply connection (Remote type controller)

8.6 OPTION CABLE INTERFACE

⚠ WARNING

- Only use appropriately-specified mechanical unit cables.
- Do not add user cables or hoses inside of the mechanical unit.
- Please do not obstruct the movement of the mechanical unit cable when cables are added to outside of mechanical unit.
- Please do not perform remodeling (adding a protective cover, or secure an additional outside cable) that obstructs the behavior of the outcrop of the cable.
- When external equipment is installed in the robot, make sure that it does not interfere with other parts of the robot.
- Cut and discard any unnecessary length of wire rod of the end effector (hand) cable. Insulate the cable with seal tape. (See Fig. 8.6 (a))
- If you have end effector wiring and a process that develops static electricity, keep the end effector wiring as far away from the process as possible. If the end effector and process must remain close, be sure to insulate the cable.
- Be sure to seal the connectors of the end effector and robot and terminal parts of all cables to prevent water from entering the mechanical unit. Also, attach the cover to the unused connector.
- Frequently check that connectors are tight and cable jackets are not damaged.
- When precautions are not followed, damage to cables might occur. Cable failure may result in incorrect function of end effector, robot faults, or damage to robot electrical hardware. In addition, electric shock could occur when touching the power cables.

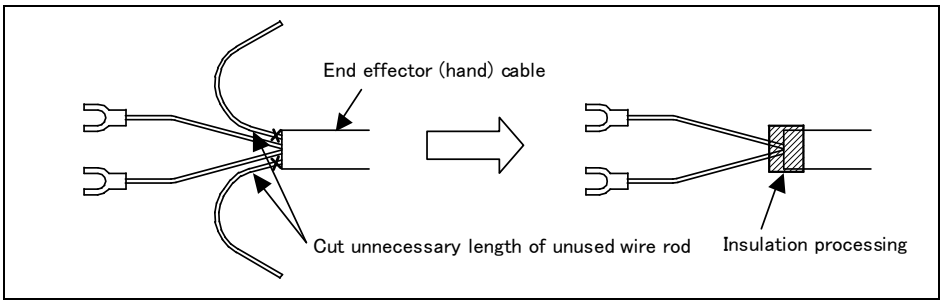


Fig. 8.6 (a) Treatment method of end effector (hand) cable

Fig. 8.6 (b) and (c) show the position of the end effector interface. EE interface, user cable (signal line) interface, servo hand cable interface, camera cable interface are prepared as basic function.

NOTE

Each option cable is written like below on connector panel
EE(RI/RO) interface : EE
User cable (signal) : AS
Servo hand cable (Pulsecoder) : M5P
Servo hand cable (power, brake) : M5M
Camera cable : CAM

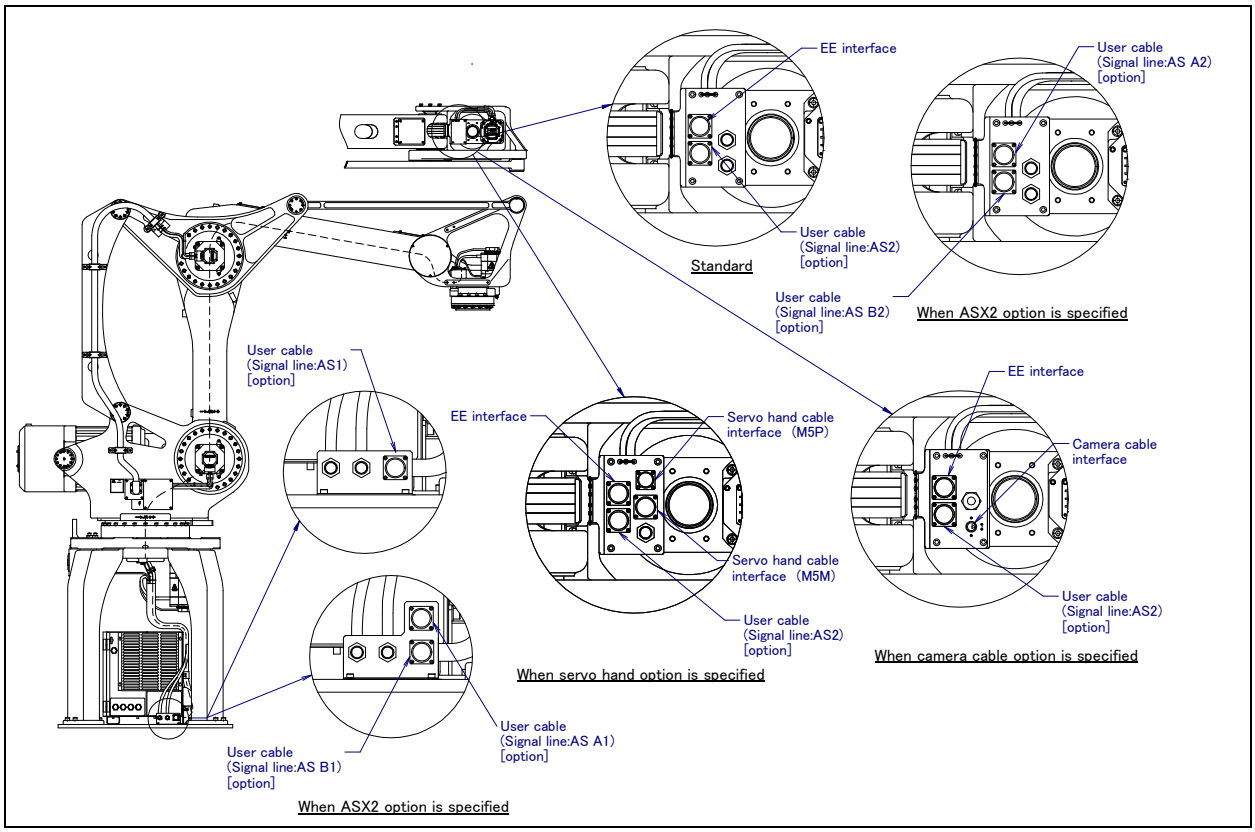


Fig. 8.6 (b) Interface for EE (Integrated controller)

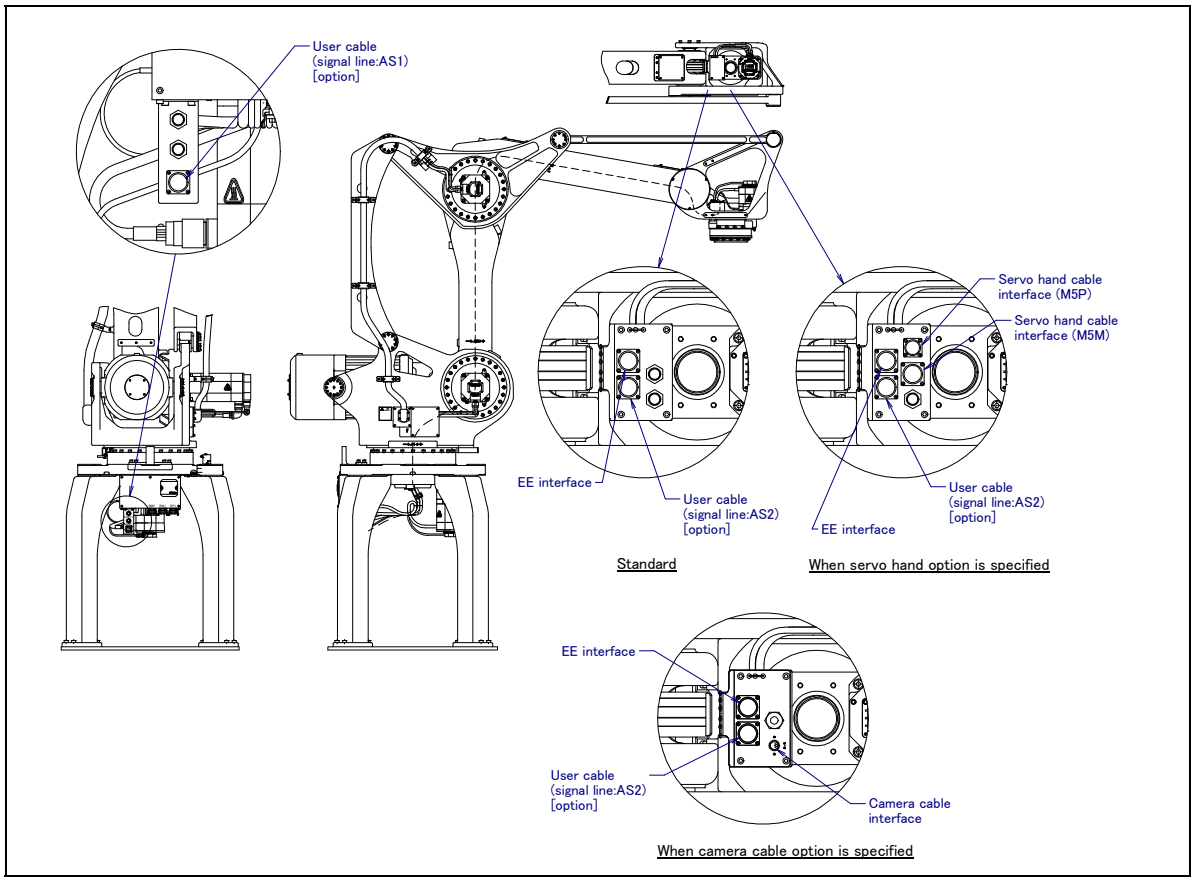


Fig. 8.6 (c) Interface for the EE (Remote type controller)

(1) EE interface (EE)
Fig. 8.6 (d) and (e) shows pin layout for EE interface.

> **⚠ WARNING**
> The RDO signal for the R-J3*i*B controller and the RO signal for the R-30*i*A/ R-30*i*B controller are incompatible with each other because different output formats are used. For details, refer to the maintenance manuals for the controllers.

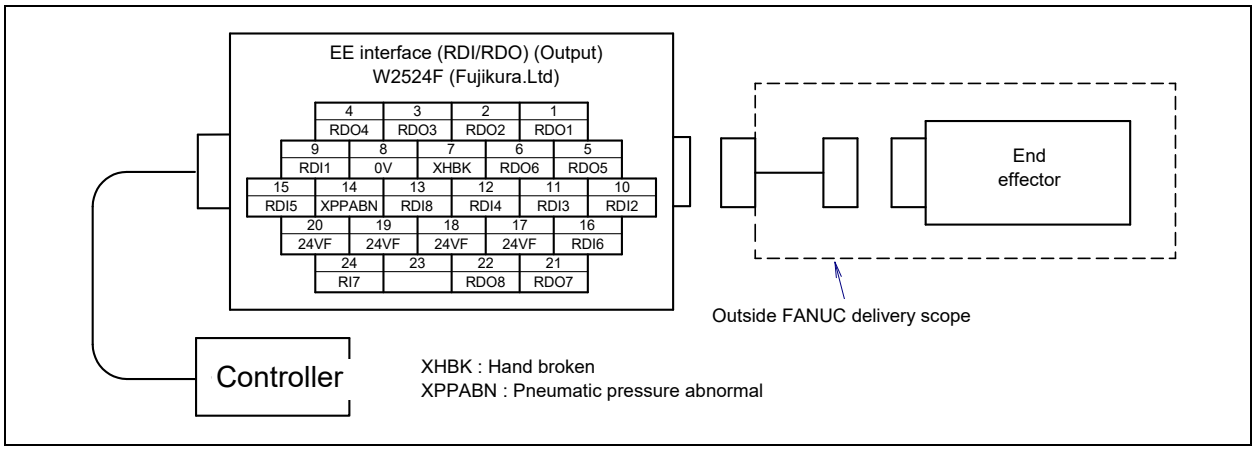


Fig. 8.6 (d) Pin layout for EE interface (EE) (for R-J3*i*B controller)

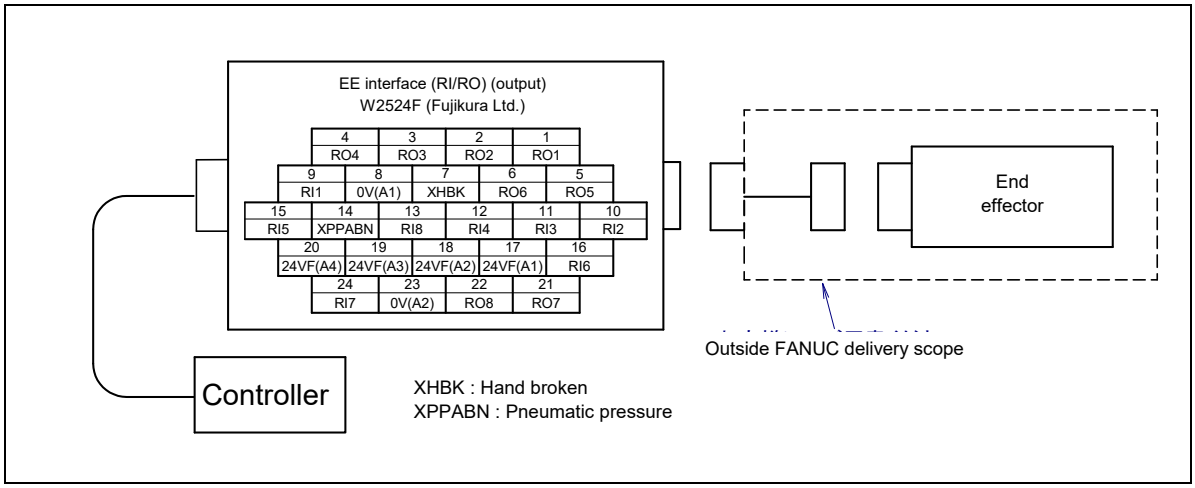


Fig 8.6 (e) Pin layout for the EE interface (EE) (R-30*i*A/R-30*i*B controller)

(2) User cable (signal line) interface (Option)
Fig. 8.6 (f) shows pin layout for user cable (signal line) interface.

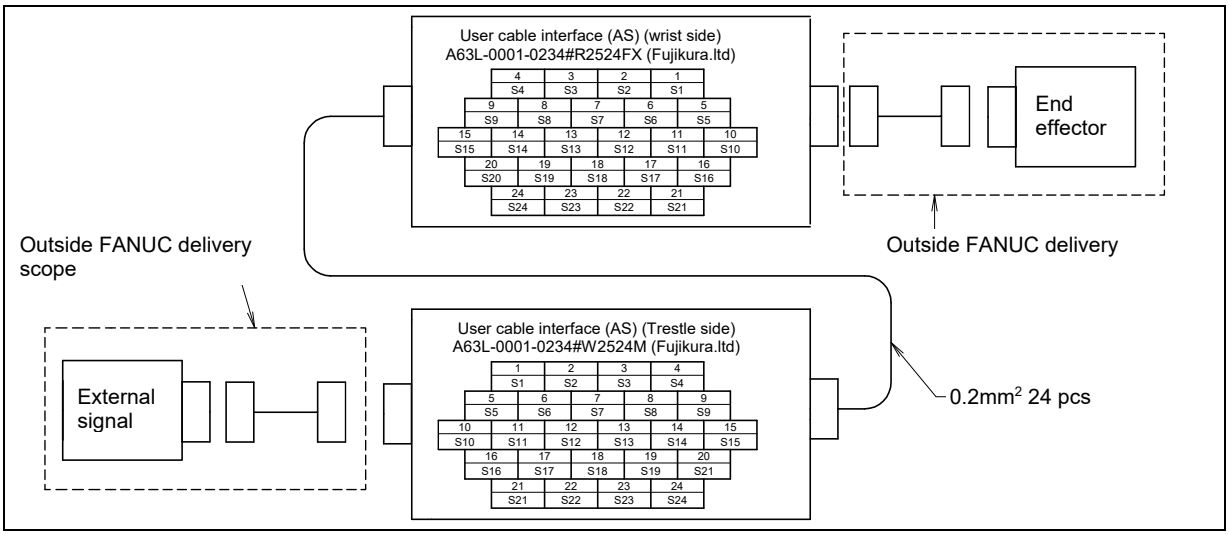


Fig. 8.6 (f) Pin layout for the user cable (signal line) interface (option)

(3) Servo hand cable interface (option)
Fig. 8.6 (g) shows the pin layout for the servo hand cable interface connector.

NOTE
A connector prepared by the customer for the servo cable interface must be a straight type; an elbow type cannot pass through the hole in the J4 axis.

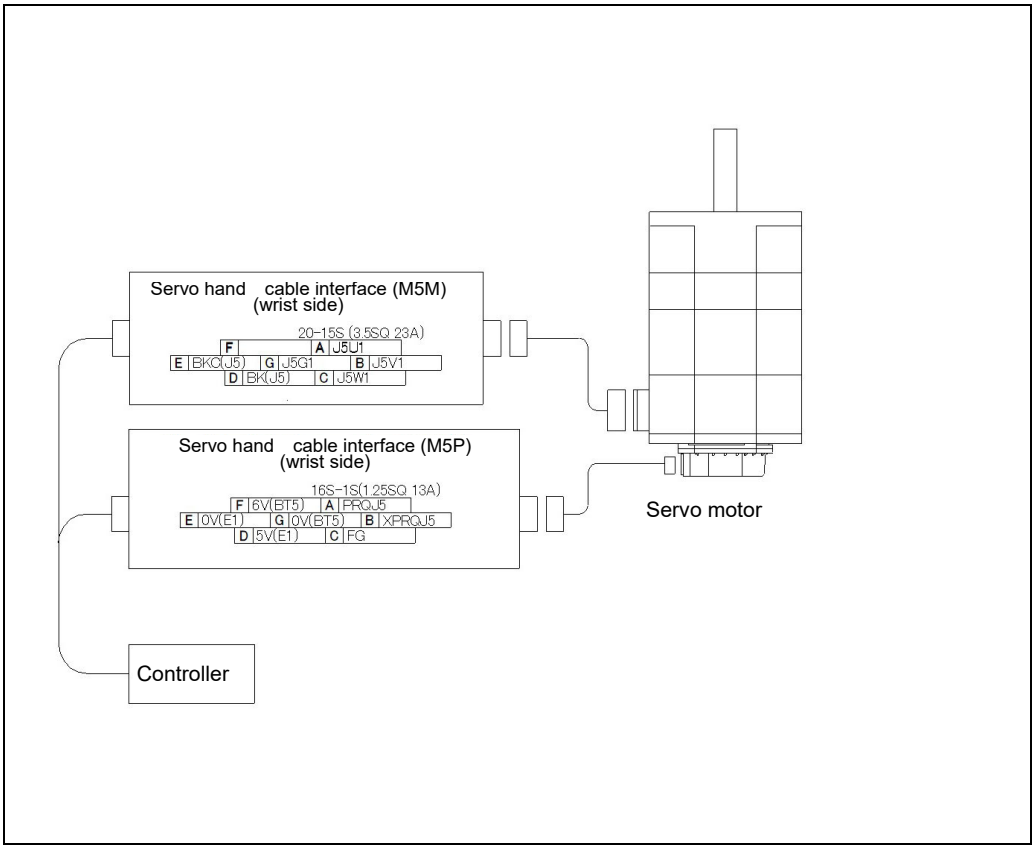


Fig. 8.6 (g) Pin layout for additional axis motor cable (M5M, M5P) interface (option)

Table 8.6 (a) Comparative table of signal name according to the motor

ARP	α motor,β motor	αI, αi –B motor, βi, βi-B motor
SPD	SD	-
XSPD	*SD	-
PRQ	REQ	RD
XPRQ	*REQ	*RD

Connector specifications

Table 8.6 (b) Connector specifications (Mechanical unit side)

Cable	Input side (J1 base)	Output side (wrist side)	Maker /dealer
EE(RI/RO)	———	FANUC spec.: A63L-0001-0234#R2524F	Fujikura Ltd.
AS	FANUC spec:A63L-0001-0234#W2524M	FANUC spec.: A63L-0001-0234#R2524FX	
M5P	———	MS3102A 16S-1S	Fujikura.Ltd Japan Aviation Electronics Industry, Ltd.
M5M	———	MS3106B 20S-15S	

Table 8.6 (c) Connector specifications (User side)

Cable	Input side (J1 base)	Output side (wrist side)	Maker /dealer
EE(RI/RO)	———	JMSP2524M (*1) Straight plug JMLP2524M Angle plug	Fujikura Ltd.
AS	JMSP2524F (*2) Straight plug	JMSP2524MX (*3) Straight plug	

NOTE
1 Below shows spec. to order in our company.
(*1)A63L-0001-0234#S2524M (Appendix)
(*2)A63L-0001-0234#S2524F
(*3)A63L-0001-0234#S2524MX
2 For details, such as the dimensions, of the parts listed above, refer to the related catalogs offered by the respective manufactures, or contact your local FANUC representative.

9 TRANSPORTATION AND INSTALLATION

9.1 TRANSPORTATION

The robot can be transported by a crane or by a forklift. Fig. 9.1 (a) and (b) show the postures in transportation.

⚠ WARNING

When a peripherals are installed on a robot, the center of gravity of the robot changes and the robot might become unstable while being transported.
Robot becomes unstable when it is transported with the end effector applied to wrist ,and it is dangerous.
Please be sure to remove end effector when robot is transported.
Use the forklift pockets only to transport the robot with a forklift. Do not use the forklift pockets for any other transportation method. Do not use the forklift pockets to secure the robot.
Before moving the robot by using forklift pockets, check and tighten any loose bolts on the forklift pockets.
Do not pull eyebolts sideways.
Prevent the forks of the forklift from having impact on a transport equipment.
Do not thread a chain or the like through a transport equipment.

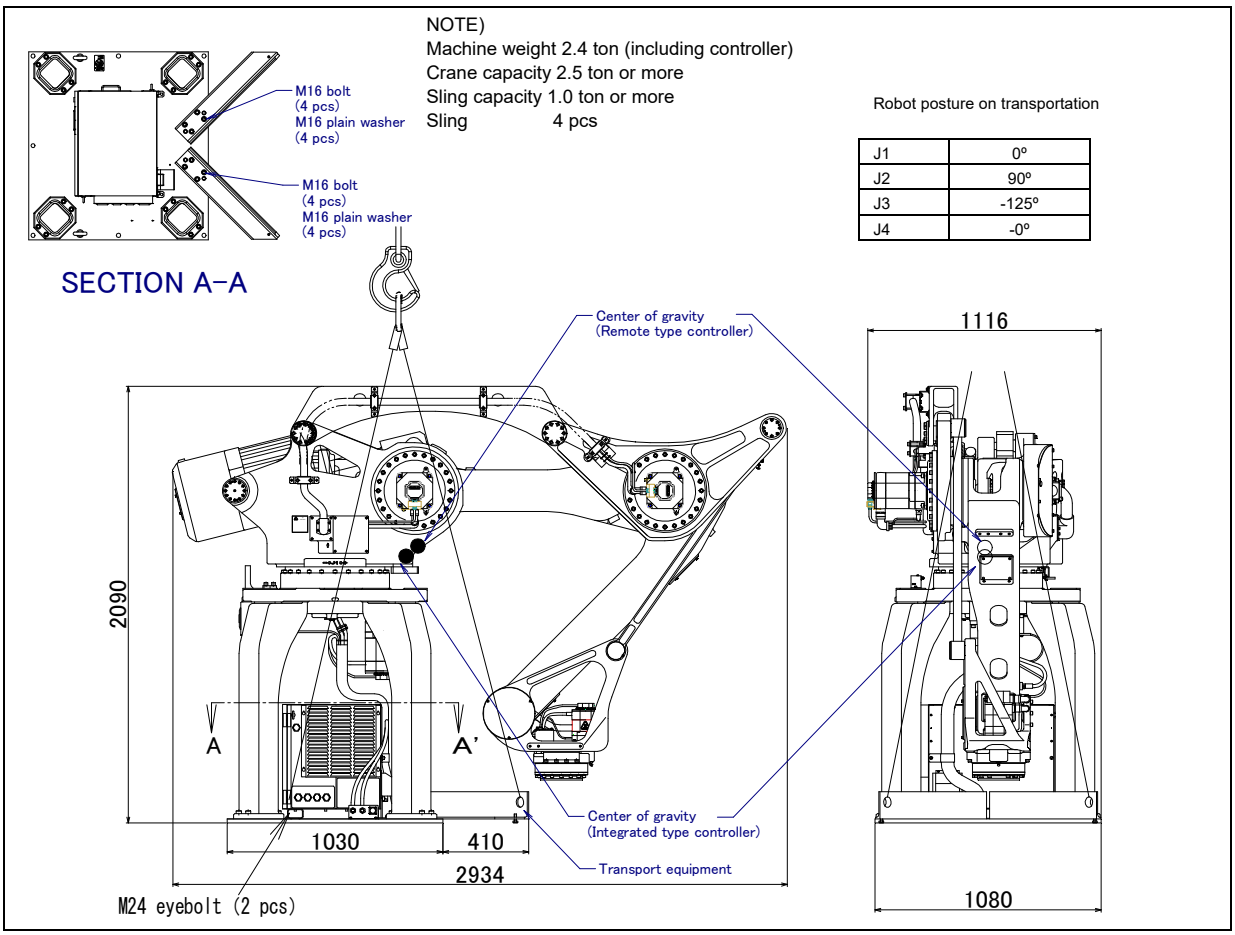


Fig. 9.1 (a) Transportation by crane

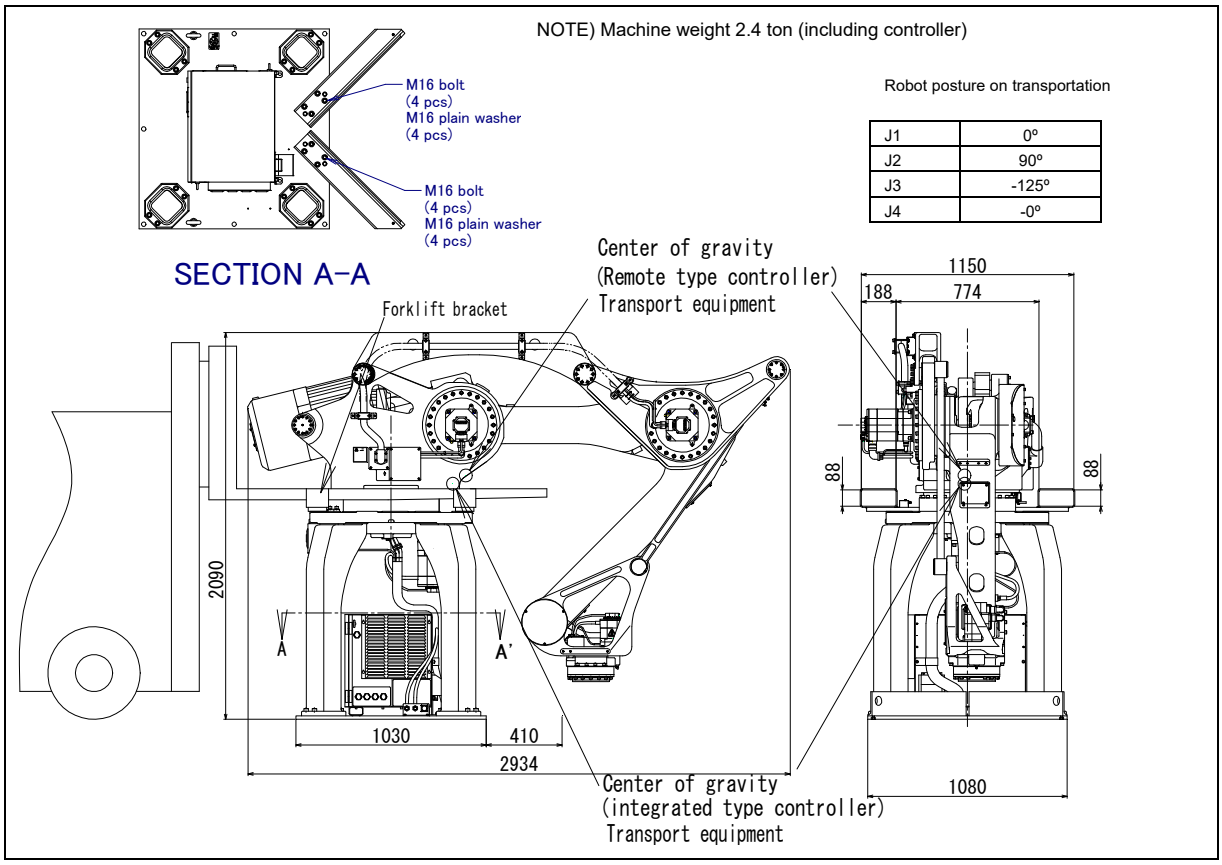


Fig. 9.1 (b) Transportation by forklift

> ⚠ **CAUTION**
> Be careful not to strike the transport equipment with the forklift forks.

9.2 INSTALLATION

(1) Installing the robot using the standard pedestal

Described below is how to install the robot using the standard pedestal, which is factory-assembled with the robot.

Fig. 9.2 (a) shows the robot base dimensions. Fig. 9.2 (b) shows an actual example of robot installation. Secure the floor plate (iron plate) to the floor using 16 M20 chemical anchors (Tensile strength 400N/mm^2 or more). Then, secure the robot to the floor plate with eight M20 bolts (Tensile strength 1200N/mm^2 or more), which are at least 40 mm in length.
Those bolts for which no tightening torque is specified must be tightened according to the APPENDIX B BOLT TIGHTENING TORQUE TABLE.

⚠ CAUTION

1 If the robot base is secured directly to the floor with chemical anchors, the anchors may fail due to fluctuating load during robot operation.
2 Do not provide leveling (with a wedge, for example) between the robot base and floor plate. Otherwise, any robot vibration may be accentuated due to the robot not being in close contact with the floor plate.
3 Flatness of robot installation surface must be less than or equal to 0.5mm. Inclination of robot installation surface must be less than or equal to 0.5º. If robot base is placed on uneven ground, it may result in the base breakage or low performance of the robot.

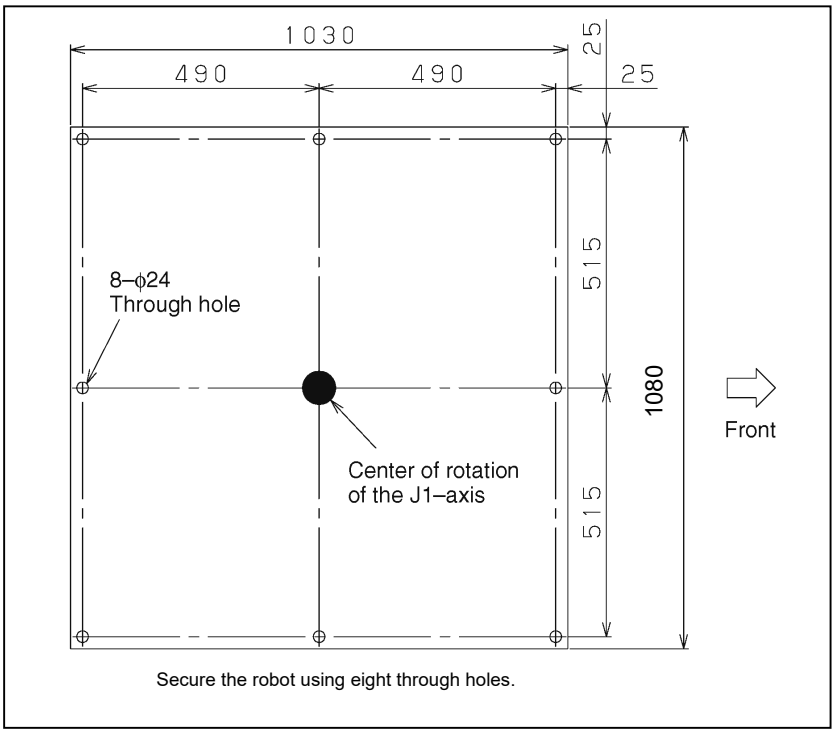


Fig. 9.2 (a) Installation hole dimensions of the robot base

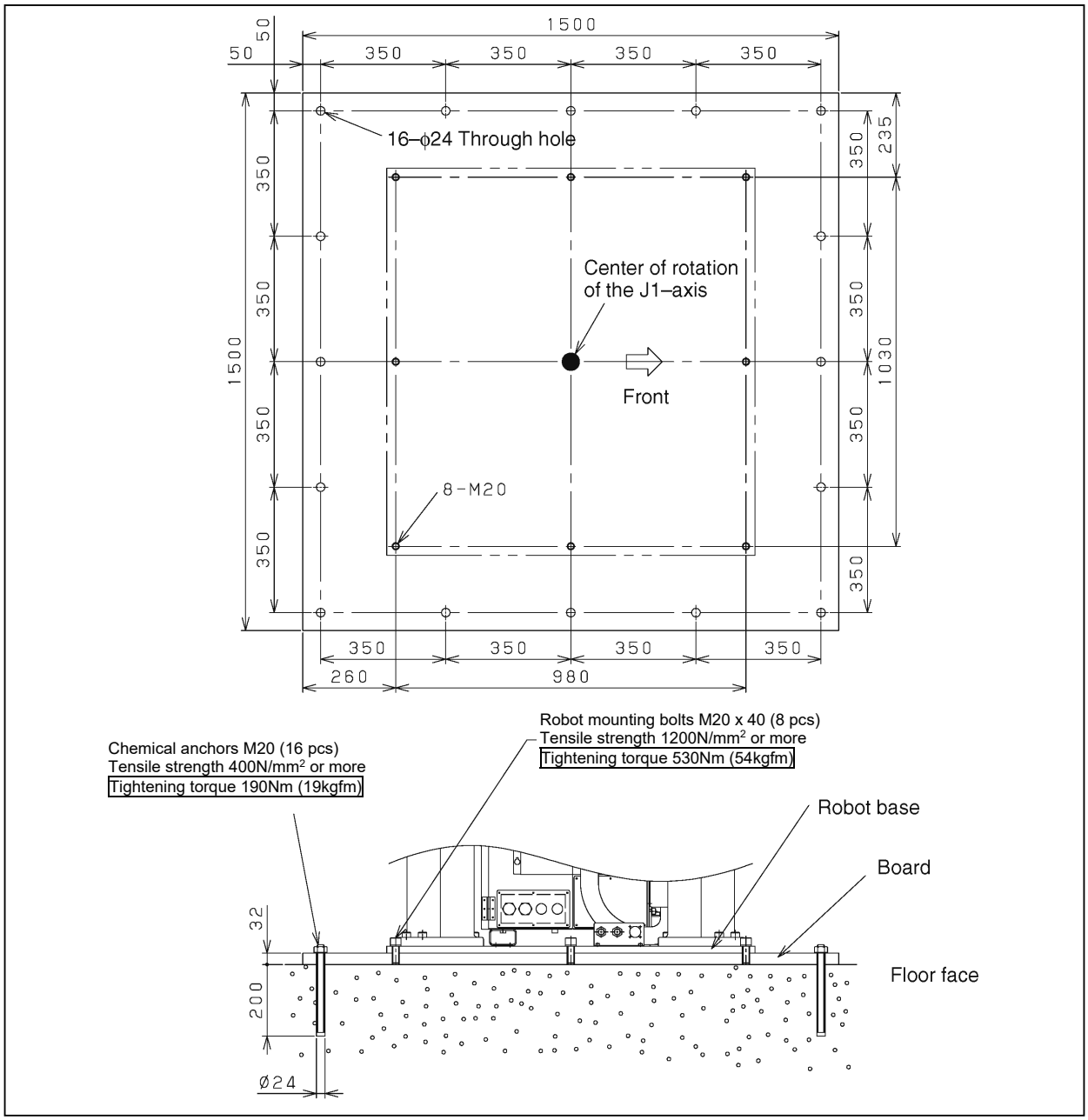


Fig. 9.2 (b) Sample installation

NOTE

1 The customer should prepare the following parts:
- Eight robot securing bolts : M20 x 40 (Tensile strength 1200N/mm^2 or more)
- 16 chemical anchors : M20 (Tensile strength 400N/mm^2 or more)
- One floor plate : 32t in thickness

2 The customer is responsible for preparation prior to installation (mounting of anchors, for example)

Table 9.2 (a) and Fig. 9.2 (c) indicate the force and moment applied to the robot base plate.
Table 9.2 (b), (c) indicates the coasting time and distance of the J1 through J3 axes until the robot stopping by Power-Off stop or by Controlled stop after input of the stop signal.
Refer to the data when considering the strength of the installation face.

NOTE
Table 9.2 (b) and (c) are measured reference value complied with ISO10218-1. Values differs depending on each robot individual difference, payload and the program. So confirm the real value by measurement. Values in Table 9.2 (b) is affected by the robot operating status and number of times of the Servo-Off stop. Periodically measure the real values and confirm those.

Table 9.2 (a) Force and moment acting to base plate

	At stop	At acceleration / deceleration	At Power-Off stop
Vertical moment M_V	27000 Nm (2755 kgfm)	35000 Nm (3571 kgfm)	104000 Nm (10612 kgfm)
Foce in vertical direction F_V	28000 N (2857 kgf)	31000 N (3163 kgf)	56000 N (5714 kgf)
Horizontal moment M_H	0 Nm (0 kgfm)	10000 Nm (1020 kgfm)	44000 Nm (4490 kgfm)
Force in horizontal direction F_H	0 N (0 kgf)	9000 N (918 kgf)	21000 N (2143 kgf)

Table 9.2 (b) Stopping time and distance until the robot stopping by Power-Off stop after input of stop signal

Model		J1-axis	J2-axis	J3-axis
M-410*i*B/450	Stopping time [msec]	636	212	148
	Stopping distance [deg] (rad)	21.8 (0.38)	6.8 (0.12)	5.4 (0.09)

Table 9.2 (c) Stopping time and distance until the robot stopping by Controlled stop after input of stop signal

Model		J1-axis	J2-axis	J3-axis
M-410*i*B/450	Stopping time [msec]	844	836	820
	Stopping distance [deg] (rad)	31.4 (0.55)	29.2 (0.51)	29.5 (0.51)

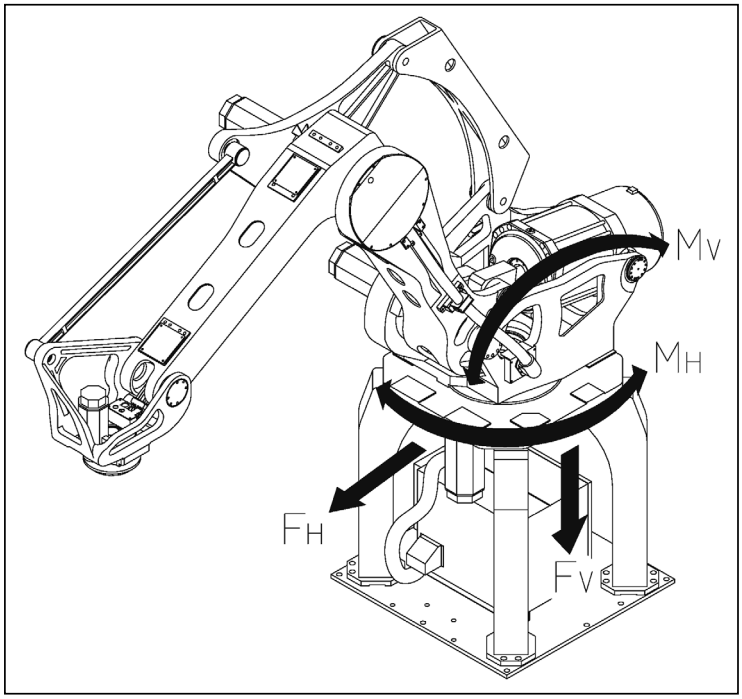


Fig. 9.2 (c) Force and moment acting to the robot base

(2) Installing the robot without using the standard pedestal

A robot with a separate controller can be installed on a customer-prepared pedestal, without using the standard pedestal, which is factory-assembled with the robot.

Fig. 9.2 (d) shows how to remove the standard pedestal from the robot. First put the robot in the posture of J1-axis = 0°, J2-axis = -45°, J3-axis = -25°, and J4-axis = 0°, then prepare to sling up the robot portion above the J1 base with rope. Remove the J1-axis mounting bolts (sixteen M16 x 65 bolts), and separate the J1 base from the pedestal.

Fig. 9.2 (e) shows the installation interface for the robot. Design a pedestal while taking care of the following points:

- Provide space required when replacing the J1-axis motor.
- Provide space required when mounting and dismounting the mastering fixture.
- Provide space for periodic maintenance (such as battery exchange and degreasing)
- Avoid interference of the robot with the cables and connector box.
- Make sure that the setup is strong enough to withstand the force and moment listed in Table 9.2 (a).

To fasten the J1 base to the pedestal, use sixteen bolts having a size of M16 (Tensile strength 1200N/mm^2 or more) and a length of at least 65 mm.

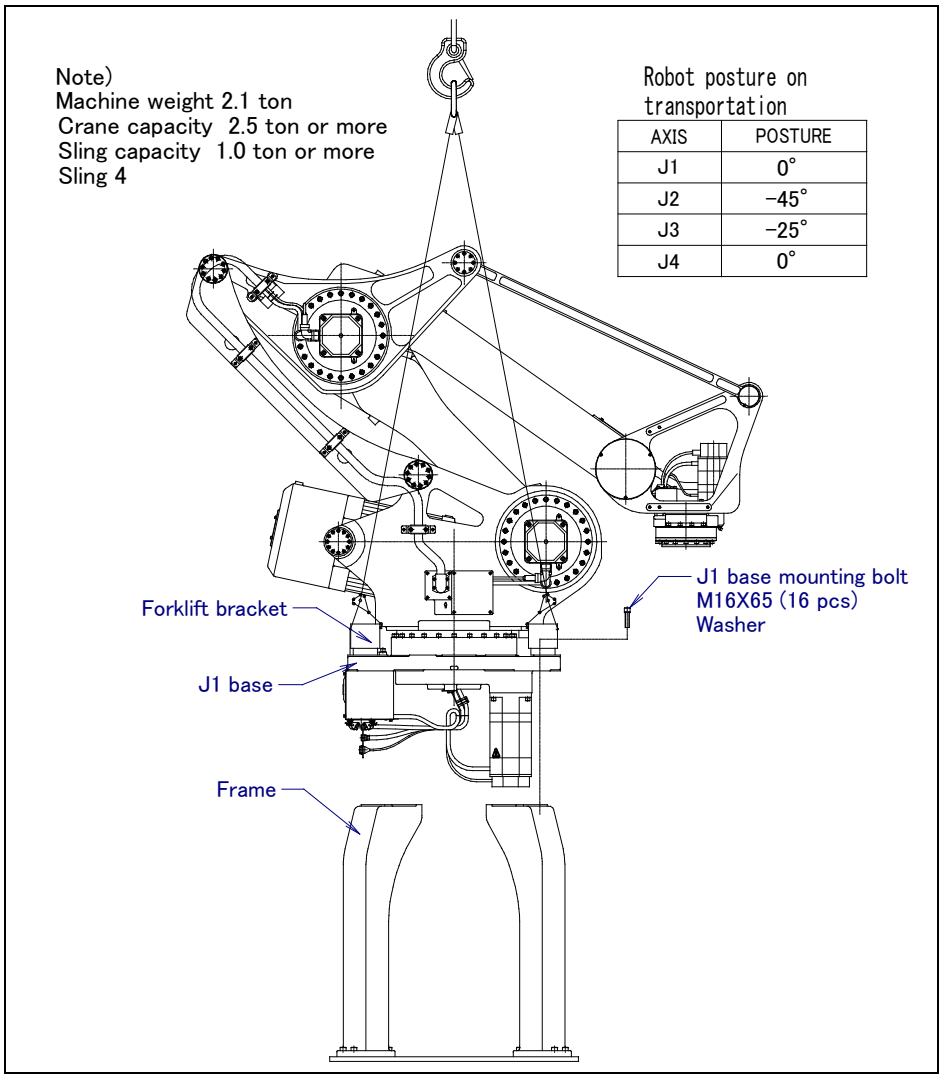


Fig. 9.2 (d) How to remove the pedestal (robot with a separate controller)

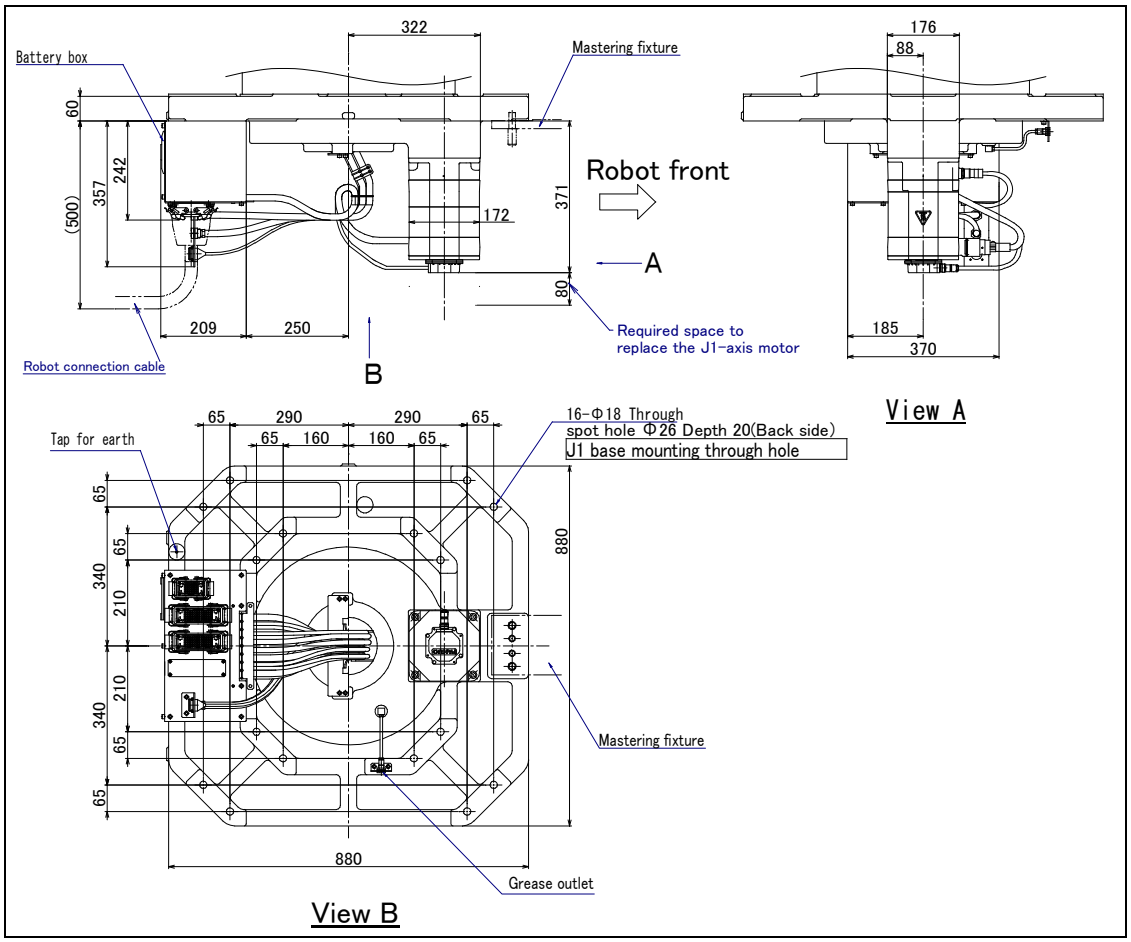


Fig. 9.2 (e) Installation interface for the robot (with a separate controller) with the standard pedestal removed

9.3 MAINTENANCE AREA

Fig. 9.3 (a) shows the maintenance area of the mechanical unit.

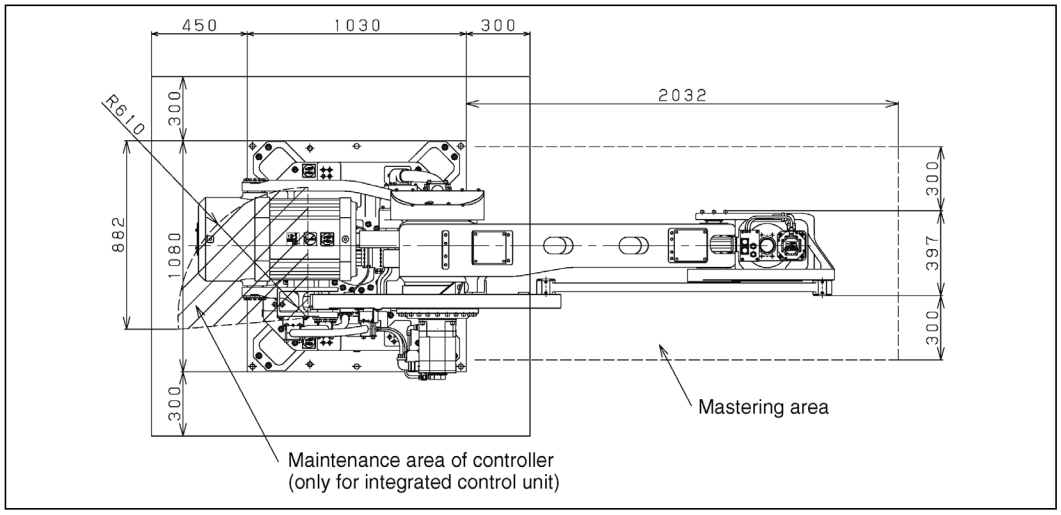


Fig. 9.3 (a) Maintenance area

9.4 INSTALLATION CONDITION

Refer to specification of “PREFACE” about installation conditions.

10 CONNECTION WITH THE CONTROLLER

10.1 CONNECTION WITH THE CONTROLLER

In case of integrated controller type, cable of controller is connected to motor of robot directly.

In case of remote controller type, the robot is connected with the controller via the power cable, signal cable, and the earth cable. Connect these cables to the connectors on the back of the base.
For details on air and option cables, see Chapter 8.

> ⚠ **WARNING**
> Before turning on controller power, be sure to connect the robot and controller with the earth line (ground). Otherwise, there is the risk of electrical shock.

> ⚠ **CAUTION**
> 1 Before connecting the cables, be sure to turn off the controller power.
> 2 Do not use 10m or longer coiled cable without first untying it. The long coiled cable could heat up and become damaged.

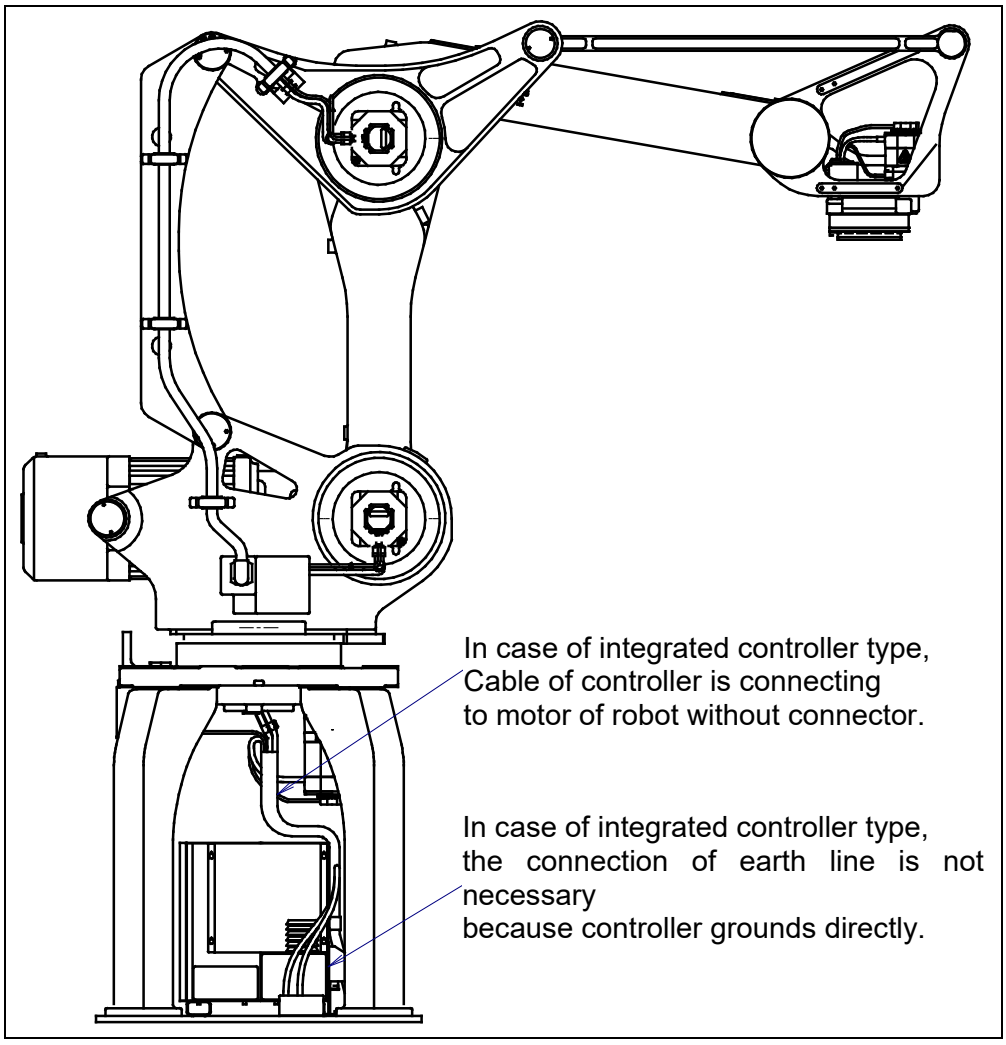


Fig. 10.1 (a) Cable connection (integrated type controller)

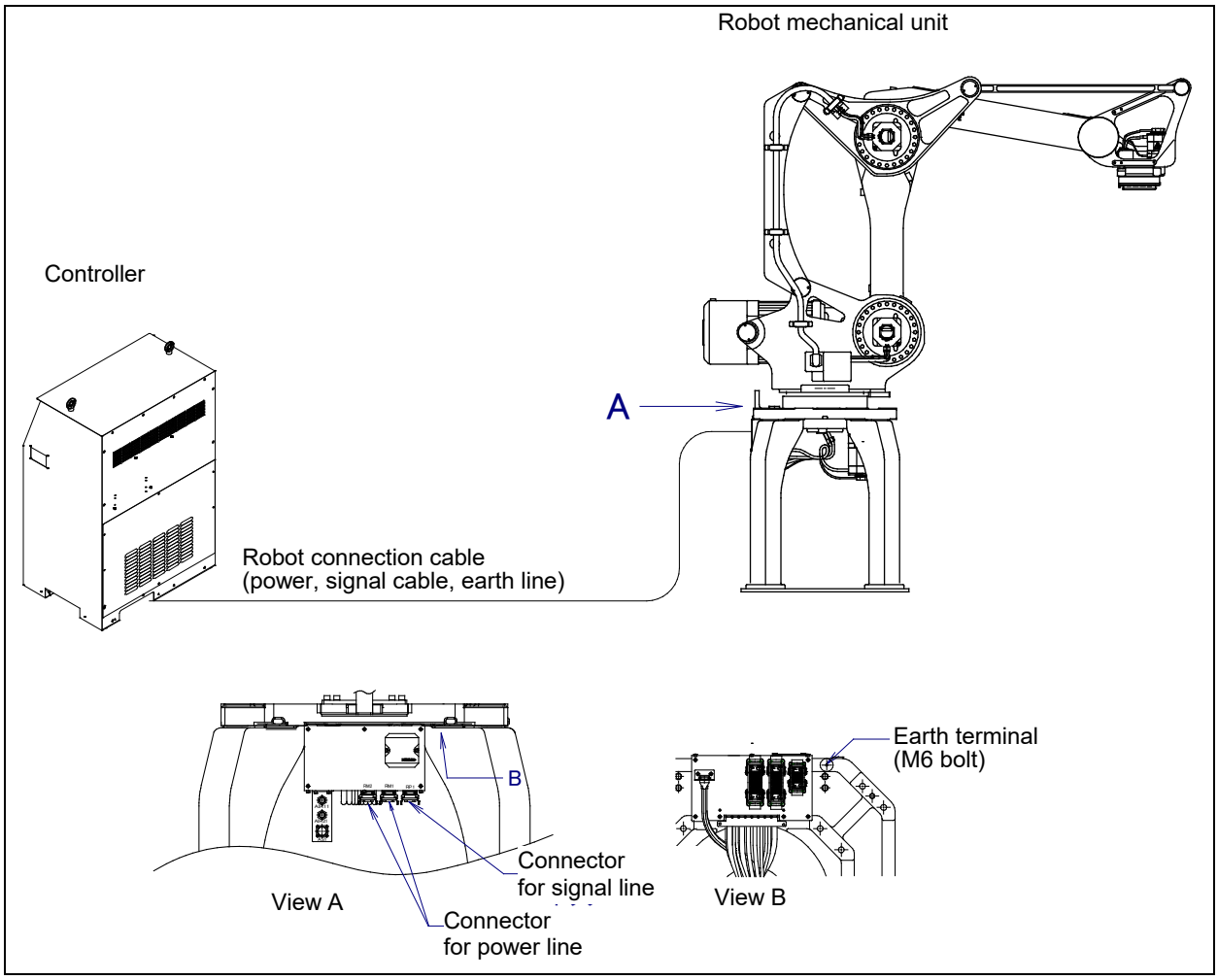


Fig. 10.1 (b) Cable connection (remote type controller)

APPENDIX

A PERIODIC MAINTENANCE TABLE

FANUC Robot M-410*i*B/450 Periodic Maintenance Table

Items			Check time	Grease amount	First check 320	3 months 960	6 months 1920	9 months 2880	1 Year 3840	4800	5760	6720	2 Years 7680	8640	9600	10560
Mechanical unit	1	Check the mechanical cable. (damaged or twisted)	0.2H	—		○			○				○			
	2	Check the motor connector. (loosening)	0.2H	—		○			○				○			
	3	Tighten the end effector bolt.	0.2H	—		○			○				○			
	4	Tighten the cover and main bolt.	2.0H	—		○			○				○			
	5	Check the mechanical stopper and adjustable mechanical stopper	0.1H	—		○			○				○			
	6	Remove spatter and dust etc.	1.0H	—		○			○				○			
	7	Check the end effector (hand) cable	0.1H	—		○			○				○			
	8	Check the fan	0.1H	—		○			○				○			
	9	Replacing battery.	0.1H	—							●					
	10	Replacing grease of J1 axis reducer *1	1.8H	10800ml												
	11	Replacing grease of J2 axis reducer *1	0.9H	2300ml												
	12	Replacing grease of J3 axis reducer *1	0.5H	2300ml												
	13	Replacing grease of J4 axis gearbox *1	0.5H	1600ml												
	14	Apply greasing to the bush of the balancer (2 places) *1	0.5H	each 10ml					●				●			
	15	Apply greasing to the J3-axis cross roller bearing *1	0.1H	40ml												
	16	Apply greasing to the J4-axis cross roller bearing *1	0.1H	20ml												
	17	Replacing the mechanical unit cable	4.0H	—												
Controller	18	Check the robot cable, teach pendant cable and robot connecting cable	0.2H	—		○			○				○			
	19	Cleaning the ventilator	0.2H	—	○	○	○	○	○	○	○	○	○	○	○	○
	20	Replacing batteries *2	0.1H	—												

*1 Refer to this manual about greasing points.
*2 Refer to manual of controller
*3 ●: Requires order of parts
○: Does not require order of parts

3 years 11520	12480	13440	14400	4 years 15360	16320	17280	18240	5 years 19200	20160	21120	22080	6 years 23040	24000	24960	25920	7 years 26880	27840	28800	29760	8 years 30720	Item
○				○				○				○				○					1
○				○				○				○				○					2
○				○				○				○				○					3
○				○				○				○				○					4
○				○				○				○				○					5
○				○				○				○				○					6
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				●																	20

Overhaul

B STRENGTH OF BOLT AND BOLT TORQUE LIST

NOTE

When applying LOCTITE to a part, spread the LOCTITE on the entire length of the engaging part of the female thread. If applied to the male threads, poor adhesion can occur potentially loosening the bolt. Clean the bolts and the threaded holes and wipe off any oil on the engaging section. Make sure that there is no solvent left in the threaded holes. After you screw the bolts into the threaded holes, remove any excess LOCTITE.

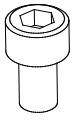
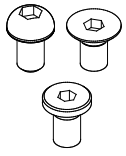
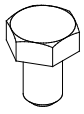
Use the following strength bolts. Comply with any bolt specification instructions.
Hexagon socket head bolt made of steel:

Size M22 or less: Tensile strength 1200N/mm^2 or more
Size M24 or more: Tensile strength 1000N/mm^2 or more
All size plating bolt: Tensile strength 1000N/mm^2 or more

Hexagon bolt, stainless bolt, special shape bolt (button bolt, low-head bolt, flush bolt .etc.)
Tensile strength 400N/mm^2 or more

Refer to the following tables if the bolts tightening torque is not specified.

Recommended bolt tightening torques **Unit: Nm**

Nominal diameter	Hexagon socket head bolt (steel)		Hexagon socket head bolt (stainless steel)		Hexagon socket head button bolt Hexagon socket head flush bolt Low-head bolt (steel)		Hexagon bolt (steel)	
	Tightening torque		Tightening torque		Tightening torque		Tightening torque	
	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit
M3	1.8	1.3	0.76	0.53	———	———	———	———
M4	4.0	2.8	1.8	1.3	1.8	1.3	1.7	1.2
M5	7.9	5.6	3.4	2.5	4.0	2.8	3.2	2.3
M6	14	9.6	5.8	4.1	7.9	5.6	5.5	3.8
M8	32	23	14	9.8	14	9.6	13	9.3
M10	66	46	27	19	32	23	26	19
M12	110	78	48	33	———	———	45	31
(M14)	180	130	76	53	———	———	73	51
M16	270	190	120	82	———	———	98	69
(M18)	380	260	160	110	———	———	140	96
M20	530	370	230	160	———	———	190	130
(M22)	730	510	———	———	———	———	———	———
M24	930	650	———	———	———	———	———	———
(M27)	1400	960	———	———	———	———	———	———
M30	1800	1300	———	———	———	———	———	———
M36	3200	2300	———	———	———	———	———	———
								

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