FANUC Robot

CR-4*i*A, CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L

MECHANICAL UNIT

OPERATOR'S MANUAL

B-83774EN/04

- **Original Instructions**

Thank you very much for purchasing FANUC Collaborative Robot.
Before using the Robot, be sure to read the "SAFETY PRECAUTIONS" in this manual and understand the content.

SAFETY PRECAUTIONS

This chapter explains cautions for safety usage of FANUC collaborative robot.

Robot cannot work without the end effector or peripheral equipment. By combined with the end effector and peripheral equipment and assembling the system, robot can demonstrate works. In other words the robot is one part of the system.

FANUC is not and does not represent itself as an expert in safety systems, safety equipment, or the specific safety aspects of your company and/or its workplace. It is the responsibility of the owner, employer, or user to take all necessary steps to guarantee the safety of all personnel in the workplace.
The appropriate level of safety for your application and installation can best be determined by safety system professionals.

FANUC therefore, recommends that each customer consult with such professionals in order to provide a safe application.

Additionally, robot system owner, it is your responsibility to arrange for the training of the operator of a robot system to recognize and respond to known hazards associated with robot to be aware of the recommended operating procedures. Because FANUC prepare for the professional training course of the robot, please use it.

It is recognized that the operational characteristics of robots can be significantly different from those of other machines and equipment.
Robots are capable of high energy movements through a large volume beyond the base of robots.
Although, robot is substitution for work at dangerous zone or harmful zone, but it may cause work-related accident by mistake. So perfect safety precautions for usage is required when installing it.
In order to prevent work-related accident by robot, as indicators of the steps that an employer should take each safe standard (JIS, ISO, IEC) are provided, these shows the contents for during installation and usage.

This chapter provides some hints and guidelines for the robot system safety design.

Before using the FANUC collaborative robot, be sure to read this manual to become familiar with those contents.

1 DEFINITION OF WARNING AND CAUTION

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**". Please read each "**WARNING**", "**CAUTION**" and "**NOTE**" before using the robots.

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.

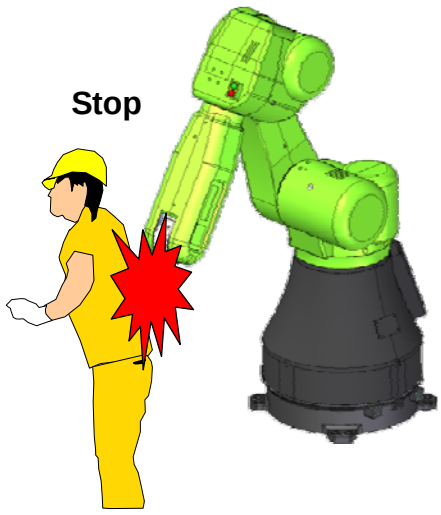
- Check this manual thoroughly, and keep it handy for the future reference.

2 FANUC COLLABORATIVE ROBOT SYSTEM

2.1 OVERVIEW

The collaborative robot means the robot that work with workers.
The robot system that is designed with following this manual, can admit the safety work of person near the moving robot.

System example :
Robot hands parts to person



If the robot contacts to person,
The robot stops.

This chapter explains cautions for safety usage of collaborative robot. So unless otherwise specified, in this manual, “robot” means “collaborative robot”.

2.2 PURPOSE OF ROBOT

FANUC Robot series can be used for the following applications.
- Handling
- Assembling

Required functionality for these applications is implemented by selecting an appropriate TOOL software. Please consult your FANUC sales representative if you want to use the robot for any application other than listed above.

Even when you use the robot for the purpose of any of the applications listed above, the robot must not be under any of the conditions listed below. Inappropriate usage of robots may cause not only damage to the robot system, but also serious injury or even death of the user in the premises.
- Flammable atmosphere
- Explosive atmosphere
- Radioactive environment
- In water or any kind of liquid
- Use of robot for the purpose of transferring human or animals
- Use of robot as a step (climbing upon the robot)
- Outdoor
- Use of robot under conditions not in accordance with FANUC recommended installation or usage

FANUC is not responsible for any damage caused by misuse of the robots.
Before using the robot, check the specifications of the robot, and then take adequate safety measures to prevent hazardous conditions.

2.3 CONFIGURATION OF ROBOT SYSTEM

The following elements has been verified their safety.
- Robot
- Robot controller
- Robot teach pendant
- End effector
- Other peripheral devices (machine)
- Workpiece

Users conduct risk assessment of robot system, and the following elements must be prepared by the user according to system configuration as the need arises.
- Safeguard
- Interlocked gate
- Interlocking device

Except the robot, the robot controller and the robot teach pendant depend on the system, so please them by users. FANUC Robot has an interface to connect interlocking devices. So confirm the specifications and design the interlock system.

Security is already confirmed against following components.
- Robot
- Robot controller and teach pendant

FANUC can not guarantee safety for end effector, other peripheral equipment and workpiece. System designer must design the system in consideration of security according to safety standard. Robot system designer must design the robot system to secure the security according to EN ISO 10218 (ANSI RIA ISO 10218) and Annex I of Machinery Directive.

2.4 DEFNITION OF THE USER

The user can be classified as follows.

Collaborative worker

- Enter collaborative workspace, work with the robot
- Change the robot attitude by forcing robot directly, example push to escape function
- Restart the program with operator button set for collaborative worker.

Operator:

- Turns robot controller power ON/OFF
- Starts robot program from operator's panel

Programmer:

- Operates the robot
- Teaches robot inside the safety fence

Maintenance technician:

- Operates the robot
- Teaches robot inside the safety fence
- Maintenance (repair, adjustment, replacement)

Programmer and maintenance technician must be trained specialized training for the robot.

Collaborative worker that may contact to robot must be informed regularly about the risks, emergencies and necessary safety measures.

Table 2.4 (a) shows the workings to the collaborative robot. In this table, the symbol "○" means the working allowed to be carried out by the personnel.

Table 2.4 (a) List of workings to the collaborative robot

	Collaborative worker	Operator	Programmer or Teaching operator	Maintenance technician
Power ON/OFF for Robot controller		○	○	○
Select operating mode (AUTO/T1/T2)			○	○
Select Remote/Local mode			○	○
Select robot program with teach pendant			○	○
Select robot program with external device			○	○
Start robot program with operator's panel		○	○	○
Start robot program with teach pendant			○	○
Reset alarm with operator's panel			○	○
Reset alarm with teach pendant			○	○
Set data on the teach pendant			○	○
Teaching with teach pendant			○	○
Emergency stop with operator's panel	○	○	○	○
Emergency stop with teach pendant	○	○	○	○
Maintenance for operator's panel				○
Maintenance in for teach pendant				○
Enter collaborative workspace, work with the robot	○	○	○	○
Restart the program with operator button which is set for collaborative worker	○	○	○	○

The collaborative worker, programmer and maintenance technician take care of their safety using the following safety protectors as the need arises, for example.

- Adequate clothes, uniform, overall for operation
- Safety shoes
- Helmet
- Protective glasses

In addition, a user in this manual means collaborative worker, programmer, teaching operator and maintenance technician.

2.4.1 Robot Training

When people access the robot, the collaborative robot may move not stop. All people that may enter the area where the collaborative robots are placed, must be trained following training. For detailed information of training, please see "www.fanuc.com".

- The worker must be trained for the characteristic of the collaborative robot. The characteristic of the collaborative robot is described in the whole this manual. Especially, refer to 3.6 in particular.

- Collaborative worker, operator work with collaborative robot may contact with the collaborative robot. The workers must periodically trained for its danger and method to secure safety in emergency.

The programmer, teaching operator and maintenance technician must be trained for the robot operating and maintenance.
The required items are:

- Robot basic knowledge,
- Robot safety (laws, ordinances labor security hygiene rule, safety precautions)
- Practice of jog feed,
- Practice of robot manual operation and teaching
- Programming practice, teaching and playback practice,
- Practice of automatic operation,
- Explanation of configuration and function of robot,
- Explanation and practice of setting up frame,
- Explanation of interface between robot and peripheral device,
- Explanation and practice of initial setting,
- Explanation and practice of troubleshooting
- Explanation and practice of periodic checks and periodic replacement
- Explanation and practice of file input/output
- Explanation and practice of mastering, and
- Explanation and practice of disassemble and assemble of robots.

Some training courses for these items for the maintenance technician or system engineer are provided in the robot school and each technical service center. Contact your local FANUC representative

> ⚠ **WARNING**
> Robot operating personnel such as programmers, teaching operators or maintenance technicians must be trained properly according to the laws and regulations in the country or area where the robot is installed and used. Failure to follow appropriate procedures in or around the robot operationg space may cause very severe injury or even death.

2.4.2 Safety of the Working Person

Working person safety is the primary safety consideration. As it is very dangerous to enter the operating area of the robot during its automatic operation, adequate safety precautions must be observed.

The following lists the general safety precautions. Careful consideration must be made to ensure working person safety.

(1) We obligate the Working person to take a FANUC training courses.

FANUC provides various training courses. Contact your local FANUC representative for details.

(2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure working person safety, provide the system with an alarm to indicate visually or aurally that the robot is in motion.
(3) Implement the Risk assessment, if necessary, install a safety fence with a gate so that no working person can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to **"STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS** for detail of stop type). For connection, refer to below Fig. 2.4.2 (b).

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).
(5) Recommend to install the peripheral device outside of the work area.
(6) Draw an outline on the floor, clearly indicating the range of the robot motion, including the tools such as a hand.
(7) Implement the Risk assessment, if necessary, install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a working person enters the work area.
(8) If necessary, install a safety lock so that no one except the working person in charge can turn the power on the robot.

The circuit breaker installed in the controller is designed to disable anyone from turning it on when it is locked with a padlock.

(9) When adjusting each peripheral device independently, make sure to turn the power off the robot.
(10) Operators must take the gloves off while manipulating the operator's panel or teach pendant. Operation with gloved fingers may cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident. (Refer to Controller maintenance manual.)
(12) The robot must be transported and installed by accurate procedure recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When connecting the peripheral devices related to stop (safety fence etc.) and each signal (external emergency, fence etc.) of robot. Be sure to confirm the stop movement and do not take the wrong connection.
(16) In preparing the trestle, please secure the maintenance worker safety at high place in reference to Fig. 2.4.2 (c). Design with the Scaffolding and Safety harness with circumspection.

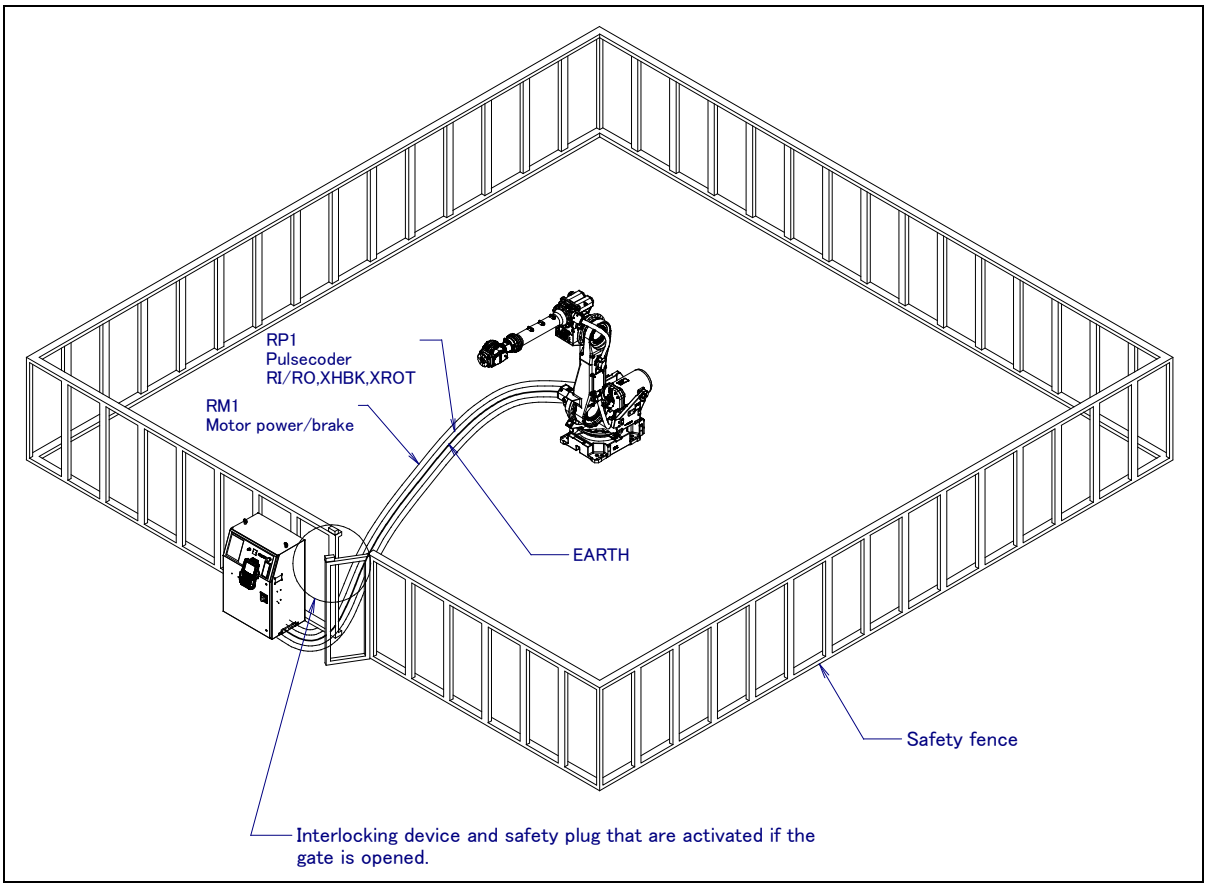


Fig. 2.4.2 (a) Safety fence and safety gate

⚠ WARNING

1 When you close a fence, Make sure that no one is around the robot in closing the safety fence.
2 After the door interlock switch is actuated, robot slows down and stops within 2 seconds, and then servo power is cut off. Before cutting off the servo power, never enter the safeguarded area (inside of safety fence, etc.).

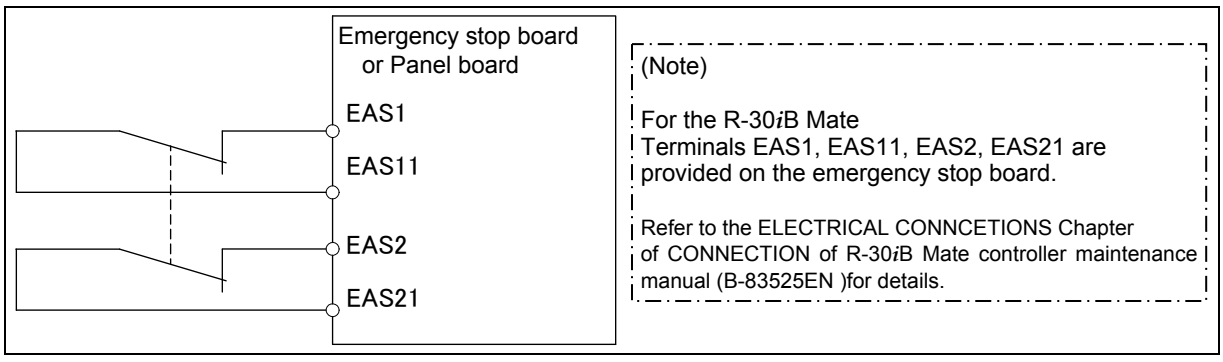


Fig. 2.4.2 (b) Connection diagram for the signal of the safety fence

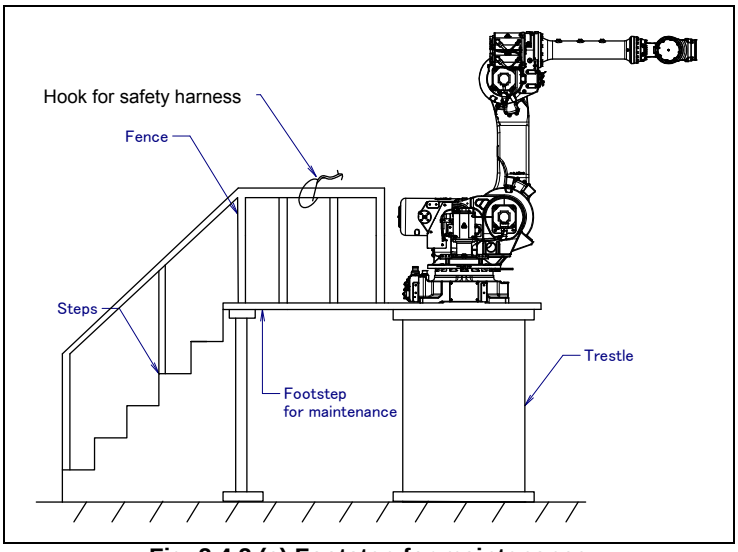


Fig. 2.4.2 (c) Footstep for maintenance

2.4.3 Safety of the Collaborative Worker

A collaborative workers indicates the personnel who work with collaborative robot, and if necessary, perform the start operation of the program with operator button for collaborative worker. Because they may contact with the collaborative robot, they must periodically be trained about its danger and securing safety method at emergency.

2.4.4 Safety of the Operator

An "**Operator**" indicates a person who turns on and off the power to the robot system, and starts ~~a robot~~ the program with operator's panel (in a daily operation.). Prohibit operators from working inside the safety fence.

(1) If you don't need to operate the robot, turn the power off the robot controller, or press the "**EMERGENCY STOP**" button, and then proceed your work.
(2) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and the worker from entering a hazardous area.
(3) Install one or more necessary quantity of EMERGENCY STOP button(s) within the operator's reach in appropriate location(s) based on the system layout.

The robot controller is designed to be connected to an external EMERGENCY STOP button. With this connection, the controller stops the robot operation (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type), when the external EMERGENCY STOP button is pressed. See the diagram below for connection.

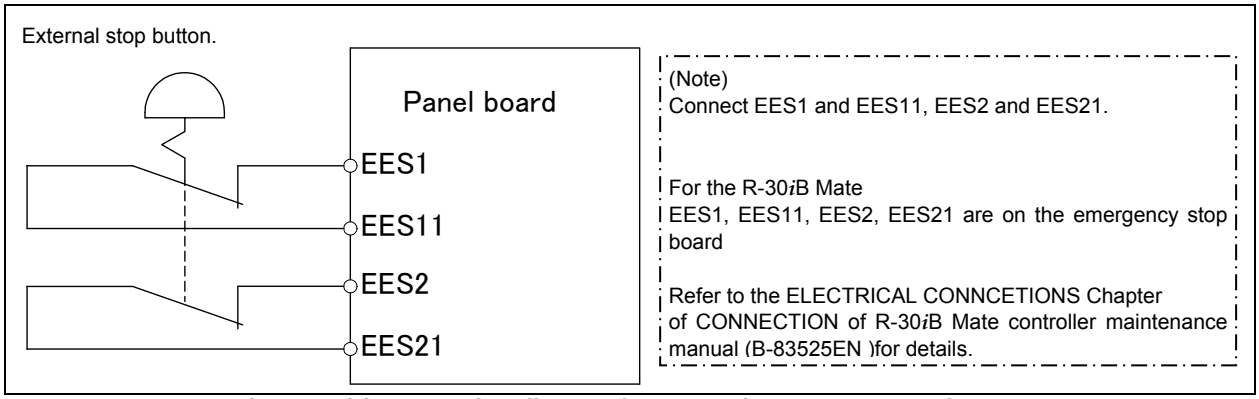


Fig. 2.4.4 (a) Connection diagram for external emergency stop button

2.4.5 Safety of the Programmer

While teaching the robot, the operator must enter the work area of the robot. Especially the teach pendant operator must secure own safety.

(1) Unless it is specifically necessary to enter the robot work area, carry out all tasks outside the area.
(2) Before teaching the robot, check that the robot and its peripheral devices are all in the normal condition.
(3) If it is inevitable to enter the robot work area to teach the robot, check the locations, settings, and other conditions of the safety devices (such as the EMERGENCY STOP button, the enabling device (DEADMAN switch) on the teach pendant) before entering the area.
(4) The programmer must be extremely careful not to let anyone else enter the robot work area.
(5) Programming must be done outside of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer must take the following precautions:
   - Before entering the safety fence area, ensure that there is no risk of hazardous situation in the area.
   - Be ready to press the emergency stop button whenever it is necessary.
   - Operate the Robot at low speed.
   - Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would harm working person.
(6) Operator must work under the condition of Contact Stop function activates.
(7) Required to deactivate the Contact Stop temporally, take measure to disseminate Contact Stop function deactivates.

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence.

Our teach pendant is provided with a enabling device (DEADMAN switch) as well as an emergency stop button. These button and switch function as follows:
(1) Emergency stop button : Causes the stop of the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type) when pressed.
(2) Enabling device (DEADMAN switch) : Functions differently depending on the teach pendant enable/disable switch setting status.
   (a) Enable: Servo power is turned off when the operator releases the enabling device (DEADMAN switch)D or when the operator presses the switch strongly.
   (b) Disable: The enabling device (DEADMAN switch) is disabled.
   Note) The enabling device (DEADMAN switch) is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B employs a 3-position enabling device (DEADMAN switch), which allows the robot to operate when the 3-position enabling device (DEADMAN switch) is pressed to its intermediate point. When the operator releases the enabling device (DEADMAN switch) or presses the switch strongly, the robot stops immediately.

The operator's intention of starting teaching is determined by the controller through the dual operation of setting the teach pendant enable/disable switch to the enable position and pressing the enabling device (DEADMAN switch). The operator should make sure that the robot could operate in such conditions and be responsible in carrying out tasks safely.

Based on the risk assessment by FANUC, number of operation of enabling device (DEADMAN switch) should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral device interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the enabling device (DEADMAN switch) of the operator panel, the teach pendant enable switch and the remote condition on the software.

In case of operating the robot as a collaborative robot without safety fence, there may be a possibility that robot will not stop even personnel approach. In that case, the robot will suspend when personnel contact.

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Ope rator panel	Peripheral device
AUTO mode	On	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed
	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
T1, T2 mode	On	Local	Allowed to start	Not allowed	Not allowed
		Remote	Allowed to start	Not allowed	Not allowed
	Off	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed

T1, T2 mode: Enabling device (DEADMAN switch) is effective.

(8) To start the system using the operator's panel, make certain that nobody is the robot work area and that there are no abnormal conditions in the robot work area.
(9) When a program is completed, be sure to carry out the test operation according to the following procedure.
  (a) Run the program for at least one operation cycle in the single step mode at low speed.
  (b) Run the program for at least one operation cycle in the continuous operation mode at low speed.
  (c) Run the program for one operation cycle in the continuous operation mode at the intermediate speed and check that no abnormalities occur due to a delay in timing.
  (d) Run the program for one operation cycle in the continuous operation mode at the normal operating speed, and check that the system operates automatically without trouble.
  (e) After checking the completeness of the program through the test operation above, execute it in the automatic operation mode.
(10) While operating the system in the automatic operation mode, the teach pendant operator must leave the robot work area.

2.4.6 Safety of the Maintenance Technician

For the safety of maintenance technician personnel, pay utmost attention to the following.

(1) Must never be in the area during its operation.
(2) A hazardous situation may occur when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system must be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.
(3) If it becomes necessary to enter the robot operation area while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the area. The maintenance personnel must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly. (Refer to Section 4.5.)
(4) When entering the area enclosed by the safety fence, the maintenance worker must check the entire system in order to make sure that there is no dangerous situation around. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire system status must be carefully monitored.

(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.
(6) Before teaching, check the robot and its peripheral devices are all in the normal condition.
(7) Do not operate the robot in the automatic mode while anybody is in the robot work area.
(8) Make certain that their escape path is not obstructed inside the safety fence, or the robot operation area. Provided, however, that the robot secure the operation as a collaborative robot.
(9) When a tool is mounted on the robot, or any moving device other than the robot is installed, such as belt conveyor, careful attention required for those motion.
(10) Assign an expert near the operator panel who can press the EMERGENCY STOP button whenever he sees the potential danger.
(11) In case of replacing a part, please contact your local FANUC representative. Wrong procedure may cause the serious damage to the robot and the worker.
(12) Make sure that no impurity into the system in while (in) replacing or reinstalling components.
(13) Turn off the circuit breaker to protect again electric shock in handling each unit or printed circuit board in the controller during inspection. If there are two cabinets, turn off the both circuit breaker.
(14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
(15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the work area and that the robot and the peripheral devices are not abnormal.
(16) In case of remove the motor or brake, suspend the arm by crane or other equipment beforehand to avoid falling.
(17) Whenever grease is spilled on the floor, remove them as soon as possible to prevent from falling.
(18) The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside of the controller
- Reducer
- Gearbox
- Wrist unit

(19) Maintenance must be done with appropriate lightning. Be careful that those lightning will not cause any further danger.
(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.
(21) Must never climb or step on the robot even in the maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
(22) Secure footstep and wear the safety belt in performing the maintenance work in high place.
(23) Remove all the spilled oil or water and metal chips around the robot in the safety fence after completing the maintenance.
(24) All the related bolts and components must return to the original place in replacing the parts. If some parts are missing or left (remained), repeat the replacement work until complete the installation.
(25) In case robot motion is required during maintenance, the following precautions should be taken :
- Secure an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Keep vigilant attention for the potential danger. and to press the emergency stop button whenever it is necessary.

(26) Periodic inspection required. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can may adversely affect the performance or service life of the robot and may cause an accident
(27) After replacing some parts, a test run required by the predetermined method. (See TESTING section of "Controller operator's manual". During the test run, the maintenance staff must work outside the safety fence as the need arises.
(28) Make certain that their escape path is not obstructed inside the safety fence, or the robot operation area. Provided, however, that the robot secure the operation as a collaborative robot.

2.5 RELEVANT STANDARDS

FANUC robot series meets following standards.

[For CE marking : Machinery/Low voltage Directives]
- EN ISO 10218-1
- EN 60204-1
- EN/ISO 13849-1 (EN 954-1)

[For NRTL]
- UL 1740
- CAN/CSA Z434
- CSA C22.2 No.73

NOTE
For ISO 13849-1 (EN954-1), the following safety categories have been applied.

Controller model	Emergency stop	Dual Check Safety (optional functions)			Applied standard
		Position/Speed check	Safe I/O connect	Safety Network	
R-30*i*B Mate, R-30*i*B Mate Plus	Cat.4 PL e SIL 3	Cat.3 PL d SIL 2	Cat.4 PL e SIL 3		EN ISO 13849-1:2015

Controller model	Collaborative robot function (Collaborative robot safety function)	Applied standard
R-30*i*B Mate, R-30*i*B Mate Plus	Cat.3 PL d	EN ISO 13849-1:2015

[CE marking : For EMC Directive]
- EN 55011 (Group 1, Class A)
- EN 61000-6-2

For the above standards, FANUC robot systems have been certified by the following third parties (TÜV Rheinland Japan).
- CE marking : TÜV Rheinland Japan
- NRTL : TÜV SÜD America

3 ROBOT SYSTEM DESIGN

In this chapter, requirements for robot system design are described.
- Placement of Equipment
- Power Supply and Protective Earth Connection
- Other Precautions

In addition, the basic requirements for end effector, workpiece, and peripheral equipment are outlined in 3.5. The characteristic of collaborative robot are outlined in 3.6.
About the safety fence, safety gate and other protection devices, refer to Section 4.5 to 4.7.

Collaborative robot applications are different from traditional robot systems because of the capability of the robot to operate in close proximity to a person in the robot's operating space without an enabling device. Guidance in ISO 10218-2 (ANSI/RIA R15.06-2012) should be followed in the construction of the robot system using collaborative robots.

In ISO10218-2, carrying out risk assessment (a dangerous evaluation) for the whole robot system is demanded.

Depending on a result of the risk assessment (a dangerous evaluation), please carry out appropriate safe protection plan to reduce the risk that a person injures.

3.1 GENERAL

The robot system must be designed, constructed, and implemented so that **in case of a foreseeable failure of any single component, whether electrical, electronic, mechanical, pneumatic, or hydraulic, safety functions are not affected or when they are, the robot system is left in a safe condition ("Failure to safety").**

Under the intended conditions of use, the discomfort, fatigue and psychological stress faced by the operator must be reduced to the minimum possible, taking into account ergonomic principles such as:
- allowing for the variability of the collaborative worker and operator's physical dimensions, strength and stamina,
- providing enough space for movements of the parts of the collaborative worker and operator's body,
- avoiding a machine-determined work rate,
- avoiding monitoring that requires lengthy concentration,
- adapting the man/machinery interface to the foreseeable characteristics of the collaborative worker and operators.

The application of the electrical equipment of the robot system must be accordance with IEC/ EN60204-1 or NFPA70/NFPA79.

3.2 PLACEMENT OF EQUIPMENT

Please make sure the following requirements are all satisfied for each component of a robot system.

- Be sure to perform the risk assessment and be sure to design the appropriate safeguarding measures.

- If the result of risk assessment requires safety fence/guard, Appropriate safety fence/guard must be placed according to safety standard.Directive. Please refer to section 3.5 and 3.6 for the basic requirement of the safety fence/guard and protection devices.

- As the need arises, the additional space are required beyond the restricted space to define the safeguarded space.

- The operator panel must be located at a safe place:
  - outside the safety fence, and cannot be reached from inside the safety fence, if the robot system has safety fence.
  - where it can be easily seen, and easily operated by the operator,
  - where the operator can operate it without hesitation or loss of time and without ambiguity,
  - where collaborative worker or operator can confirm the emergency stop button easily and can operate it easily, and
  - where no dangerous situation is created by operating it.

- If the robot controller is placed inside or near the robot operating space, the distance between the maintenance space of robot controller and robot operating space should be sufficient(over 1.22m from the opening section of robot controller, or opening section of robot controller is placed to opposite direction of robot operating space.

- The operating position must be designed and constructed in such a way as to avoid any risk due to exhaust gases and/or lack of oxygen.

- If the robot system is intended to be used in a hazardous environment presenting risks to the health and safety of the collaborative worked and operator or if the robot system itself gives rise to a hazardous environment, adequate means must be provided to ensure that the operator has good working conditions and is protected against any foreseeable hazards.

- Where appropriate, the operating position must be fitted with an adequate cabin designed, constructed and/or equipped to fulfill the above requirements. The exit must allow rapid evacuation. Moreover, when applicable, an emergency exit must be provided in a direction which is different from the usual exit.

- A large space must be secured around each component enough for the maintenance and inspection of the robot system.

- The robot system must be designed and constructed in such a way as to allow access in safety to all areas where intervention is necessary during operation, adjustment and maintenance.

- The space inside or near the robot operating space for maintenance and inspection, must be designed to protect the user from falling off or slipping off the step, and where appropriate, handholds that are fixed relative to the operator and that enable them to maintain their stability should be prepared.

- The robot system must be secured on a stable floor. Especially the robot mechanical unit must be attached to the stable place according to the instructions in the maintenance manual or operator’s manual.

- The robot system must be designed to avoid trapping and collision between the moving parts of the robot and other fixed or moving objects.

- The layouts must be designed in such a way that between moving parts of the robot and objects in the environment (e.g. pillars of the structure, ceiling joists, fences, supply leads) sufficient clearance is available.

- When T2 mode is used, the following clearance is required for robot system installation.
  - 0.5m or more from readily accessible areas of buildings, structures, utilities, other machines and
    equipment not specifically supporting the robot function that may create trapping or a pinch point

  Where this minimum clearance is not provided, additional safeguarding devices is required.
  - Stop robot motion while personnel are within 0.5m of the trapping or pinch hazard

  If these actions are not applied, it may cause injury of the users.

- When a limitation of the restricted space, by limiting the range of motion of the primary axes (J1, J2, J3-axes), is required by the plan, limiting devices must be provided. They should not injury to a person and must comply with one of the following.
  - Mechanical stopper which are capable of stopping the robot at any adjusted position when it is carrying its rated load at maximum velocity.
  - About J2/J3-axes, alternative methods of limiting the range of motion may be provided only if they are designed, constructed, and installed to achieve the same level of safety as the mechanical stoppers.
    This may include using DCS or the robot controller and limit switches according to IEC/EN 60204-1 or NFPA70/NFPA79.

  Note that the limiting devices must be correctly adjusted and secured.

- When it is intended that collaborative worker or operators will perform manual operations associated with the robot, such as loading and unloading of parts, this must be taken into account in the arrangement of the robot system, either by providing part loading devices so that the operator cannot access the hazardous area, or by providing appropriate safeguards for the manual activity.

- Where appropriate and where the working conditions so permit, work stations constituting an integral part of the robot system must be designed for the installation of seats.

- The operator’s seat must enable him or her to maintain a stable position. Furthermore, the seat and its distance from the operator's panel must be capable of being adapted to the operator.

- If the robot system is subject to vibrations, the seat must be designed and constructed in such a way as to reduce the vibrations transmitted to the operator to the lowest level that is reasonably possible. The seat mountings must withstand all stresses to which they can be subjected, where there is no floor beneath the feet of the operator, footrests covered with a slip-resistant material must be provided.

- On transportation of robot mechanical unit or controller, proper transportation procedure described on operator’s or maintenance manual for each models has to be followed.

> ⚠ **WARNING**
> Follow the procedure specified by FANUC when transporting the robot mechanical unit or controller. Otherwise, it may fall over due to the loss of the mechanical stability (balance), resulting in serious injury or death of personnel.

3.3 POWER SUPPLY AND PROTECTIVE EARTH CONNECTION

- The power supply and the grounding must be connected according to the maintenance manual.

- Unsafe conditions must be avoided in the event of a power down, power recovery after a power down or supply voltage fluctuations. Unsafe conditions to be avoided are ;
  - Dropping workpiece or any material,
  - Safety equipment not functioning, etc.

> ⚠ **WARNING**
> Dropping workpiece or any material may result in personal injury.

- The robot system must have means to isolate its power sources. These means must be located in such a way that no person will be exposed to any hazard, as well as must have a lockout/tagout capability.

> ⚠ **WARNING**
> The robot mechanical unit and controller have to be properly connected by PE (Protective Earth). Without PE connection, electric shock can occur.

3.4 OTHER PRECAUTIONS

- Shutdown (removal of power) to the robot system or any peripheral equipment must not result in a hazardous condition.

- All environmental conditions must be evaluated to ensure compatibility of the robot and the robot system with the anticipated operational conditions. These conditions include, by are not limited to, explosive mixtures, corrosive conditions, humidity, dust, temperature, electromagnetic interference (EMI), radio frequency interference (RFI), and vibration.

- The control position where the operator stands must be predetermined.
  The control position must satisfy the following conditions.
  - The operator can easily operate the operator panel or the teach pendant.
  - The operator can easily make sure that nobody is inside or near the robot operating space or inside the safety fence (if safety fence is placed).
  - The operator can easily verify the operation of the system.
  - The operator can immediately stop the entire or partial system in the event a malfunction of the system or any dangerous condition.

- The following safety measure must be used if the operator cannot easily verify nobody is inside the safety fence, or as required by the risk-assessment result.
  - A visible/audible warning (complying EN/ISO/IEC standards or OSHA) is used before robot starts moving.
  - A measure for the collaborative worker inside or near the robot operating space to stop the robot system or a measure for the person to evacuate outside the robot operating space.
  - The control system is designed and constructed in such a way that starting is prevented while someone is in the danger zone.

- If necessary, means must be provided to ensure that the robot system can be controlled only from control positions located in one or more predetermined zones or locations.

- Where there is a more than one control position, the control system must be designed in such a way that the use of one of them precludes the use of the others, except for stop controls and emergency stops.

- When the robot system has two or more operating positions, each position must be provided with all the required control devices without the operators hindering or putting each other into a hazardous situation.

- The manual intervention and reset procedure to restart the robot system after an emergency stop must take place outside the restricted space.

- A warning device must be such that the operator and people in dangerous area can easily recognize it.

- For UL standard compliance, "a yellow or amber visual indicator" specified by CL 36.1 of UL 1740 was to be installed by the end-user or system manufacturer. SYSRDY or PROGRUN output signals are available for installing such a visual indicator.

- The area must be appropriately lighted, especially for maintenance and inspection.
  The lighting must not create a new dangerous situation (e.g. dazzled).

> ⚠ **CAUTION**
> Operation inside of the safety fence (teaching, maintenance, etc.) without suitable ambient lighting can cause hazards of collision (with some obstacles inside of the safety fence) or slipping/falling down of personnel.

- It is recommended that adjustment, greasing or oiling, and other maintenance work can be performed from outside the dangerous area while the system is stopping.
  If it is not feasible, a method to perform these operations safely must be established.

- If the robot and the peripheral equipment synchronously move in the robot system, an appropriate measure must be provided to avoid unsafe condition by stopping the entire system in the event any of the equipment stops due to malfunction.

- Any robot that can be controlled from a remote location must be provided with an effective means that must prevent hazardous conditions of the robot being initiated from any other location.

- It is recognized that for certain phases of the robot system life (e.g. commissioning, process changeover, cleaning, and maintenance) it may not be possible to design completely adequate safeguards to protect against every hazard or that contain safeguards may be suspended.
  Under these conditions, appropriate safe working procedures must be used.

- A robot system manufacturer must provide an operation manual according to EN ISO 10218 etc.

- Requirements of each safety standard (EN ISO, IEC, JIS etc.) and labor security hygiene rule must be considered when a robot application system is designed.

- Keep the component cells of the robot system clean, operate the robot where insulated from the influence of grease, water, and dust.

- Don't use unconfirmed liquid for cutting fluid and cleaning fluid.

- Adopt limit switches or mechanical stoppers to limit the robot motion, and avoid the robot from collisions against peripheral devices or tools.

- Observe the following precautions about the mechanical unit cables. Failure to follow precautions may cause mechanical troubles.
  - Use mechanical unit cable that have required user interface.
  - Do not add user cable or hose to inside of mechanical unit.
  - Please do not obstruct the movement of the mechanical unit cable when cables are added to outside of mechanical unit.
  - In the case of the model that a cable is exposed, Please do not perform remodeling (Adding a protective cover and fix an outside cable more) obstructing the behavior of the outcrop of the cable.
  - When installing user peripheral equipment on the robot mechanical unit, please pay attention that equipment does not interfere with the robot itself.

- The frequent power-off stop for the robot during operation causes the trouble of the robot. Please avoid the system construction that power-off stop would be operated routinely. (Refer to bad case example.) Please execute power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type.)
  (Bad case example)
  - Whenever poor product is generated, a line stops by emergency stop and power-off of the robot is executed.
  - When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed for the robot during operation.
  - An operator pushes the emergency stop button frequently, and a line stops.
  - An area sensor or a mat switch connected to safety signal operate routinely and power-off stop is executed for the robot.
  - Power-off stop is regularly incurred due to an inappropriate setting for Dual Check Safety (DCS).

- Power-off stop of Robot is executed when collision detection alarm (SRVO-050) etc. occurs. Please try to avoid unnecessary power-off stops. It may cause the trouble of the robot, too. So remove the causes of the alarm.

- Operating the robot in the jog mode, set it at an appropriate speed so that the operator can manage the robot in any eventuality.

- Before pressing the jog key, be sure to comprehend the robot movement by the key in advance.

3.5 END EFFECTOR, WORKPIECE AND PERIPHERAL EQUIPMENT

It is the responsibility of the robot system manufacturer to perform the risk assessment of the end effector, workpiece and peripheral equipment.

This section outlines the basic requirement for the risk assessment of these components.

End Effector

- End effectors must be designed and constructed, or safeguarded, so that
  - Power failure does not cause release of the load (workpiece) or result in a hazardous condition.
  - The static and dynamic forces created by the load (workpiece) and the end effector together are within the load capacity and dynamic response of the robot.
  - Shape or motion of the end effector does not harm the personnel.

- We recommend to protect the hard part with sponges, and relax the force when the personnel contact it.

- If it is equipped with a tool where it performs operations under different conditions of use, it must be designed and constructed in such a way that selection and adjustment of these conditions can be carried out safely and reliably.

Workpiece

- The material and its shape must not be dangerous and if unsafe, safety measures must be provided.

- If the workpiece is in extreme high or low temperature, safety measures must be provided to avoid personnel from touching or getting too close to it.

> ⚠ **WARNING**
> Dropping workpiece or any material may result in personal injury.

Peripheral Equipment (including end effector)

- The material and shape must not be dangerous.

- If any component could break down during operation, it must be placed so that it will not scatter if it breaks down.

- Pipes (for liquid/gas) must have enough strength for its internal / external pressure.

- Pipes must be secured and protected from the external pressure or tension.

- Be sure to provide measures to avoid a dangerous situation if a pipe is broken causing sudden movement of the pipe or the high speed flow of material.

- If a pneumatic device is used, be sure to install an air valve which shuts off the air supply to the robot.

- If a power source other than the electricity (e.g. pneumatic, water, heat) is used in the system, be sure to perform appropriate risk-assessment, and be sure to provide appropriate safety measures.

- Be sure to provide safety measures to avoid swapping of components that cause unsafe conditions, by
  - design to avoid mount mistakes,
  - indication of necessary information on the parts.

- Be sure to provide safety measures to avoid inferior contacts, by
  - design,
  - displaying the information on the connectors, pipes and cables.

- Be sure to provide safety measures to avoid an unsafe condition by touching an extremely high/low temperature parts (if any).

- Be sure to provide safety measures to avoid fire or explosion through sufficient amount of investigation.

- Vibration and sound noise must be kept to a minimum.

- For place where personnel may contact, get rid of sharp points and rough surfaces, because those may harm personnel by contact.

- If a laser equipment is used, the following must be considered.
  - avoid unexpected emission of laser light
  - direct/indirect emission of light must give no harm to the health
  - laser light must give no harm to health during maintenance / adjustment.

3.6 THE CHARACTERISTIC OF COLLABORATIVE ROBOT AND LIMITATIONS AND USAGE NOTES

This section describes that the characteristic of collaborative robot and limitations and usage notes.
Refer to OPERATOR'S MANUAL (Collaborative Robot Function)(B-83744EN) about the detail of each function.

CONTACT STOP FUNCTION

- When the external force exceeds the active force limit, the robot stops. Example, when a person contacts to robot and big external force add to robot, the robot stops. This function does not guarantee safety in the all situation. The notice must be followed and additional appropriate safeguarding measures must be placed as the need arises.

- There is a function which resume the program automatically after contact stop. If this function is effective, Even if the robot stops, program is restarted automatically when required condition is met.

> ⚠ **WARNING**
> Motion groups other than Collaborative robot are outside of the scope of the contact stop function. If a person comes into contact with the motion group other than Collaborative robot, a serious personal injury could result. If the robot system is designed to include the motion group other than Collaborative robot, adequate risk assessment for the whole robot system is necessary to verify that the motion group other than Collaborative robot are outside of the scope of the contact stop function.

- When a person contacts to the parts of robot showed in Fig. 3.6 (a), the robot doesn't stop.

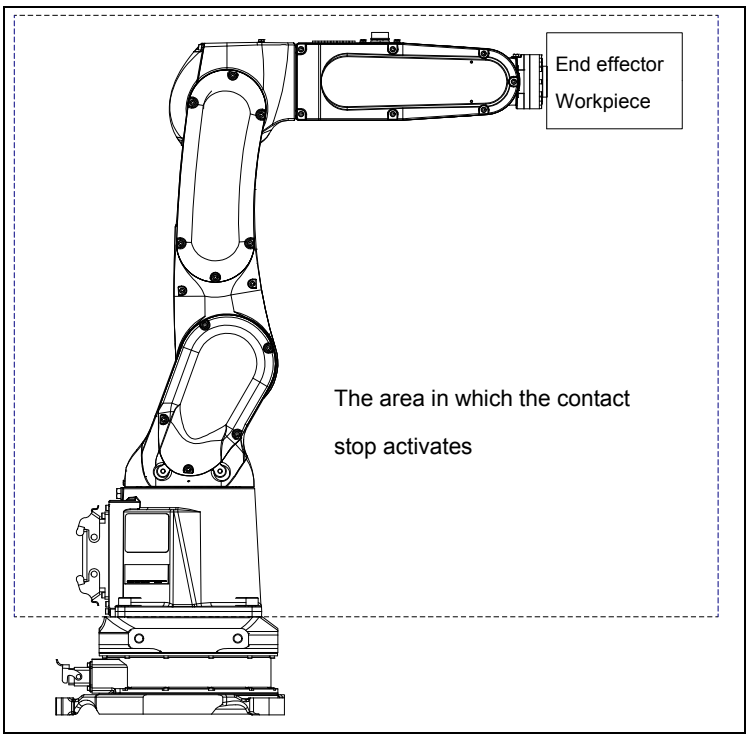


Fig 3.6 (a) Contact stop parts of robot

GUIDANCE FOR EXTERNAL FORCE LIMIT AND MOTION SPEED

- Risk assessment is required to determine the external force limit which is appropriate for the application and possible person/robot/tooling contact. A default value of external force limit is 70N (CR-4*i*A, CR-7*i*A, CR-7*i*A/L) or 90N (CR-14*i*A/L) and the maximum setting is 150N.

- Be sure to set external force limit and motion speed in order to prevent injury caused by the force of contact to human body as determined by the risk assessment. In case of CR-4*i*A, CR-7*i*A, CR-7*i*A/L, please note that a default value of collaborative motion speed is 500mm/s, and the maximum setting value is 1000mm/s (The maximum setting value is 500mm/s when software version is before 7DC3/42 or 7DF1/14.). In case of CR-14*i*A/L, please note that a default value of collaborative motion speed is 400mm/s, and the maximum setting value is 500mm/s. For reference, acceptable motion speed for body regions are shown below.

Acceptable motion speed for body regions

Body region	Acceptable motion speed (mm/s)	
	CR-4*i*A, CR-7*i*A, CR-7*i*A/L	CR-14*i*A/L
Skull, Forehead, Face, Neck	Not applicable	
Lower legs	Not applicable	
Arms, Hands, Fingers	1000	500
Body region excluding the above region	500	400

- When the robot operates at the speed corresponding to body regions, please use so that other body regions never touch the robot. Below are examples of system that restricts body regions of the human in contact with the robot.

> ⚠ **WARNING**
> If the acceptable motion speed corresponding to body regions is not kept, this may result in personal injury.

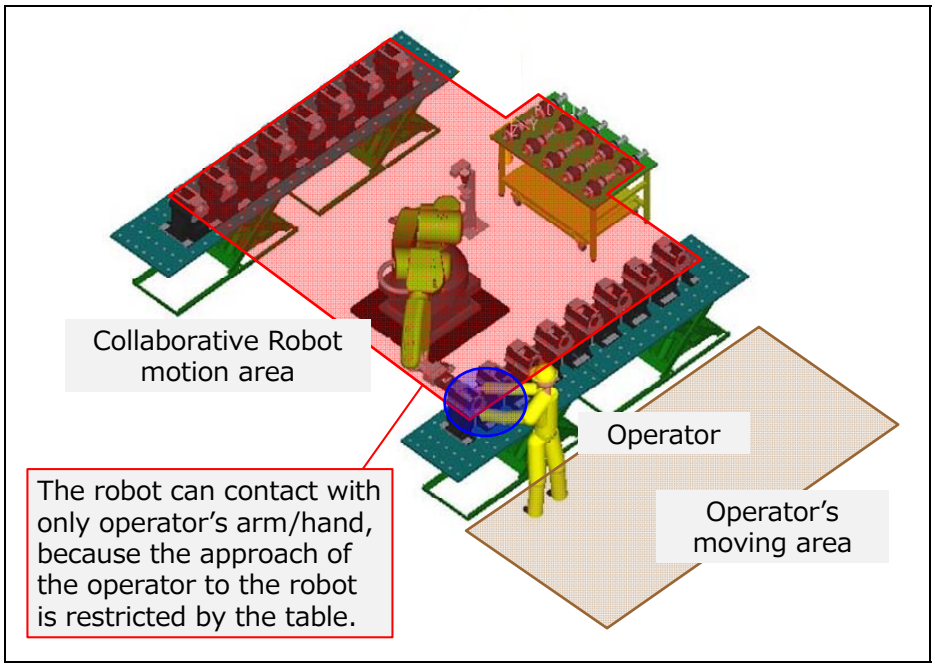


Fig. 3.6 (b) Example of system

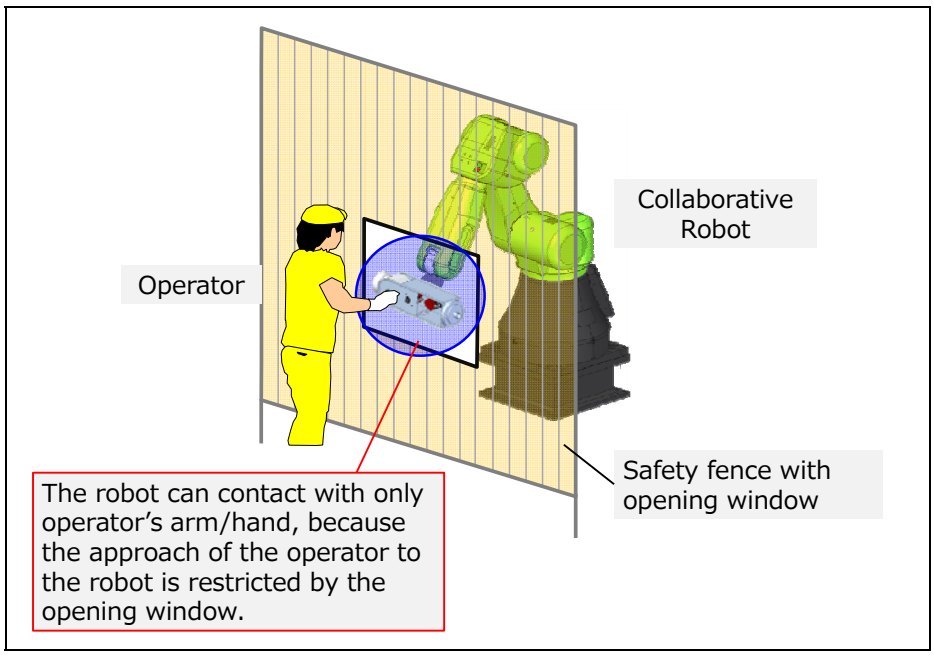


Fig. 3.6 (c) Example of system

RESTART AFTER CONTACT STOP

- Restart by the switch and others installed on or near the robot is possible. In that case, be sure to install the emergency stop button near the restart switch. (If the switches on the robot are used as restart switch, be sure to install the emergency stop button to the position that is near the robot and accessed easily

PUSH TO ESCAPE

- When a person pushes the robot, the robot escapes. Only J1 axis and J2 axis can respectively escape by pushing. The robot stops after certain distance escape. In this case, release your hand for a moment and push again. When the robot escapes, the attitude of TCP changes.

RETREAT AFTER CONTACT STOP

- When the robot was stopped by the contact stop and if strong force to robot remains, the robot will retreat slightly.

NOTE TO DESIGN THE COLLABORATIVE WORKSPACE

When the designer of a robot application system design the workspace where person work near robot, the designer must follow the following notes.

> ⚠ **WARNING**
> Pinching between the robot and the other object (wall, floor, etc.) may result in personal injury.

- The space where a person escapes at contacting to robot must be placed between collaborative workspace and wall, floor, etc. If the space can't be placed, the robot system must be designed to use additional appropriate safeguarding measures. Example, when a person access to dangerous space, the robot stops.

- The following countermeasure is effective as a measure to reduce the generation force when pinching between the robot and the other object.
  - Reduce the robot's motion speed near the place where pinching is occurred.
  - Cover the object or the table with a soft material because the lower the rigidity of the contact point becomes, the smaller the generated force becomes.

> ⚠ **WARNING**
> The robot may not stop when a body part bigger than upper limbs is clamped between the robot arms under the situation where the operator cannot move. This may result in personal injury.

- The example of body part bigger than upper limbs are head, trunk, leg. The robot system must be designed to avoid clamping these body parts.

- The collaborative workspace shall be marked appropriately. (floor marking, signs, etc.)
  Access or admittance restrictions shall be marked be placement of appropriate signs, such as "Active Robotic Collaborative workspace; authorized persons only", "Caution, robot can move at any time".

- Untrained (according to Subsection 2.4.1) people must not enter collaborative workspace.

- The ambient working space in which people may collide with the collaborative robot shall be arranged so they can move safely.

> ⚠ **WARNING**
> Inappropriate collaborative workspace may result in personal injury.

INDICATION OF COLLABORATION MODE

- The visual indication, for example lamp, indicating that the robot is in collaborative operation is necessary. Install collaboration mode LED (standard option) A05B-1701-K061 to K064 or the switch box A05B-1701-K071 on the robot or near the robot so that it lights up during collaboration mode. Depending on the system, install it in a place where collaborative workers can see.

> ⚠ **CAUTION**
> When using a collaborative robot, be sure to install and light the Collaboration Mode LED.

For collaboration mode LED, refer to Subsection 3.6.1. For the switch box, refer to Subsection 3.6.2.

WORKING NOTE INSIDE THE COLLABORATIVE WORKSPACE

- Please don't put any objects on the robot. Foreign objects may cause an improper detection of the external contact seen by the robot. (the objects they are installed to equipment mounting surface and appropriate load setting is performed are no problem)

- When people enter the collaborative workspace, please take care of their safety using the personal protective equipment (helmet, safety shoes, protective glasses etc.), as the need arises.

PROTECT OF HEAD, NECK

> ⚠ **WARNING**
> An impact force to the head or neck from contact with the robot may cause death or heavy injury of the users.

- The robot system must be designed not to contact robot to head or neck of person with frequency.

> ⚠ **WARNING**
> If a part of body is pinched, it might cause heavy injury.

- Please do not operate the robot with putting your hands on the following parts. (Refer to Fig. 3.6 (d), (e))

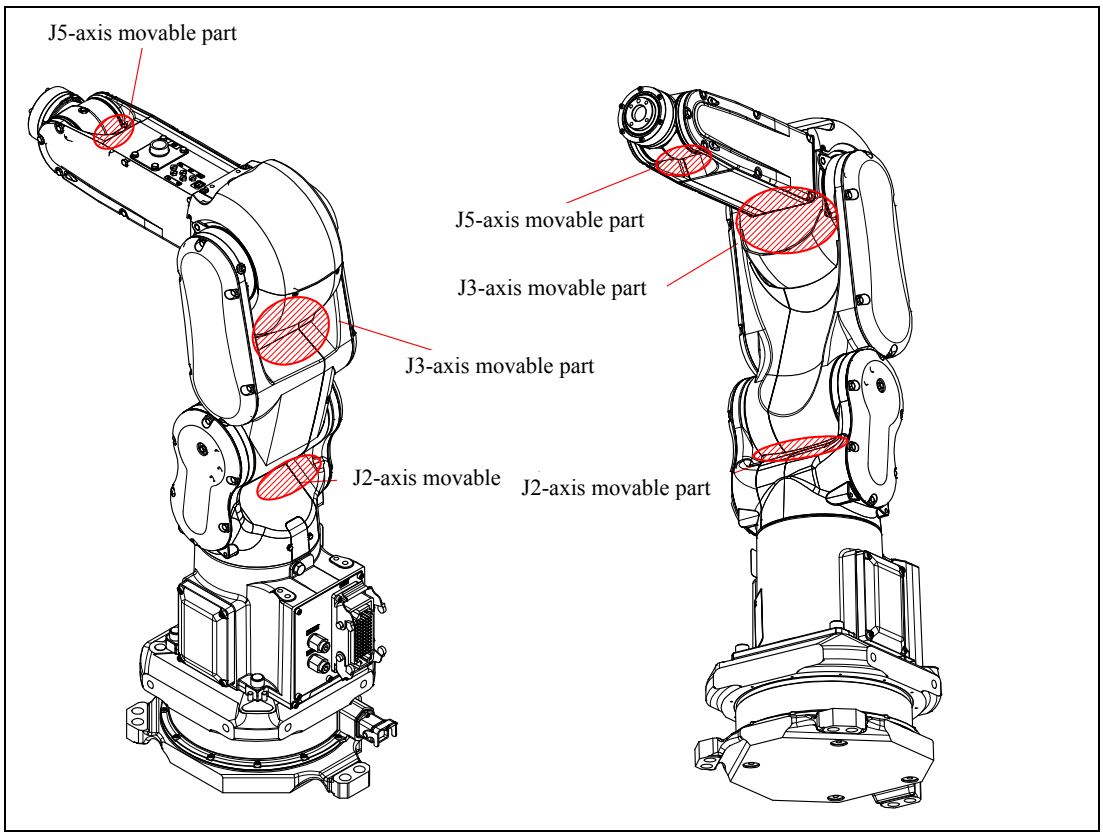


Fig. 3.6 (d) Note place for pinching (CR-4*i*A)

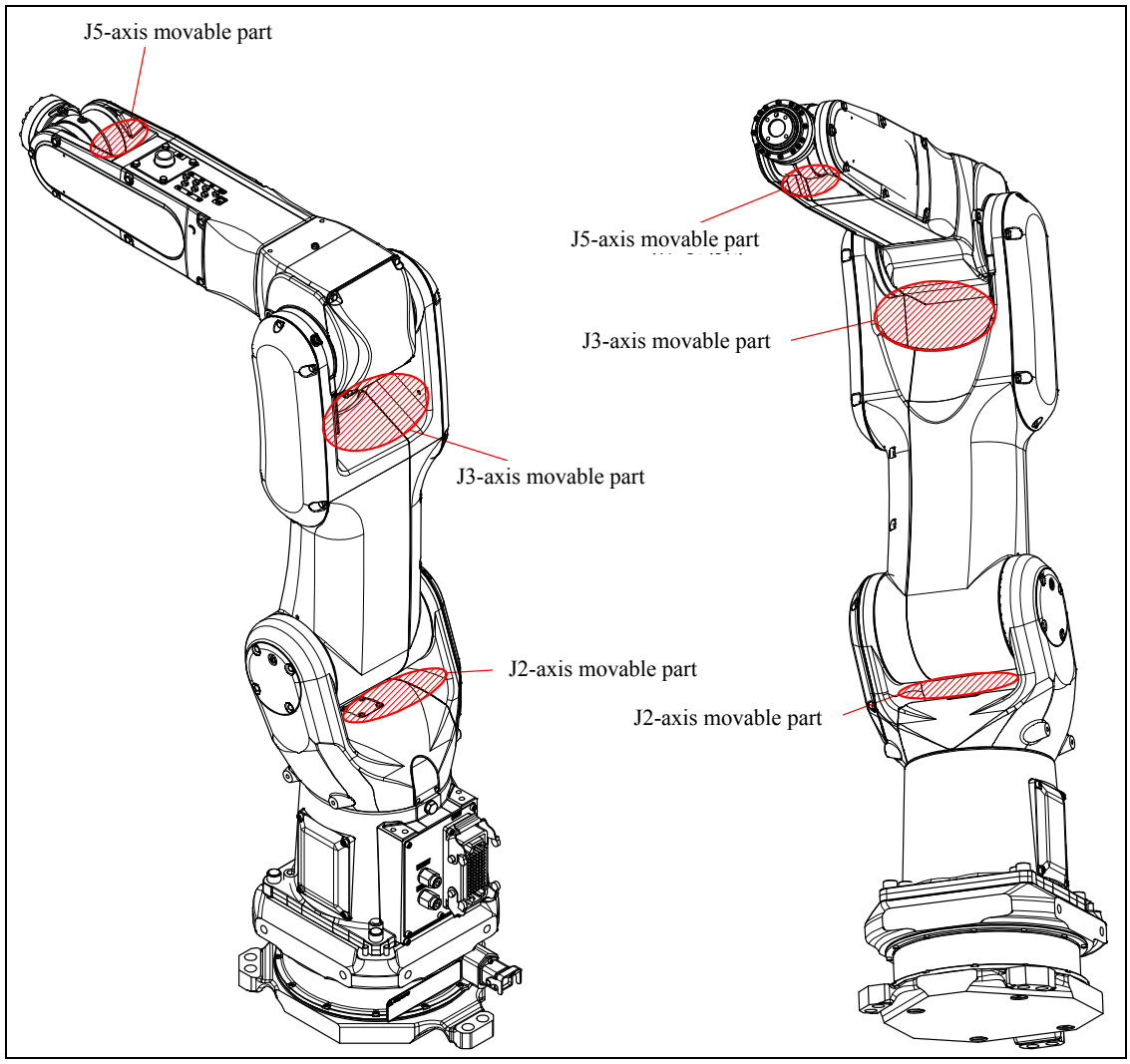


Fig. 3.6 (e) Note place for pinching (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

EXTERNAL FORCE AGAINST THE ROBOT

- If force generated from the end effector, force of pushing direction or pulling direction generated from the cables and hoses connected to the end effector exceeds the restriction value of the external force Design a system during considering to avoid force mentioned above is applied to the robot. For information of the external force and load monitoring method, refer to Subsection 4.2.2 “Payload Monitor” of the OPERATOR’S MANUAL (Collaborative Robot Function) (B-83744EN).

HIGH SPEED MODE

- The maximum speed in collaborative mode is determined by system risk assessment (CR-4*i*A, CR-7*i*A, CR-7*i*A/L : maximum 1000 mm/s, CR-14*i*A/L: maximum 500mm/s), but in high speed mode (contact stop function disabled) the robot can move up to 1000 mm/s (CR-4*i*A, CR-7*i*A, CR-7*i*A/L) or 500mm/s(CR-14*i*A/L). If the robot is operated in high speed mode (contact stop function disabled), risk assessment for traditional robot (no-collaborative) is required and additional appropriate safeguarding measures is required as the need arises. In this case, safety protection measures are basically the installation of safety fences, but based on the risk assessment results depending on the system, other measures may be necessary.

- Contact stop function is not available with this mode.

3.6.1 Collaboration Mode LED

Connect the collaboration mode LED to the I/O device according to the following table. Stick terminal (Φ0.8mm, length 8mm) is attached on the end of the collaboration mode LED cable. Use I/O devices which connectable to this shape. Rating of LED is 17mA-24V, used voltage is 24V±10%. Use the I/O device which satisfy this condition.

Table 3.6.1 (a) Collaboration mode LED wiring

Wire mark	Color	I/O device access point
24V	Red	DO (24V±10%)
0V	Green	GND

- Fig. 3.6.1 (a) shows dimension of collaboration mode LED. Fig. 3.6.1 (b) shows an example of a mounting plate to be attached to the J1 base, and a mounting.

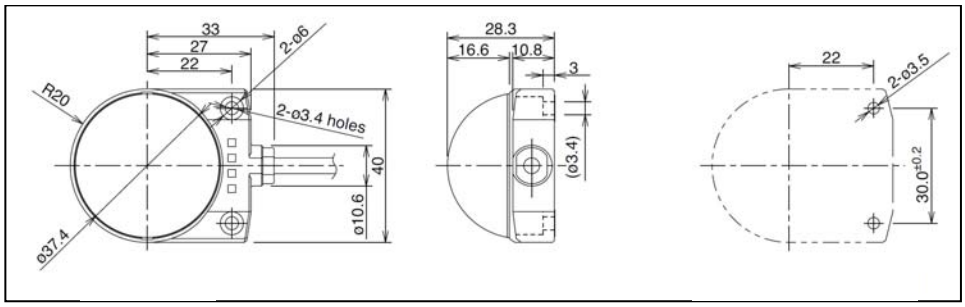


Fig. 3.6.1 (a) Dimension of Collaboration Mode LED

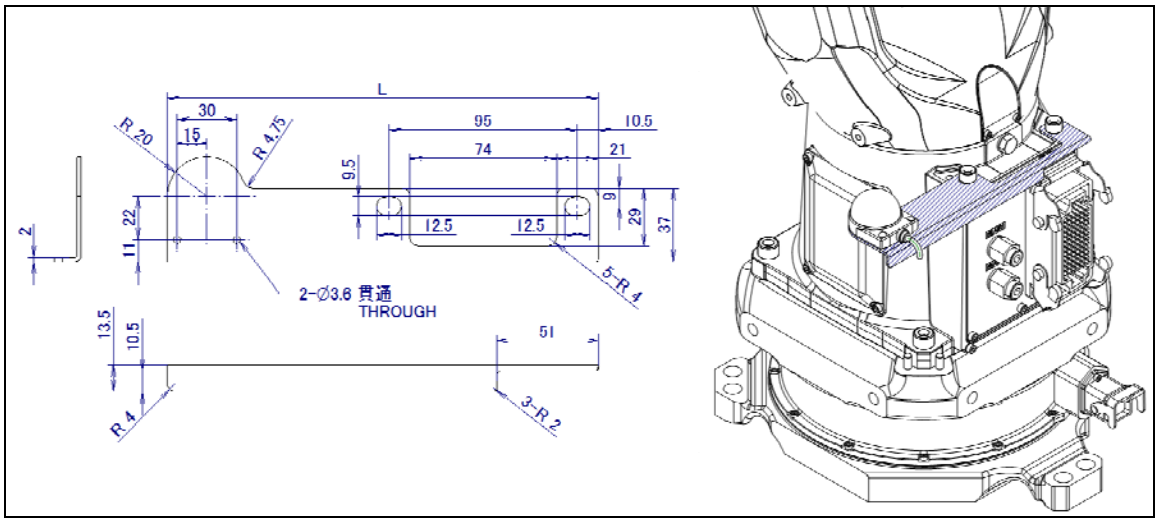
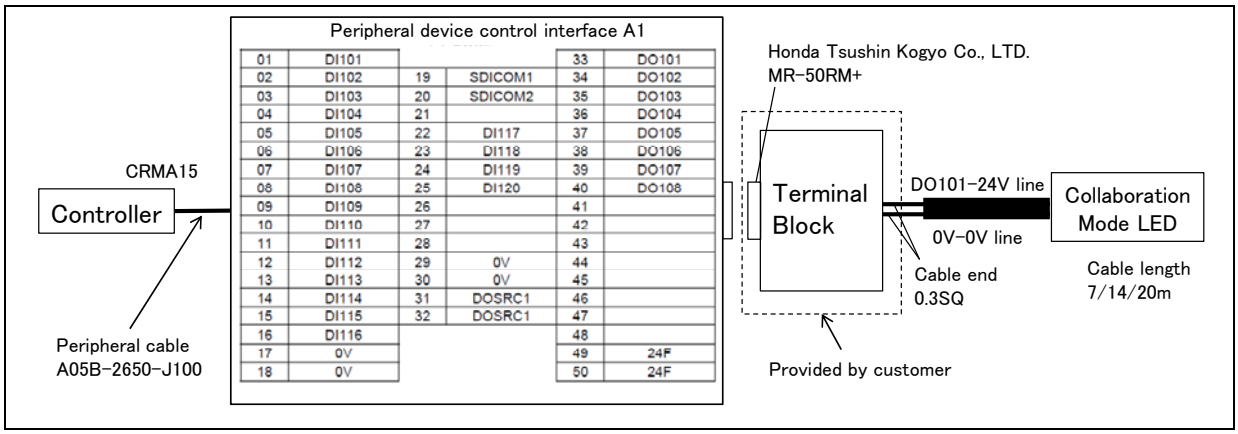


Fig. 3.6.1 (b) Example of a mounting plate to be attached to the J1 base, and a mounting (Applied model CR-4*i*A, CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

- Fig. 3.6.1 (c) shows an example of collaboration mode LED connection. Use the DO signal to light the LED. Refer to section 2.3 of OPERATOR'S MANUAL (Collaborative Robot Function) (B-83744EN) for how to set the signal. Also, ensure the waterproof measures as necessary for the terminal block connecting part.



01	DI101			33	DO101
02	DI102	19	SDICOM1	34	DO102
03	DI103	20	SDICOM2	35	DO103
04	DI104	21		36	DO104
05	DI105	22	DI117	37	DO105
06	DI106	23	DI118	38	DO106
07	DI107	24	DI119	39	DO107
08	DI108	25	DI120	40	DO108
09	DI109	26		41	
10	DI110	27		42	
11	DI111	28		43	
12	DI112	29	0V	44	
13	DI113	30	0V	45	
14	DI114	31	DOSRC1	46	
15	DI115	32	DOSRC1	47	
16	DI116			48	
17	0V			49	24F
18	0V			50	24F

Fig 3.6.1 (c) Example of Collaboration Mode LED connection

3.6.2 Switch box

There are two methods to use the switch box.

- Method by connection to the CRMA52 connector of the process I/O board MA
- Method by connection to the general-purpose device

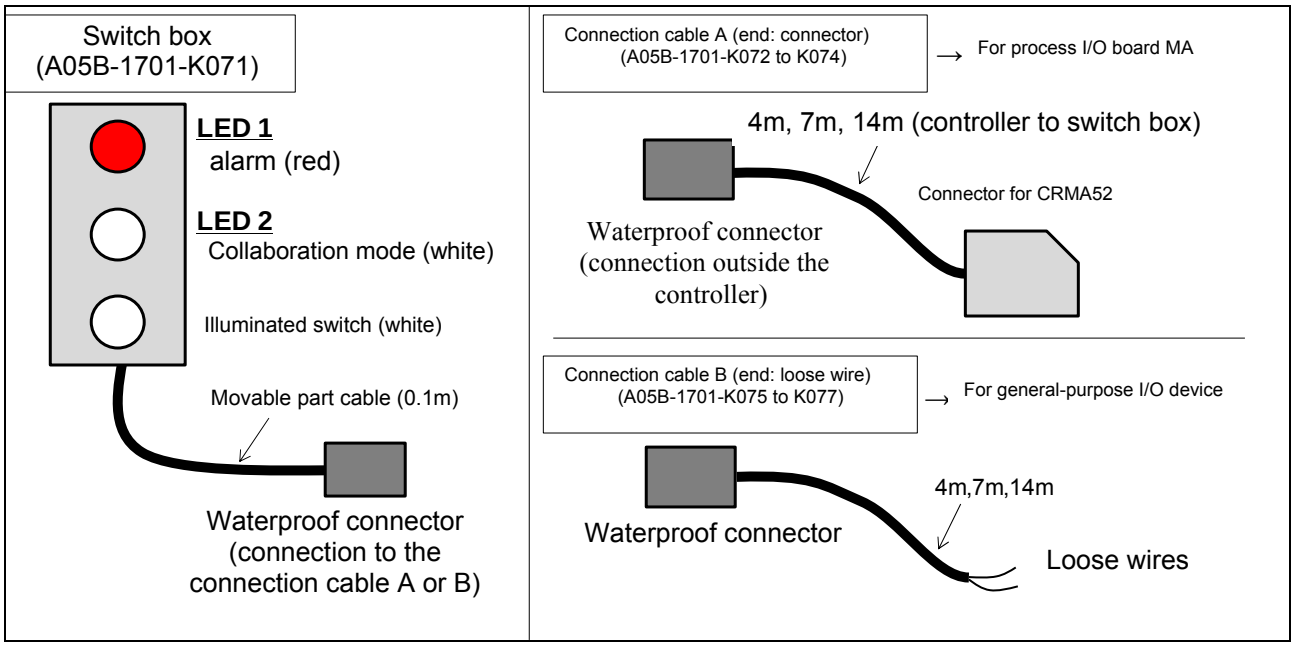


Fig. 3.6.2 (a) Usage of the switch box

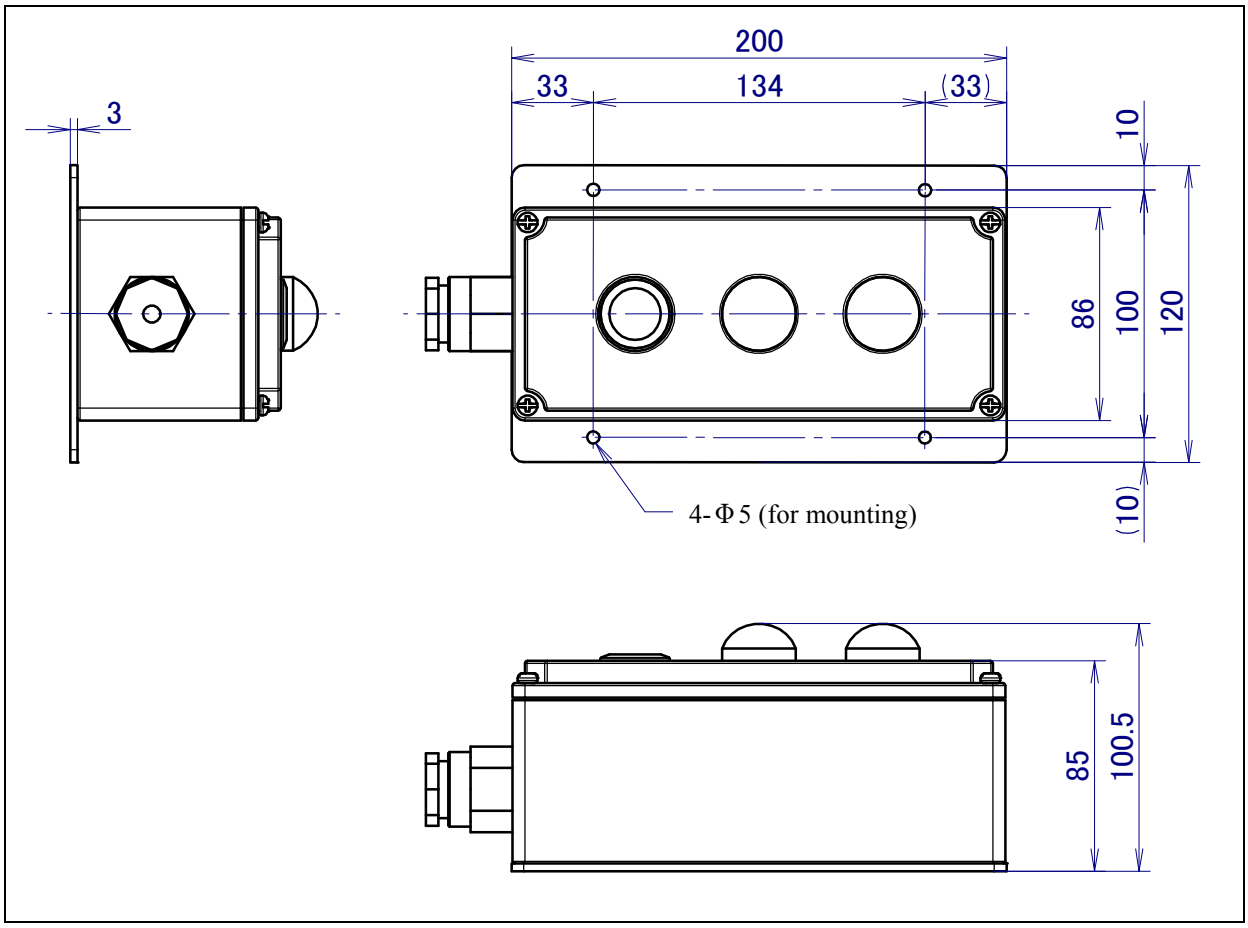


Fig. 3.6.2 (b) External dimensions of the switch box

Switch box installation method

When using CRMA52 only for the switch box

1 Use the clamp (A99L-0035-0001) (connection cable A appendix), perform grounding in the controller.

2 Insert the short connector (A660-2007-T413) which is appendix of the connection cable A.

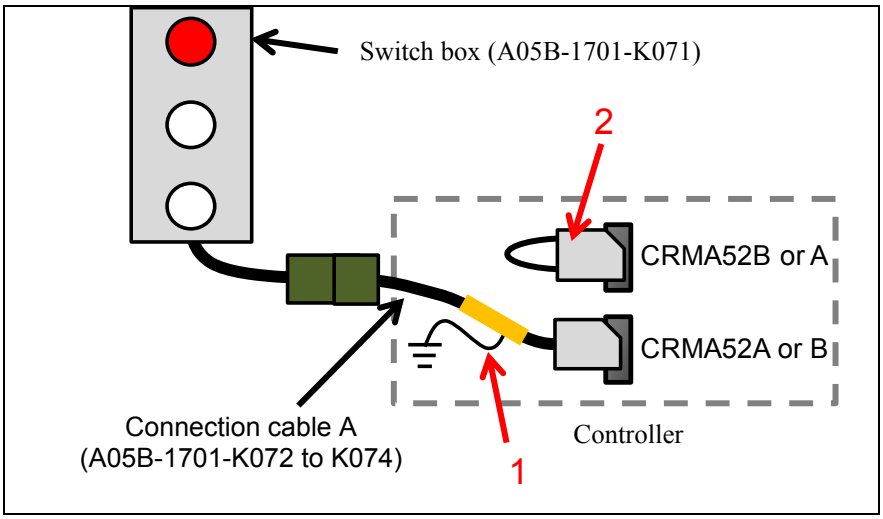


Fig. 3.6.2 (c) Switch box installation method (When using CRMA52 only for the switch box)

When CRMA52 to the switch box and general-purpose device

1 Use the clamp (A99L-0035-0001) (connection cable A appendix), perform grounding in the controller.
2 By external power supply or short with 24F in the connector, supply 24V to the DOSRC3 (refer to the controller maintenance manual (B-83525EN)).

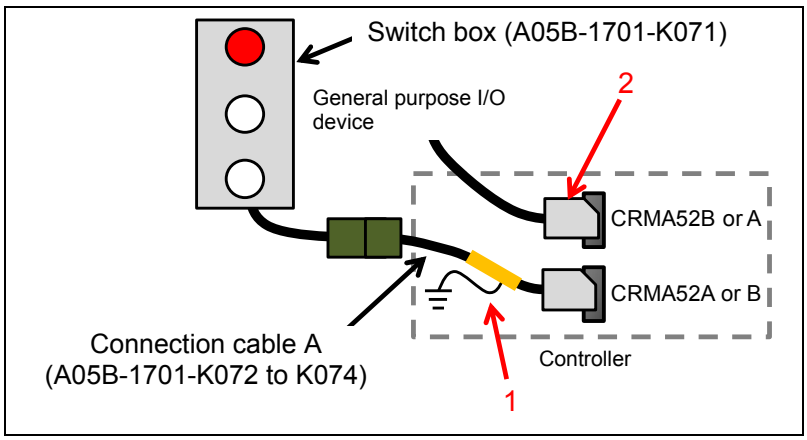


Fig. 3.6.2 (d) Switch box installation method
(When using CRMA52 to the switch box and general-purpose device)

Signal allocation of the switch box

For CRMA52 I/O signal allocation, refer to the following.
For I/O signal allocation, refer to Subsection 3.1.1 of the controller operator's manual (B-83284EN).

Table 3.6.2 (a) Access point of the connection cable A

	Access point of the connection cable A	
	CRMA52A	CRMA52B
LED(red) lights up	DO121	DO129
LED(white) lights up	DO122	DO130
LED(switch: white)	DO123	DO131
Switch operation detection	DI121	DI131

NOTE
Switch of the switch box is momentary type (ON during pressing the switch) only.

When using the switch box by connection to general-purpose device

1 End of the connection cable B is loose wire. So processing by the customer for installation to the I/O device is required. Perform waterproof measures to the terminal box if necessary.
2 Rating of the LED is 17mA-24V. Used voltage is 24V±10%. Use a general-purpose I/O device which satisfy this condition.
3 Perform grounding. The ground line is single line with y type terminal which comes from the connection cable B.

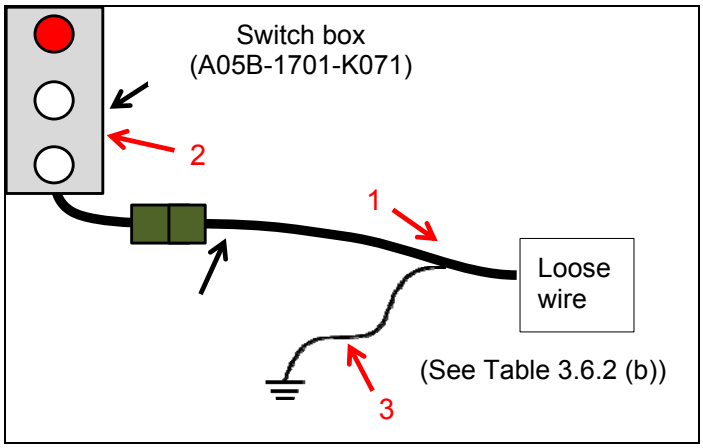


Fig. 3.6.2 (e) Signal allocation of the switch box (When using the switch box by connection to general-purpose device)

Table 3.6.2 (b) Access point of the connection cable B

Wire mark	Color	Access point of the switch box	Access point of the I/O device
A	Blue	Switch contact 1	DI
B	White	LED(red) : minus LED(white) : minus LED(switch) : minus	GND
C	Yellow	LED(white) : plus	DO
D	White	LED(red) : plus	DO
E	Green	Switch contact 2	Power supply
F	White	LED(switch) : plus	DO

4 SAFETY DEVICES

4.1 STOP TYPE OF ROBOT

There are following four types of Stopping Robot.

Power-Off Stop (Category 0 following IEC 60204-1)

Servo power is turned off, and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.

"**Power-Off stop**" performs following processing.

- An alarm is generated, and then the servo power turns off. Instantly the robot stops.
- Execution of the program is paused.

Frequent Power-Off stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Power-Off stop conditions.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.

"**Controlled stop**" performs following processing.

- The alarm "**SRVO-199 Controlled stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.

Smooth stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
"**Smooth stop**" performs following processing.

- The alarm "**SRVO-289 Smooth Stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.
- In Smooth stop, the robot decelerates until it stops with the deceleration time shorter than Controlled stop.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
"**Hold**" performs following processing.

- The robot operation is decelerated until it stops. Execution of the program is paused.

⚠ WARNING

1 The stopping distance and time of Controlled stop and Smooth stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time is necessary when Controlled stop or Smooth Stop is used. Please refer to the operator's manual of a particular robot model for the data of stopping distance and time.
2 In multi arm system, the longest stopping distance and time of Controlled Stop or Smooth Stop among each robot are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the multi arm system.
3 In the system which has extended axis, the longer stopping distance and time of Controlled Stop or Smooth Stop among robot and extended axis are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the system which has extended axis. Please refer to the extended axis setup procedure of the controller operator's manual for considering the stopping distance and time of the extended axis.
4 When Smooth stop occurs during deceleration by Controlled stop, the stop type of robot is changed to Power-Off Stop.
When Smooth stop occurs during deceleration by Hold, the stop type of robot is changed to Power-Off Stop.
5 In case of Controlled stop or Smooth Stop, motor power shutdown is delayed for a maximum of 2 seconds. In this case, a risk assessment for the whole robot system is necessary, including the 2 seconds delay.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Power-Off stop, Controlled stop, or Smooth stop. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	enabling device (DEADMAN switch) (*)
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	-
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	-
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
D	AUTO	S-Stop	S-Stop	C-Stop	C-Stop	-
	T1	S-Stop	S-Stop	-	C-Stop	S-Stop
	T2	S-Stop	S-Stop	-	C-Stop	S-Stop

P-Stop: Power-Off stop
C-Stop: Controlled stop
S-Stop: Smooth stop
-: Disable
(*) The stop pattern of NTED input is same as enabling device (DEADMAN switch).

The following table indicates the Stop pattern according to the controller type or option configuration.

Option	R-30*i*B/ R-30*i*B Mate
Standard	A(**)
Controlled stop by E-Stop (A05B-2600-J570)	C(**)
Smooth E-Stop (A05B-2600-J651)	D(**)

(**) R-30*i*B Mate does not have SVOFF input.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Controlled stop by E-Stop" option

When "**Controlled stop by E-Stop**" (A05B-2600-J570) option is specified, the stop type of the following alarms become Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Controlled stop is different from **Power-Off stop** as follows:

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and time of Controlled stop is longer than those of Power-Off stop, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Controlled stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

"Smooth E-Stop Function" option

When "**Smooth E-Stop Function**" (A05B-2600-J651) option is specified, the stop type of the following alarms becomes Smooth stop in all operation modes (AUTO, T1 and T2 mode).

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-003 Deadman switch released	Both enabling device (DEADMAN switch) on Teach pendant are released.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-037 IMSTP input (Group: %d)	IMSTP input (*IMSTP signal for a peripheral device interface) is OFF.
SRVO-232 NTED input	NTED input (NTED1-NTED11, NTED2-NTED21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.
SRVO-410 DCS SSO NTED input	In DCS Safe I/O connect function, SSO[5] is OFF.
SRVO-419 DCS PROFIsafe comm. error	PROFINET Safety communication error occurs.

Smooth stop is different from **Power-Off stop** as follows:

- In Smooth stop, the robot is stopped along the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Smooth stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and time of Smooth stop is longer than those of Power-Off stop, depending on the robot model and axis.

Smooth stop is different from **Controlled stop** as follows:

- The stopping distance and time of Smooth stop is normally shorter than those of Controlled stop, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Smooth stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

4.2 EMERGENCY STOP

This robot has following emergency stop devices.

- emergency stop button (They are on the operator panel and teach pendant.)
- external emergency stop (input signal)

When emergency stop button is pushed, the robot stops immediately (refer to Section 3.1).
The external emergency stop input signal is input from peripheral devices.
The signal terminal is inside of the robot controller.

4.3 MODE SELECT SWITCH

The MODE SELECT SWITCH is installed on the robot controller. You can select one of the operation modes using this switch. The selected operation mode can be locked by removing its key.
When the mode is changed by this switch, the robot system stops and a message is shown in teach pendant LCD.

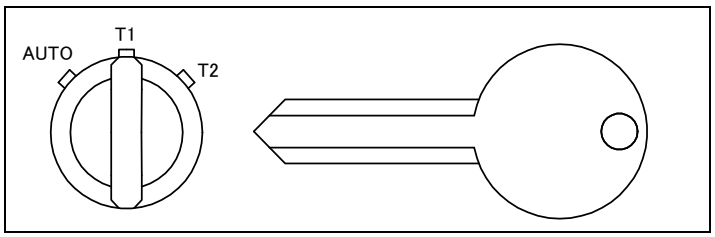


Fig. 4.3 (a) Example of mode select switch

4.3.1 Operating Modes

There are two or three operating modes.

> ⚠ **CAUTION**
> When high speed mode (contact stop function is disabled) is applied, contact stop function, push to escape function, retreat function after contact stop are set to disabled.

AUTO: Automatic Mode

- The operator panel/box becomes enable.
- The robot program can be started by the operator panel/box start button or peripheral device I/O.
- If the robot system has safety fence, safety fence is enabled.
- The robot can be operated at the specified maximum speed.
- The contact stop function is enabled.
- The push to escape function is enabled
- The retreat function after contact stop is enabled

T1: Test Mode 1

- Program can be activated from the teach pendant only.
- The robot cannot be operated at speeds higher than 250mm/s at both of tool center point (tool coordinate origin) or wrist flange center.
- If the robot system has safety fence, safety fence is disabled.
- The contact stop function is enabled.
- The push to escape function is disabled
- The retreat function after contact stop is disabled at jogging

T2: Test Mode 2 (Optional)

- Program can be activated from the teach pendant only.
- The robot can be operated at the specified maximum speed.
- If the robot system has safety fence, safety fence is disabled.
- The contact stop function is enabled.
- The push to escape function is disabled
- The retreat function after contact stop is disabled at jogging

Please refer to the operator's manual of robot controller for detail.

4.4 ENABLING DEVICE (DEADMAN SWITCH)

The enabling device (deadman switch) is used as an "enabling device".
When the teach pendant is enabled, robot motion is allowed only while at least one of enabling devices (deadman switches) is gripped. If you release or hard grip switches, the robot stops immediately.

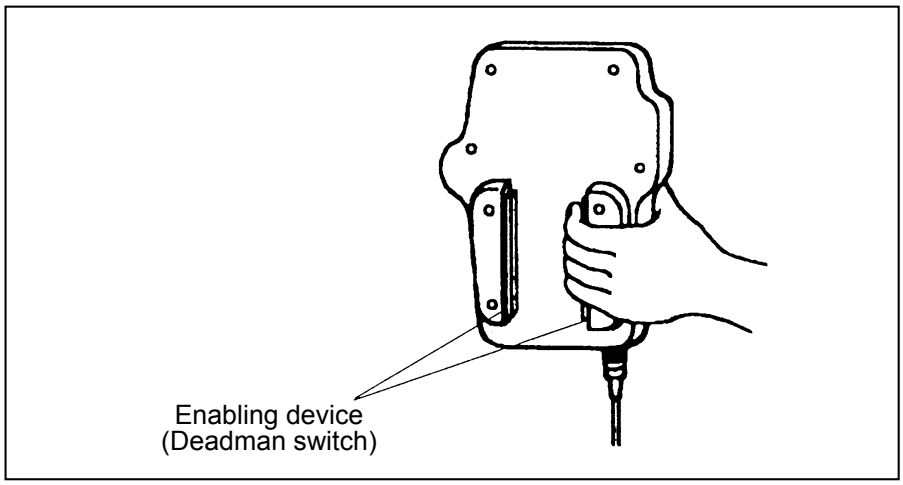


Fig. 4.4 (a) Enabling device (Deadman switch) (Tablet TP)

Based on the risk assessment by FANUC, number of operation of enabling device (DEADMAN switch) must not exceed about 10000 times per year.

4.5 SAFEGUARDS

The safeguards consists of:

- safety fence (fixed guard),
- safety gate (with interlocking devices),
- safety plug and socket, and
- other protection devices.

These safety devices must be complied with EN ISO, IEC and so on In addition, system designers must install these devices according to the risk assessment.

This section describes the basic requirements for these devices. Please refer to EN ISO 10218 and so on for detail. Note that these safety devices must be fitted to the robot system by the system house, etc.

> ⚠ **WARNING**
> Suitable safety guards are installed around robot system as the need rises. Robot operation without safety guards required from the result of risk assessment can cause serious injury or death of personnel.

4.5.1 Safety Fence

The basic requirements for Safety Fence are as follows.

- The fence is constructed to withstand foreseeable operational and environmental forces.
- The fence is free of sharp edges and projection and is not themselves a hazard.
- The fence prevents access to the safeguarded space except through openings associated with interlocking devices.
- The fence is permanently fixed in position and is removable only with the aid of tools.
- Fixing system of the safety fence must remain attached to the safety fence or to the robot system when they are removed.
- Where possible, safety fence must be incapable of remaining in place without their fixings.
- The fence cause minimum obstruction to the view of the production process.
- The fence is located at an adequate distance from the maximum space.
- The fence should be connected to PE (protective Earth) to prevent the electric shock with accident.
- Please refer to the following and their related standards for detail of safety fence aperture size, minimum size of grids and so on.
  - EN ISO 13855
  - EN ISO 13857
  - ANSI B11.19

4.5.2 Safety Gate and Plugs

The basic requirements for Safety Gate are as follows.

- The gate prevents the robot system from automatic operation until the gate is closed.
- The closure of the gate is not the control to restart automatic operation. This must be a deliberate action at a control station.
- The gate has plug and socket for interlock. The plug and socket must be selected appropriate things for safety.

This gate must be the one either it remains locked closed until the risk of injury from the hazard has passed (interlocking guard with guard locking) or opening the guard while the robot system is working gives a stop or emergency stop instruction (interlocking guard).

Please refer to EN ISO 14119 or ANSI B11.19 for detail of interlocking system.

If a personnel whole body can enter the safeguard space via the interlocking door, installing a device that the door does not close without intending.

Care should be taken to ensure that actuation of an interlock installed to protect against on hazard (e.g. stopping hazardous motion of the robot system) does not create a different hazard (e.g. the release of hazardous substances into the work zone).

4.5.3 Other Protection Devices

Protection devices must be designed and incorporated into the control system so that:

- they can be adjusted only by means of an intentional action, such as the use of a tool, key, etc.,
- the absence or failure of one of their components prevents starting or stops the moving parts.

As the need arises, the robot system must be designed so that

- moving parts cannot start up while they are within the operator's reach,
- the exposed person cannot reach moving parts once they have started up.

If some presence sensing devices are used for safety purposes, they must comply with the following.

- A presence sensing device must be installed and arranged so that persons cannot enter and reach into a hazardous area without activating the device.
- A presence sensing device must be installed and arranged so that persons cannot reach the restricted space before the hazardous conditions have ceased.
- Barriers used in conjunction with the presence-sensing device may be required to prevent persons from bypassing the device.
- Their operation must not be adversely affected by any of the environmental conditions for which the system was intended.
- When a presence-sensing device has been activated, it may be possible to restart the robot system from the stopped position provided that this does not create other hazards.
- As the need arises, resumption of robot motion must require the removal of the sensing field interruption. The result of risk assessment may require that this must not be the control to restart automatic operation.

4.6 OPERATION INSIDE OF THE SAFETY FENCE

When some workers (programmer, maintenance technician) have to enter the safety fence, the following care has to be taken into account.

- Make sure that the robot system has been completely stopped before entering the safety fence. Never enter the safety fence during the robot moving. If the robot is moving, stop the robot by hold button (or input signal), and after "controlled stop" it (servo power off), then you can enter the safety fence. (In case a safety fence is installed.)

- Make sure that an indicator lamp for stop condition (to be suitably installed by the end user) shows the stopped status of the robot, and enter the safety fence from the safety gate.

- To inform you are working in the safety fence, display “working”. During robot teaching or test operation, robot may move to an unexpected direction. So exercise special care, and perform teaching in the position where you can escape from the robot in case of dangerous situation.

- Set "Safe speed" signal enabled.

- When more than one worker collaborates for their operation, a user in charge should be equipped with teach pendant, and other users have to follow his order.
  Any operations from the external interface and robot controller operation panel without his order have to be prohibited.

- All users inside of the safety fence always have to secure the escape zone to avoid hazards from unintended movement of the robot.

- Care should be taken by all workers not to close off the escape routes for each other.

- Do not operate the robot resting against the wall, apparatus installed inside of the safety fence, etc. those take away escape zone from the operator.

- Keep watching the robot during operation in jogging, program verification, etc.

- Stop the robot immediately by E-stop SW when somebody recognizes dangerous situation.
  Whenever possible, other user who is readily accessible to the E-stop SW keeps watch from the outside of the safety fence.

- Make sure that enabling device (deadman switches) on teach pendant are operated only by hand.

- Make sure that nobody still exists inside of the safety fence when the safety gate is going to be closed.

- Do not leave tools etc. inside of the operating space of robot or peripheral devices, when operation inside of the safety fence has been finished.

⚠ WARNING

1 Safety procedures of entering the safety fence have to be established and observed. Improper procedure of entering the safety fence can cause serious injury or death of personnel who enter the safety fence.
2 During teaching or maintenance of robot system with safety fence opened, special care shall be take not to enter any other personnel who is not work for these operations. Unauthorized entry to inside of safety fence can cause serious injury or death of personnel who enter the safety fence.

4.7 THE SAFETY SEQUENCE FOR FENCE ENTRY

This section describes the safety procedure of entering the safety fence.

Note that only a programmer or a maintenance person can enter the safety fence. A general person CANNOT enter the safety fence.

Entering into the SAFETY FENCE

0. The robot is moving automatically (in AUTO mode).
1. Stop the robot by pressing HOLD buttons or HOLD input signal.
2. Change the operating mode to T1 or T2 from AUTO.
3. Remove the operating mode key switch for mode lock to prevent other persons change the operating mode.
4. Remove the plug2 from socket 2.
5. Open the gate of the safety fence, and put the plug2 to socket4.
6. Remove the plug1 from socket1
7. Enter inside of the safety fence, and put the plug 1 to socket 3.

Please refer to Fig. 4.7 (a) for details of safety fence and safety plug configurations.

The key of operating mode key switch and the safety plug1 must be carried into the safety fence. The safety plug1 must be put to the socket3 inside fence.

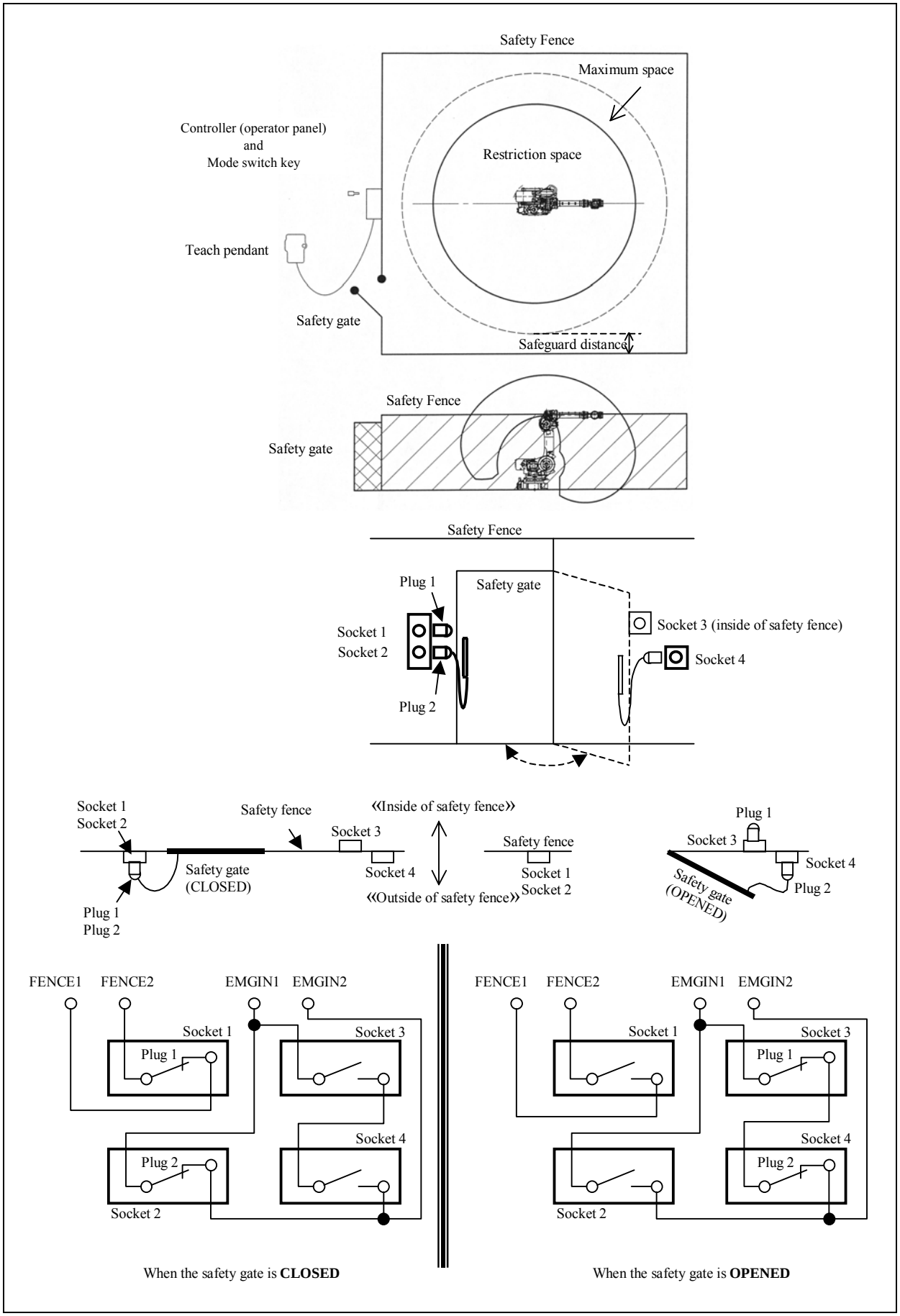


Fig. 4.7 (a) SAFETY FENCE and SAFETY GATE example

5 GENERAL CAUTIONS

In this chapter, the requirements for safety during the following situations are described:
- Installation (5.1)
- Commissioning and functional testing (5.2)
- Programming (5.3)
- Program verification (5.4)
- Troubleshooting (5.5)
- Saving programmed data (5.6)
- Automatic operation (5.7)
- Maintenance (5.8)
- Dismantling / scrapping (5.9)
- Procedure to move arm without drive power in emergency or abnormal situations (5.10)
- Warning & Caution label (5.11)

The user must ensure that the safeguarding methods are provided, utilized, and maintained for each operation associated with the robot system and in particular for personnel other than those utilizing the teach pendant or enabling device.

The user must ensure that a teach pendant not connected to the robot controller must be inaccessible.

⚠ WARNING
1 Safety procedures of entering the safety fence have to be established and observed. Improper procedure of entering the safety fence can cause serious injury or death of personnel who enter the safety fence.
2 During teaching or maintenance of robot system, special care shall be take not to access any other personnel who is not work for these operations. Unauthorized entry to inside of safety fence can cause serious injury or death of personnel who enter the safety fence.

⚠ CAUTION
The servo motors, the regenerative resistor units and the isolated transformers on the AC power supply may be hot even after robot operation. Touching the surface of these components should be therefore avoided as much as possible. When touching any of these components is nonetheless required (ex.: for maintenance purposes), special care must be applied in order to avoid burn injury.

5.1 INSTALLATION

Be sure to install the robot system in accordance with FANUC's requirements. The safeguarding methods must be identified by the hazard analysis and the risk assessment. The user must review the safety requirements to ensure that the appropriate safeguards are applied and operational prior to use in production.

5.2 COMMISSIONING AND FUNCTIONAL TESTING

During the testing of robots or robot systems after installation or relocation, be sure to follow the following procedures. These procedures are also applied to robots or robot systems after modifications (e.g. changes in hardware or software, replacement of parts, adjustments) and after maintenance or repairs that can adversely affect their operation.

5.2.1 Designation of the Restricted Space and Restriction of User

During the commissioning and functional testing, if the contact stop function is enabled, it is admitted that people they are trained about collaborative robot access the robot

During the commissioning and functional testing, if the contact stop function is disabled or untrained people may access the robot, and the safeguarding methods are not in place, interim means of designating the restricted space must be in place before proceeding. And users must not be allowed in the safeguarded space until the safeguards are functional.

5.2.2 Safety and Operational Verification

Follow the instructions by the manufacturer (FANUC) for the commissioning and functional testing of the robot or the robot system.
At the initial start-up, be sure to include the following procedure (but not limited to).

Before applying power, verify that
- the robot has been properly mechanically mounted and is stable,
- the electrical connections are correct and the power (i.e. voltage, frequency, interference levels) is within specified limits,
- the other utilities (e.g. water, air, gas) are properly connected and within specified limits,
- the peripheral equipment is properly connected,
- the limiting devices that establish the restricted space (when utilized) are installed,
- the safeguarding means are applied, and
- the physical environment is as specified (e.g. lighting and noise levels, temperature, humidity, atmospheric contaminants).

After applying power, verify that
- the start, stop, and mode selection (including key lock switches) control devices function as intended,
- each axis moves and is restricted as intended,
- emergency stop circuits and devices are functional,
- the safeguards and interlocks function as intended,
- Contact stop function correctly,
- it is possible to shut out the outer power source,
- Teaching and restarting function correctly,
- other safeguarding is in place (e.g. barriers, warning devices),
- in reduced speed, the robot operates properly and has the capability to handle the product or workpiece, and
- in automatic (normal) operation, the robot operates properly and has the capability to perform the intended task at the rated speed and load.

5.2.3 Robot System Restart Procedures

A procedure for the restart of the robot system after hardware, software or task program modification, repair, or maintenance must include but not necessarily be limited to the following:
- check any changes or additions to the hardware prior to applying power;
- functionally test the robot system for proper operation.

5.3 PROGRAMMING

Whenever possible, programming must be performed with all persons outside the safeguarded space or the robot operating space and neighborhood. When it is necessary to perform programming with personnel inside the safeguarded space, the following safety procedures are necessary.

> ⚠ **WARNING**
> No other personnel than programmer or teaching operator enter inside of safety fence during teaching. Unauthorized entry to inside of safety fence can cause serious injury or death of personnel who enter the safety fence.

5.3.1 Prior to Programming

The following conditions must be met before making taught program.

- The programmer must be trained on the type of robot used in the actual robot system and must be familiar with the recommended programming procedures including all of the safeguarding methods.
- The programmer must visually check the robot system and safeguarded space to ensure that extraneous conditions which can cause hazardous do not exist.
- When using the teach pendant to make taught program, the teach pendant must be tested to ensure proper operation.
- Any faults or failures of the robot system must be corrected prior to teaching the robot.
- Before entering the safeguarded space or robot operating space and neighborhood, the programmer must ensure that all necessary safeguards are in place and functioning.
- The programmer must set the operating mode to taught mode prior to entering the safeguarded space or robot operating space and neighborhood. Take measure to prevent the third person starting auto operation.
- The results of risk assessment may admit that people they are not programmer but trained about collaborative robot access to the robot operating space and neighborhood easily, during programming. In this case, confirm that the contact stop function is enabled.

5.3.2 During Programming

During programming, only the programmer must be allowed in the safeguarded space and the following conditions must be met.

- The robot system must be under the sole control of the programmer within the safeguarded space or robot operating space or neighborhood.
- The controls of the teach pendant must be used as intended.
- The robot system must not respond to any remote commands or conditions that would cause hazardous conditions.
- All robot system emergency stop devices must remain functional. If it is impossible, take measures to secure security of users in safeguard space or robot operating space or neighborhood.

The results of risk assessment may admit that people they are not programmer but trained about collaborative robot access to the robot operating space and neighborhood easily, during programming. In this case, confirm that the contact stop function is enabled. If the programmer changes the contact stop function to disable temporary, indicate to the surrounding people

5.3.3 Returning to Automatic Operation

The programmer must return the suspended safeguards to their original effectiveness prior to initiating automatic operation of the robot system.

5.3.4 Other Cautions for Programming

- Adopt a limit switch or other sensor to detect a dangerous state and, if necessary, design the program to stop the robot when the sensor signal is received.
- Design the program to stop the robot when an abnormal condition occurs in any other robots or peripheral devices, even though the robot itself is normal.
- For a system in which the robot and its peripheral devices are in synchronous motion, particular care must be taken in programming in order not to interfere with each other.
- Provide a suitable interface between the robot and its peripheral devices so that the robot can detect the states of all devices in the system, and can be stopped according to the states.
- Design to arrange avoiding mutual interfere when various robot's operation space crossover significantly.
- Be sure to specify the predetermined work origin in a motion program so that the robot starts from the origin and terminates at the origin. Make it possible for the operator to distinguish easily that the robot motion has terminated at a glance.
- Circumspect program with sufficient delay required for the program after executing some control command in adopting actuators (pneumatic, hydraulic, and electric)
- Adopt limit switches for the end effector, and control the robot system by monitoring the state.

5.4 PROGRAM VERIFICATION

When visual examination of the robot system response to the task program is necessary as part of the verification procedure, it should be made with all persons outside the safeguarded space and its neighborhood. When it is necessary to perform program verification with personnel inside the safeguarded space or the robot operating space and neighborhood, apply the following contents.

- Program verification must initially be performed at reduced speed.
  Special care is required when override is specified in the program.
- When it is necessary to examine the movement of the robot at full (operational) speed, apply the following contents:
  - Only the programmer can change safety operation mode to normal operation mode by means which requires careful operation;
  - Workers in safeguard space or robot operating space and its neighborhood always can use enable device or other devices with an equivalent safety level if necessary;
  - safe working procedures are established to minimize the exposure of personnel to hazards within the safeguarded space or robot operating space and its neighborhood.

5.5 TROUBLESHOOTING

When troubleshooting is performed from within the safeguarded space or the robot operating space and neighborhood, be sure to follow the following contents.

- personnel responsible for trouble shooting are specifically authorized and trained for these activities;
- personnel entering the safeguarded space or robot operating space must operate the robot with the enable machine;
- safe working procedures are established to minimize the exposure of personnel to hazards within the safeguarded space or robot operating space and its neighborhoood.

5.6 SAVING PROGRAMMED DATA

A record of the task programs together with any modifications must be maintained. The programmed date which is saved in portable media must be stored in a suitably protected environment when not in use.

5.7 AUTOMATIC OPERATION

Automatic operation must only be permissible when
- the intended safeguards are in place and functioning,
- proper safe working procedures are followed.

The results of risk assessment may require to check following items before automatic operation
- no personnel are present within the safeguarded space,

> ⚠ **WARNING**
> Please make sure that nobody remained inside of the safety fence before starting up automatic operation of robot systems. If somebody remained inside of the safety fence exists, trapped personnel inside of the safety fence might meet serious situation, which can lead them to serious injury or death.

5.8 MAINTENANCE

The robot and robot system must have an inspection and maintenance program to ensure continued safe operation of the robot system.
The inspection and maintenance program must take into account the robot and robot system manufacturer's recommendations.

Personnel who perform maintenance or repair on robots or a robot system must be trained in the procedures necessary to perform safely the required tasks.

Personnel who maintain and repair robot systems must be safeguarded from hazards.
Where possible, maintenance must be performed from outside the safeguarded space or robot operating space or neighborhood by placing the robot arm in a predetermined position.

The results of risk assessment may admit that people they don't maintain or repair but trained about collaborative robot access to the robot operating space and neighborhood easily, during maintenance. In this case, confirm that the contact stop function is enabled.

The following is the safety procedure of entering safeguarded space for maintenance.

> ⚠ **WARNING**
> Make sure the Main breaker must be shut down in the robot maintenance with the exception of following.
>
> - Replacing batteries of the Robot
> - Demand of operating the peripheral equipment in maintenance operation
> - Safety maintenance disturbance
>
> Maintenance without disconnecting the electric power supply may cause the serious electric shock.

Entering safeguarded space for maintenance

1 Stop the robot system.
2 Shut off the power of the robot system, and lock the main breaker to prevent powering on during maintenance, by mistake.

   If you have to enter the safeguarded space while power is available to the robot system, you must do the following things prior to entering the safeguarded space:
   - check the robot system to determine if any conditions exist that are likely to cause malfunctions,
   - check if the teach pendant works correctly, and
   - if any damage or malfunction is found, complete the required corrections and perform retest before personnel enter the safeguarded space.

3 Enter the safeguarded space (see Section 4.7 “THE SAFETY SEQUENCE FOR FENCE ENTRY”).
4 After the maintenance working, check if the safeguard system is effective. If it has been suspended to perform the maintenance working, return their original effectiveness.

5.9 DISMANTLING / SCRAPPING

Do not start dismantling the robot before contacting FANUC Europe, FANUC Robotics America or FANUC Corporation in Japan.
Please contact us when you have to dismantle/scrap FANUC robot systems.

⚠ WARNING
When dismantling and/or scrapping robot mechanical units equipped with spring balancers, the robot arm may move unexpectedly due to the stored elastic energy of the springs inside the balancer(s), and subsequently lose its balance. Dismantling and scrapping of such robot system must be done only after releasing the stored energy and according to the instructions provided by FANUC. Very severe injury or death of personnel may occur in case any of these instructions is not followed

⚠ CAUTION
Robot batteries used for memory and/or encoder backup must be disposed of appropriately. Failure to do so may cause short circuit during dismantling/scrapping, which potentially can cause ignition or explosion.

5.10 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), turn off the robot controller immediately, change robot posture by directly pressing robot arm and release the worker.

5.11 WARNING & CAUTION LABEL

(1) Transportation caution label 1

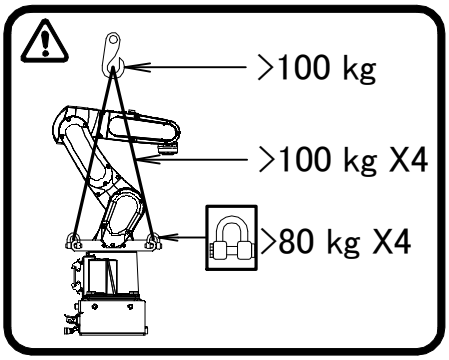


Fig. 5.11 (a) Transportation caution label 1

Description

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

1) Use a crane having a load capacity of 100 kg or greater.
2) Use four slings each having a load capacity of 100 kg or greater.
3) Use four shackles each having an allowable load of 784 N (80 kgf) or greater.

(2) Transportation caution label 2

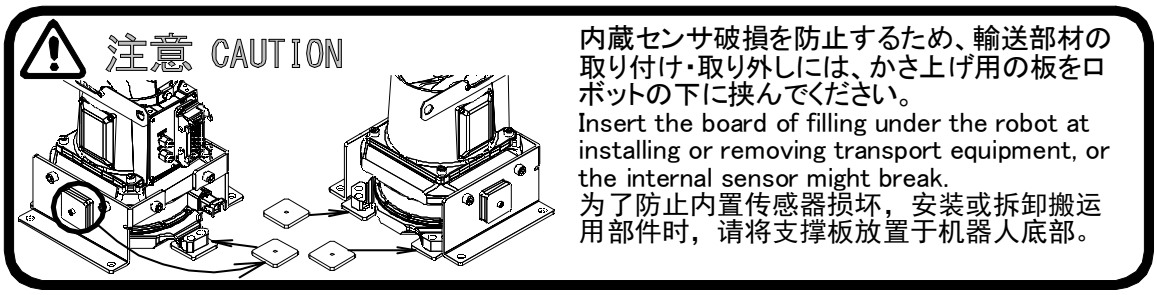


Fig. 5.11 (b) Transportation caution label 2

Description

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

Insert the board of filling under the robot a installing or removing transport equipment, or the internal sensor might break.

(3) Transportation caution label 3

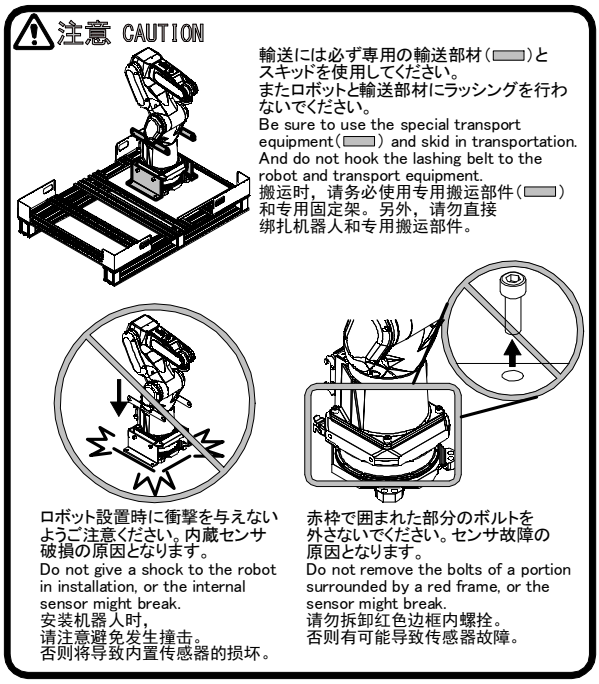


Fig. 5.11 (c) Transportation caution label 3

Description

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

1) Be sure to use the special transport equipment and skid in transportation. And do not hook the lashing belt to the robot and transport equipment.
2) Do not give a shock to the robot in installation, or the internal sensor might break.
3) Do not remove the bolts of a portion surrounded by a red frame, or the sensor might break.

(4) Greasing label (if greasing kit A05B-1142-K021 is specified)

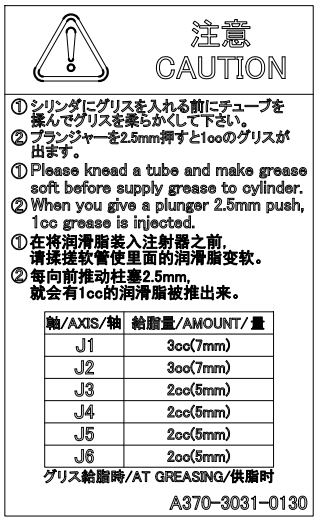


Fig. 5.11 (d) Greasing caution label

Description

When using a grease kit, observe the instructions indicated on this label.

1) Before filling the cylinder with grease from tube, squeeze the tube to make the grease in it soft.
2) Pushing in the plunger by 2.5 mm causes a grease of 1 ml to be pushed out.

(5) Operation space and payload label

The following label is added if the CE specification is requested.

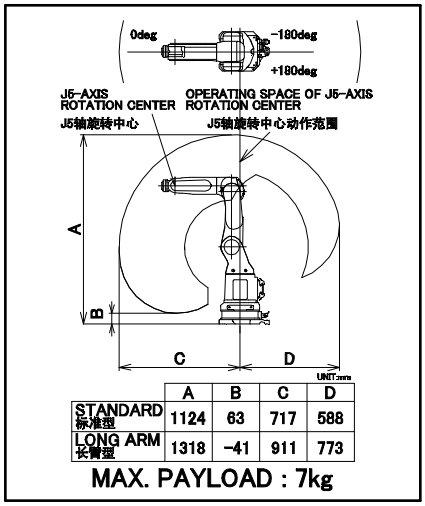


Fig. 5.11 (e) Operating space and payload label (Example of CR-7*i*A, CR-7*i*A/L)

6 DAILY MAINTENANCE

6.1 MECHANICAL UNIT

To keep the robot system safe, please perform periodic maintenance those are specified in mechanical unit operator's manual or maintenance manual.
In addition, please clean each part of the system and visually check them for any damage or cracks.
Daily check items are as follows (but not limited to).

- Input power voltage
- Pneumatic pressure
- Damage of connection cables
- Looseness of connectors
- Lubrication
- Periodic check of the force sensor precision (refer to OPERATOR'S MANUAL (Collaborative Robot Function) (B-83744EN)
- Emergency stop functions
- Effectiveness of enabling device (DEADMAN switch) on teach pendant
- Safety gate interlocks (in case the robot system has safety gate interlocks)
- Vibration, noise by the robot movement
- Functions of peripheral devices
- Fixtures of robot and peripheral devices

6.2 CONTROL UNIT

Before operating the system each day, clean each part of the system and check the system parts for any damage or cracks.

Also, check the following:

(a) Before service operation
- Check the cable connected to the teach pendant for excessive twisting.
- Check the controller and peripheral devices for abnormalities.
- Check the safety function.

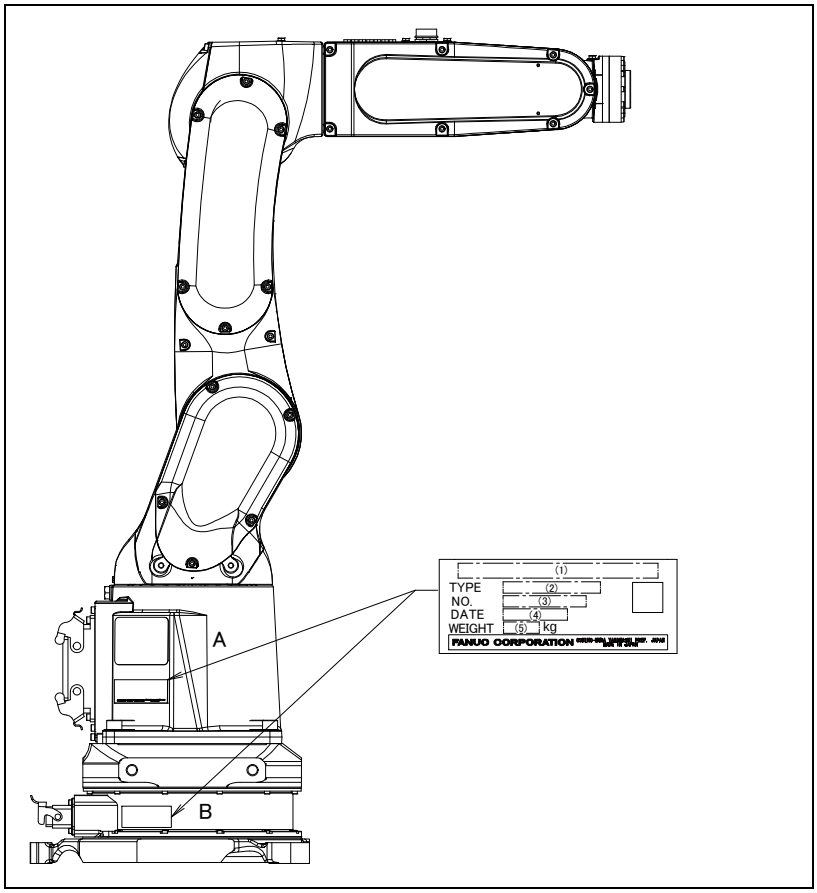
(b) After service operation
At the end of service operation, return the robot to the proper position, then turned off the controller.
Clean each part, and check for any damage or cracks.
If the ventilation port and the fan motor of the controller are dusty, wipe off the dust.

PREFACE

This manual explains operation procedures for the following mechanical units:

Model name	Mechanical unit specification No.	Maximum load
FANUC Robot CR-4*i*A	A05B-1143-B701	4kg
FANUC Robot CR-7*i*A	A05B-1142-B701	7kg
FANUC Robot CR-7*i*A/L	A05B-1142-B801	7kg
FANUC Robot CR-14*i*A/L	A05B-1142-B841	14kg

The label stating the mechanical unit and force sensor 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 and force sensor specification number

TABLE 1) A: Mechanical unit

	(1)	(2)	(3)	(4)	(5)
CONTENTS	**Model name**	**TYPE**	**No.**	**DATE**	**WEIGHT kg (Without controller)**
LETTERS	FANUC Robot CR-4*i*A	A05B-1143-B701	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	48
	FANUC Robot CR-7*i*A	A05B-1142-B701			53
	FANUC Robot CR-7*i*A/L	A05B-1142-B801			55
	FANUC Robot CR-14*i*A/L	A05B-1142-B841			55

TABLE 2) B: Force sensor

	(1)	(2)	(3)	(4)	(5)
CONTENTS	**Name**	**TYPE**	**No.**	**DATE**	**WEIGHT kg**
LETTERS	FANUC Robot CR-7*i*A Force Sensor	A05B-1425-H301	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	28
	FANUC Robot CR-7*i*A Force Sensor	A05B-1425-H302			28

In the following way, “Force Sensor Serial number on manufacturing plate” term of TABLE2 corresponds to that of “Force Sensor Serial number on TP” written in section 2.2 of OPERATOR’S MANUAL (Collaborative Robot Function) (B-83744EN). In replacing force sensor and updating software, please check that two numbers correspond.

Force Sensor Serial number (on manufacturing plate)

R▽▽■○○○○○

■=1 to 9, X, Y, Z

Force Sensor Serial number (on TP)

▽▽□□○○○○○

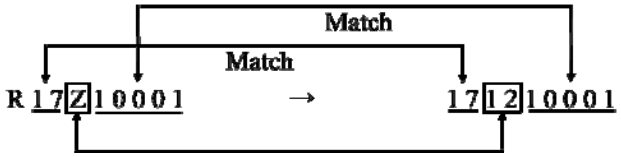
□□=01 to 09, 10, 11, 12

Correspondence table

■	1	2	3	4	5	6	7	8	9	X	Y	Z
□□	01	02	03	04	05	06	07	08	09	10	11	12

e.g.

Force Sensor Serial number (on manufacturing plate) Force Sensor Serial number (on TP)



Check that two numbers correspond by referring to the above correspondence table.

RELATED MANUALS

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

R-30*i*B Mate, **R-30*i*B Mate Plus** controller	OPERATOR'S 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-83525EN**	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

TABLE OF CONTENTS

1 TRANSPORTATION AND INSTALLATION

1.1 TRANSPORTATION

Use a crane to transport the robot. When transporting the robot, be sure to change the posture of the robot to that shown below and lift by using the eyebolts and the transport equipment at their points.

⚠ CAUTION
When hoisting or lowering the robot with a crane, move it slowly and with great care. When placing the robot on the floor, exercise care to prevent the installation surface of the robot from striking the floor with too much force.
When hoisting or lowering the robot, be sure to perform it with the robot only. Do not hoist or lower the robot with a pedestal, or an installation plate and skid for transportation.
If these cautions are not followed, the internal sensor might break.

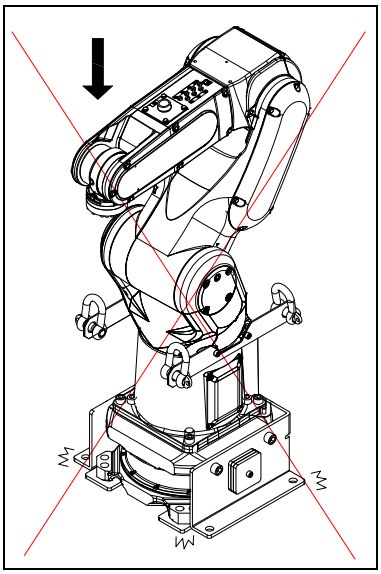


Fig. 1.1 (a) Caution for installation

⚠ WARNING
1 The robot becomes unstable when it is transported with the end effector applied to wrist. Please be sure to remove the end effector when the robot is transported.
2 Before moving the robot with a crane, check and tighten any loose bolts on the transport equipment on the robot.
3 Do not pull eyebolts sideways.

Transportation using a crane (Fig. 1.1 (c) to (e))
Fasten the transport equipments to the robot base and lift the robot with the four slings.

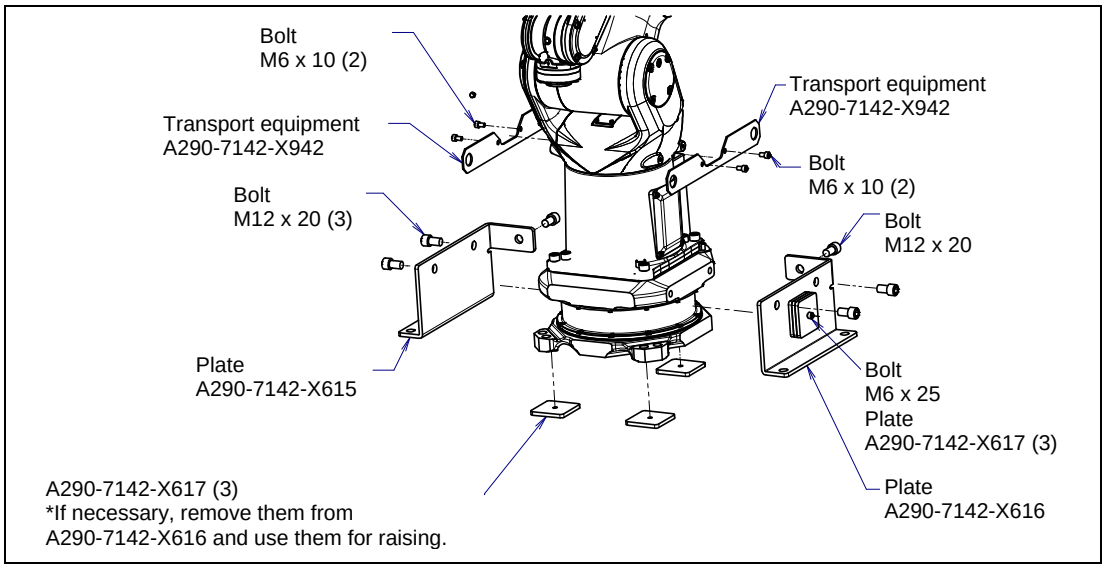


Fig. 1.1 (b) Installing the transport equipment

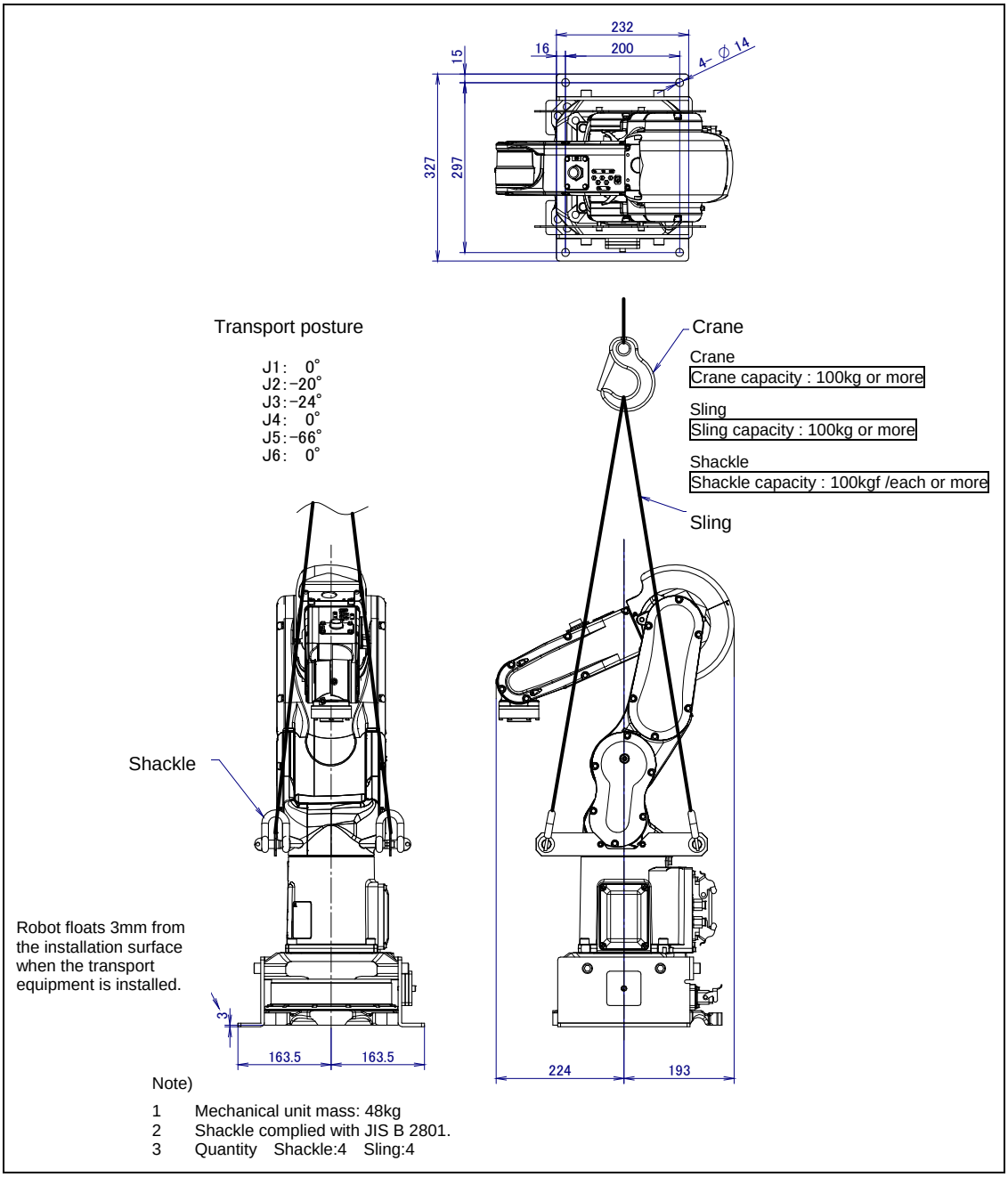


Fig. 1.1 (c) Transportation using a crane (CR-4*i*A)

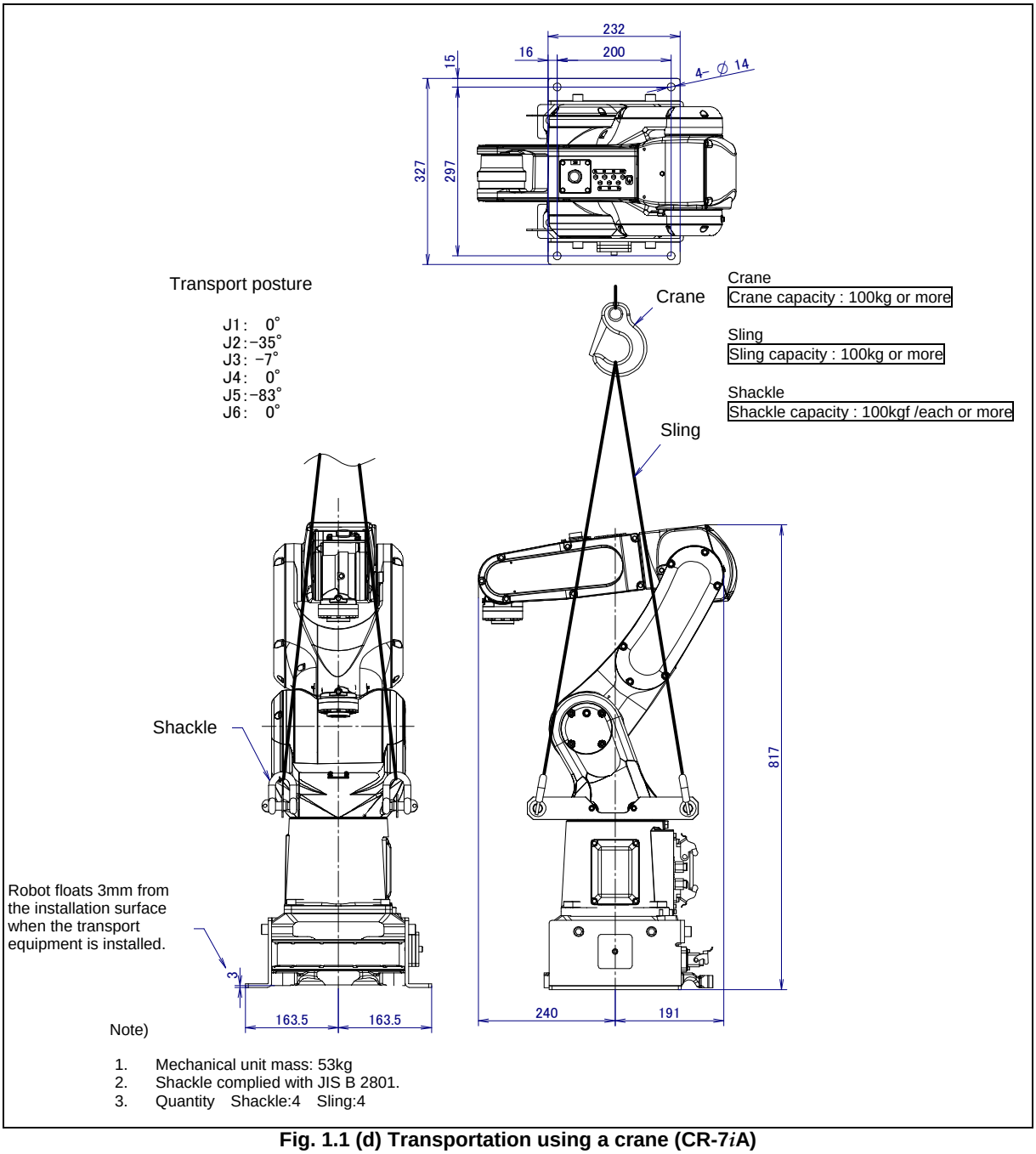


Fig. 1.1 (d) Transportation using a crane (CR-7*i*A)

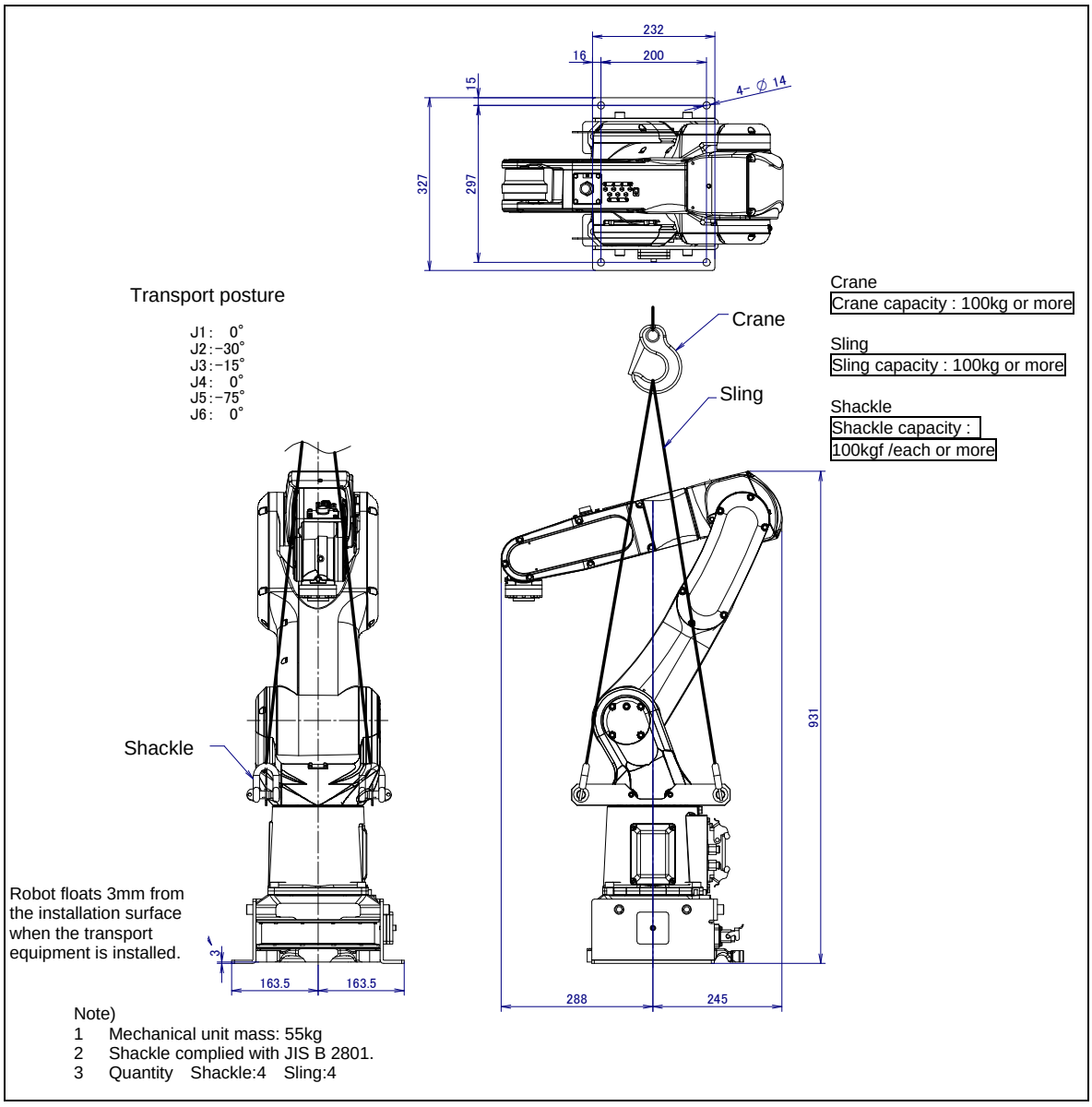


Fig. 1.1 (e) Transportation using a crane (CR-7*i*A/L, CR-14*i*A/L)

The robot is shipped with a special skid.

> ⚠ **CAUTION**
> Please be sure to use the special skid during transportation. Please do not use other skids during transportation. Please do not dispose of this skid but, instead, store it as it is necessary during transportation.
> During transportation, hook the lashing belt on the skid. Do not hook the lashing belt directly on the robot and the transport equipment. Or, it may cause damage of the internal sensor.

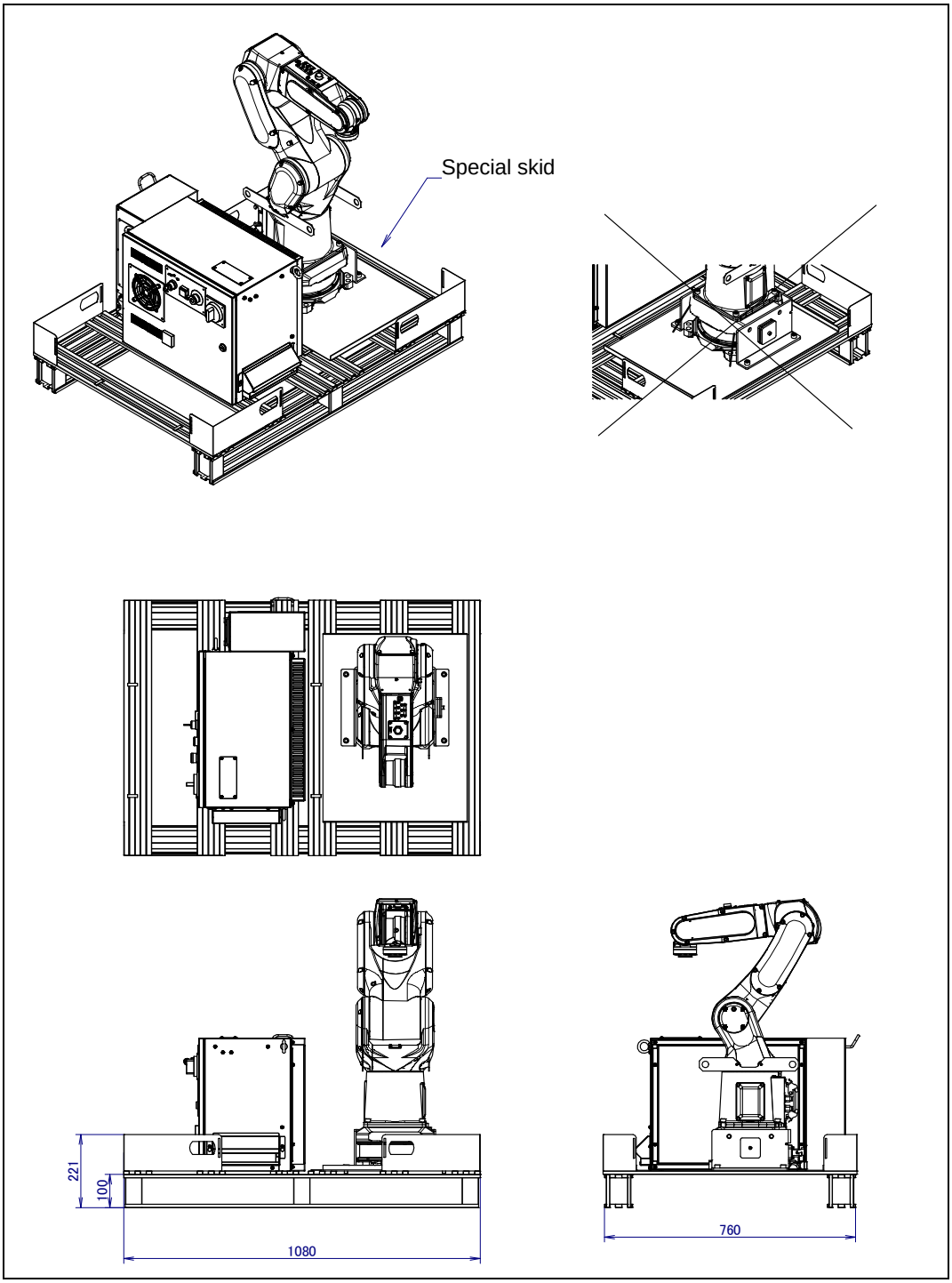


Fig. 1.1 (f) Robot shipment status

1.2 INSTALLATION

Fig. 1.2 (a) shows the robot base dimensions. Please use the Installation plate in which the flatness is 0.15 during installation.

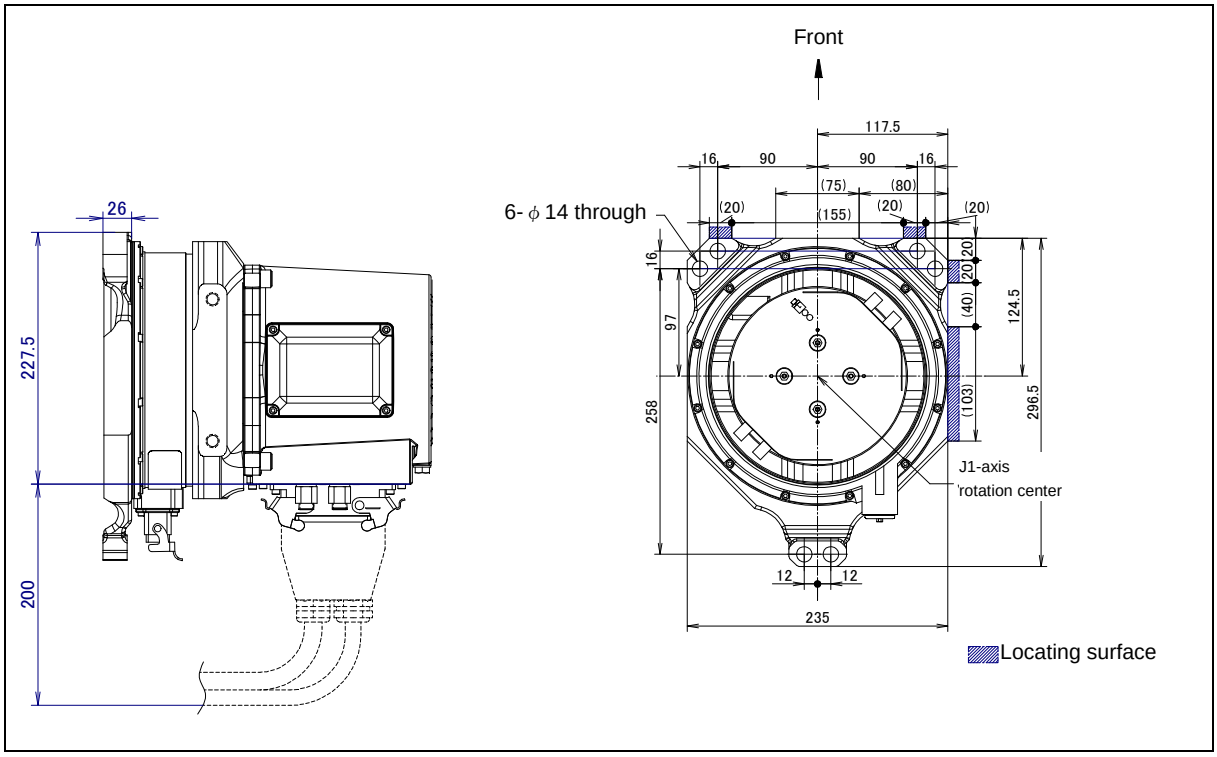


Fig. 1.2 (a) Dimensions of the robot base (back side connector plate

Prepare the recommended Installation plate for delivering high performance, referring to Fig. 1.2 (b).

Make sure that the area of 296.5mm+α, on which the robot base is to be installed, is not be painted or fabricated to ensure a level mounting area.

⚠ CAUTION

1 Flatness of robot installation surface must be less than or equal to 0.15mm. Inclination of robot installation surface must be less than or equal to 0.5º. The robot may not deliver the high performance if its installed area was not flat enough after installation on the floor. Ensure there is no gapping between the installation plate and the floor; also confirm no foreign materials are between the mounting surfaces. Fill any open spaces or gaps, especially directly underneath the robot base, with shim (spacer), grout or similar method so that the plate does not flex or become warped and so no gaps are present after installation.
2 Use six hexagon M12 bolts (Tensile strength 1200N/mm^2 or more), and tighten them diagonally evenly with a force of 94Nm.

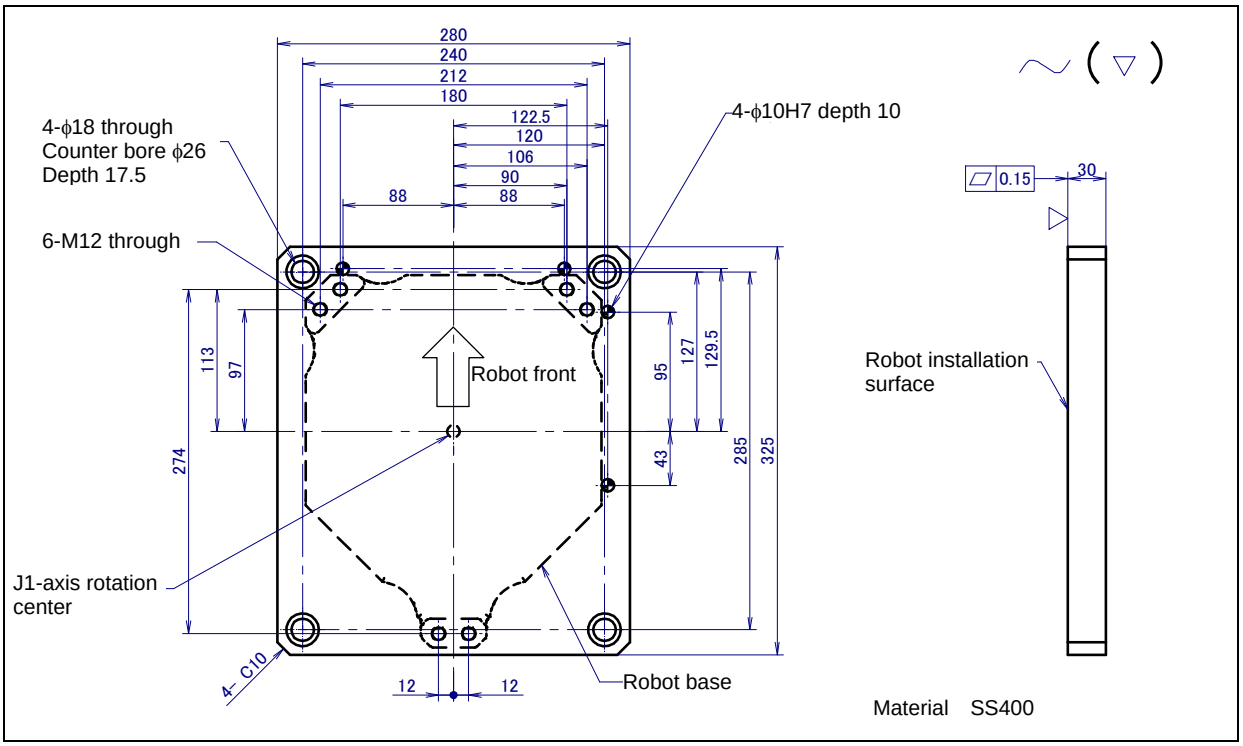


Fig. 1.2 (b) Recommended Installation Plate

Fig. 1.2 (c) and Table 1.2 (a) to (d) indicate the force and moment applied to the base plate. Table 1.2 (e) to (g) indicate the stopping distance and time of the J1 to J3 axis until the robot stopping by Power-Off stop, by Controlled stop or by Smooth stop after input of the stop signal. Refer to the data when considering the strength of the installation face.

NOTE
Table 1.2 (e) to (g) are measured reference value complied with ISO10218-1. Values differ depending on each robot individual difference, payload and the program. So confirm the real value by measurement. Values in Table 1.2 (e) are affected by the robot operating status and number of times of the Power-Off stop. Periodically measure the real values and confirm those.

Table 1.2 (a) Force and moment that acts on J1 base (CR-4*i*A)

	Vertical moment M_V (Nm)	Force in Vertical direction F_V (N)	Horizontal moment M_H (Nm)	Force in Horizontal direction F_H (N)
During stillness	58.9	509.6	0	0
During acceleration or deceleration	83.9	559.2	43.4	91.3
During Power-Off stop	377.9	864.0	204.6	599.9

Table 1.2 (b) Force and moment that acts on J1 base (CR-7*i*A)

	Vertical moment M_V (Nm)	Force in Vertical direction F_V (N)	Horizontal moment M_H (Nm)	Force in Horizontal direction F_H (N)
During stillness	115.5	588.0	0	0
During acceleration or deceleration	200.1	793.0	68.3	179.6
During Power-Off stop	704.5	1329.0	382.8	900.3

Table 1.2 (c) Force and moment that acts on J1 base (CR-7*i*A/L)

	Vertical moment M_V (Nm)	Force in Vertical direction F_V (N)	Horizontal moment M_H (Nm)	Force in Horizontal direction F_H (N)
During stillness	147.3	607.6	0	0.
During acceleration or deceleration	180.9	668.9	48.7	83.8
During Power-Off stop	794.3	1315.1	396.5	1124.4

Table 1.2 (d) Force and moment that acts on J1 base (CR-14*i*A/L)

	Vertical moment M_V (Nm)	Force in Vertical direction F_V (N)	Horizontal moment M_H (Nm)	Force in Horizontal direction F_H (N)
During stillness	219.6	676.2	0	0
During acceleration or deceleration	278.7	803.3	69.3	175.8
During Power-Off stop	523.0	1009.6	367.6	887.4

Table 1.2 (e) Stopping time and distance until the robot stopping by Power-Off stop after input of stop signal

		J1	J2	J3
CR-4*i*A	Stopping time [ms]	52	68	60
Speed 500mm/s	Stopping angle [deg] (rad)	1.0 (0.02)	1.5 (0.03)	2.1 (0.04)
CR-4*i*A	Stopping time [ms]	60	92	76
Speed 1000mm/s	Stopping angle [deg] (rad)	2.9 (0.05)	4.5 (0.08)	6.3 (0.11)
CR-7*i*A	Stopping time [ms]	62	28	68
Speed 500mm/s	Stopping angle [deg] (rad)	1.0 (0.02)	0.5 (0.01)	1.6 (0.03)
CR-7*i*A	Stopping time [ms]	92	52	164
Speed 1000mm/s	Stopping angle [deg] (rad)	3.4 (0.06)	1.6 (0.03)	5.4 (0.09)
CR-7*i*A/L	Stopping time [ms]	20	68	28
Speed 500mm/s	Stopping angle [deg] (rad)	0.4 (0.01)	0.7 (0.01)	1.0 (0.02)
CR-7*i*A/L	Stopping time [ms]	92	100	92
Speed 1000mm/s	Stopping angle [deg] (rad)	2.0 (0.03)	2.5 (0.04)	4.7 (0.08)
CR-14*i*A/L	Stopping time [ms]	36	72	112
Speed 500mm/s	Stopping angle [deg] (rad)	1.7 (0.03)	2.1 (0.04)	2.5 (0.04)

* Max payload

Table 1.2 (f) Stopping time and distance until the robot stopping by Controlled stop after input of stop signal

		J1	J2	J3
CR-4*i*A	Stopping time [ms]	628	628	628
Speed 500mm/s	Stopping angle [deg] (rad)	16.2 (0.28)	16.1 (0.28)	27.7 (0.48)
CR-4*i*A	Stopping time [ms]	628	628	628
Speed 1000mm/s	Stopping angle [deg] (rad)	32.3 (0.56)	32.2 (0.56)	55.4 (0.97)
CR-7*i*A	Stopping time [ms]	508	508	508
Speed 500mm/s	Stopping angle [deg] (rad)	10.4 (0.18)	11.1 (0.19)	19.9 (0.35)
CR-7*i*A	Stopping time [ms]	508	508	508
Speed 1000mm/s	Stopping angle [deg] (rad)	20.8 (0.36)	22.2 (0.39)	39.7 (0.69)
CR-7*i*A/L	Stopping time [ms]	508	508	508
Speed 500mm/s	Stopping angle [deg] (rad)	8.4 (0.15)	8.8 (0.15)	16.6 (0.29)
CR-7*i*A/L	Stopping time [ms]	508	508	508
Speed 1000mm/s	Stopping angle [deg] (rad)	16.7 (0.29)	17.6 (0.31)	33.1 (0.58)

* Max payload

Table 1.2 (g) Stopping time and distance until the robot stopping by Smooth stop after input of stop signal

		J1	J2	J3
CR-14*i*A/L	Stopping time [ms]	596	488	488
Speed 500mm/s	Stopping angle [deg] (rad)	25.7 (0.45)	14.2 (0.25)	13.4 (0.23)

* Max payload

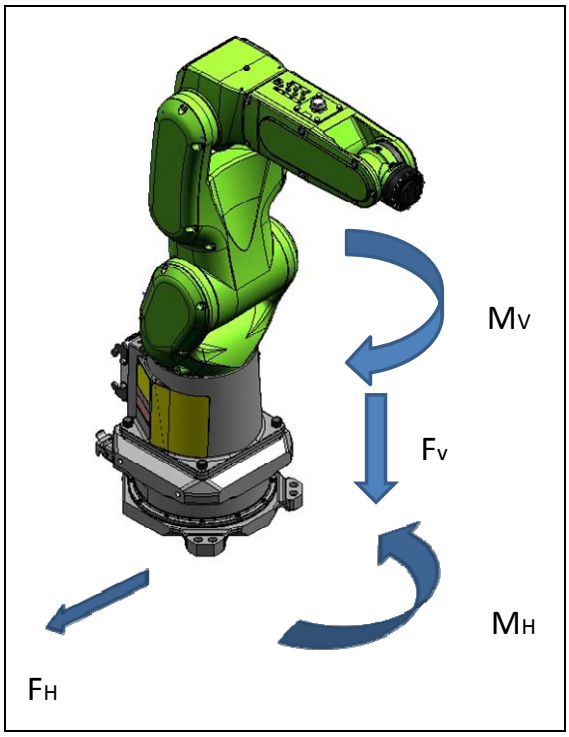


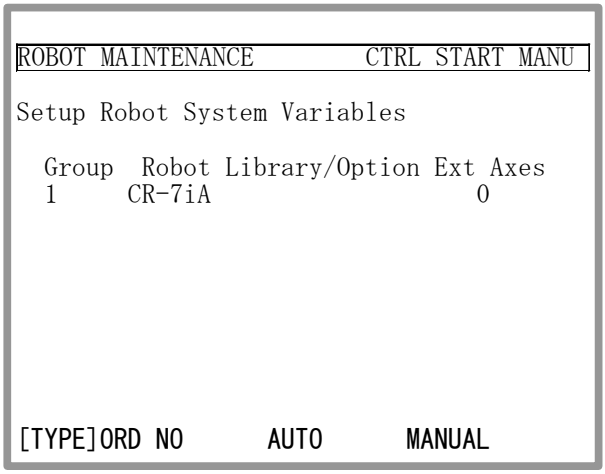
Fig. 1.2 (c) Force and moment that acts on J1 base

1.2.1 Angle of Mounting Surface Setting

For all robot mounts except floor mount, be sure to set the mounting angle referring to the procedure below. Refer to Section 3.1 for installation specifications.

> ⚠ **WARNING**
> Depends on the robot position, risk assessment has to be done.

1 Turn on the controller with [PREV] and [NEXT] key pressed. Then select [3 Controlled start].
2 Press the [MENU] key and select "9 MAINTENANCE".
3 Select the robot which you want to set mount angle and press the [ENTER] key.



4 Press the [F4] key.
5 Press the [ENTER] key until screen below will be displayed.

```
*******Group 1 Initialization***********
*************CR-7iA******************


--- MOUNT ANGLE SETTING ---

  0 [deg] : floor mount type
 90 [deg] : wall mount type
180 [deg] : upside-down mount type

Set mount_angle (-180 - 180[deg])->
Default value = 0
```

6 Input mount angle referring to Fig.1.2.1 (a).

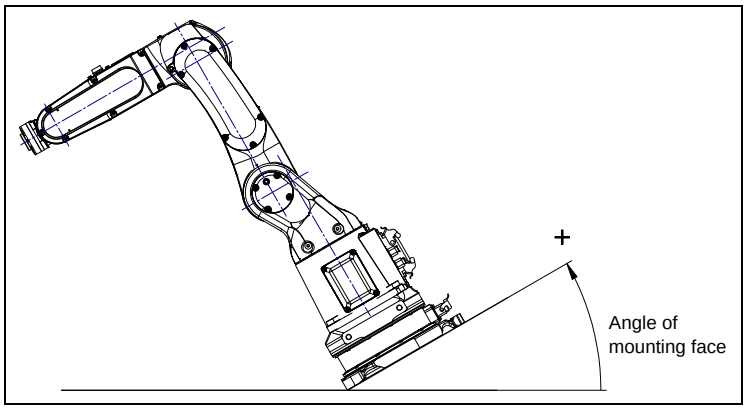


Fig.1.2.1 (a) Robot mounting angle

7 Press the [ENTER] key until screen below is displayed again.

```
ROBOT MAINTENANCE          CTRL START MANU

Setup Robot System Variables

  Group  Robot Library/Option Ext Axes
  1      CR-7iA                    0




[TYPE]ORD NO       AUTO       MANUAL
```

8 Press the [FCTN] key and select ”1 START (COLD)”.

1.3 MAINTENANCE AREA

Fig.1.3 (a), (b) show the maintenance area of the mechanical unit. Be sure to leave enough room for the robot to be mastered.
See Chapter 8 for the mastering.

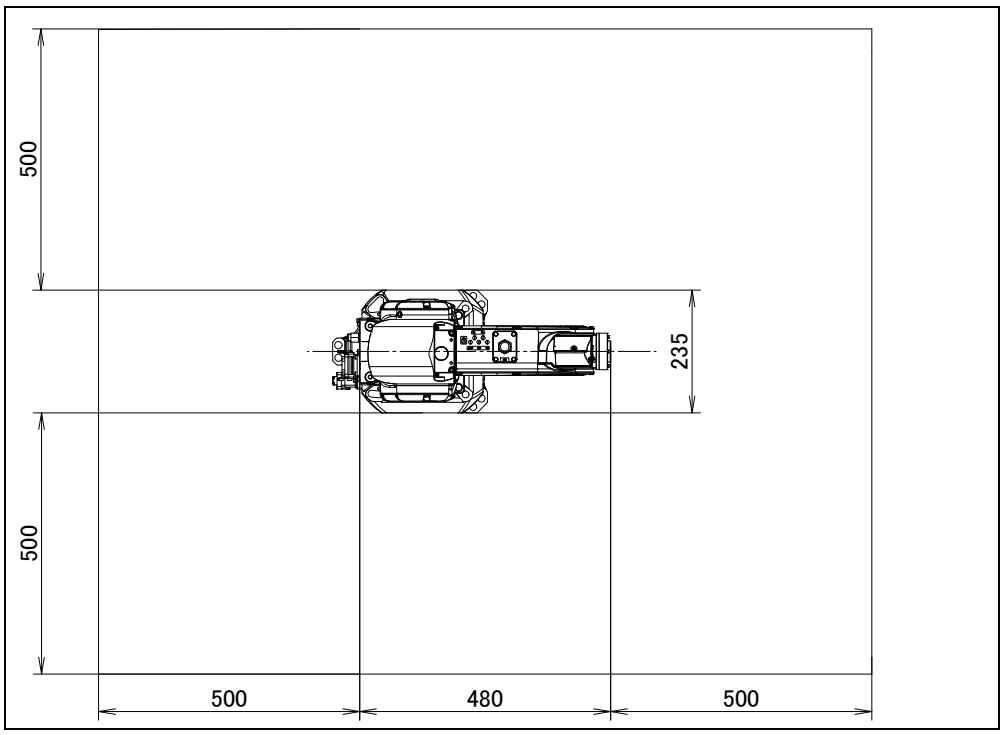


Fig. 1.3 (a) Maintenance area (CR-4*i*A)

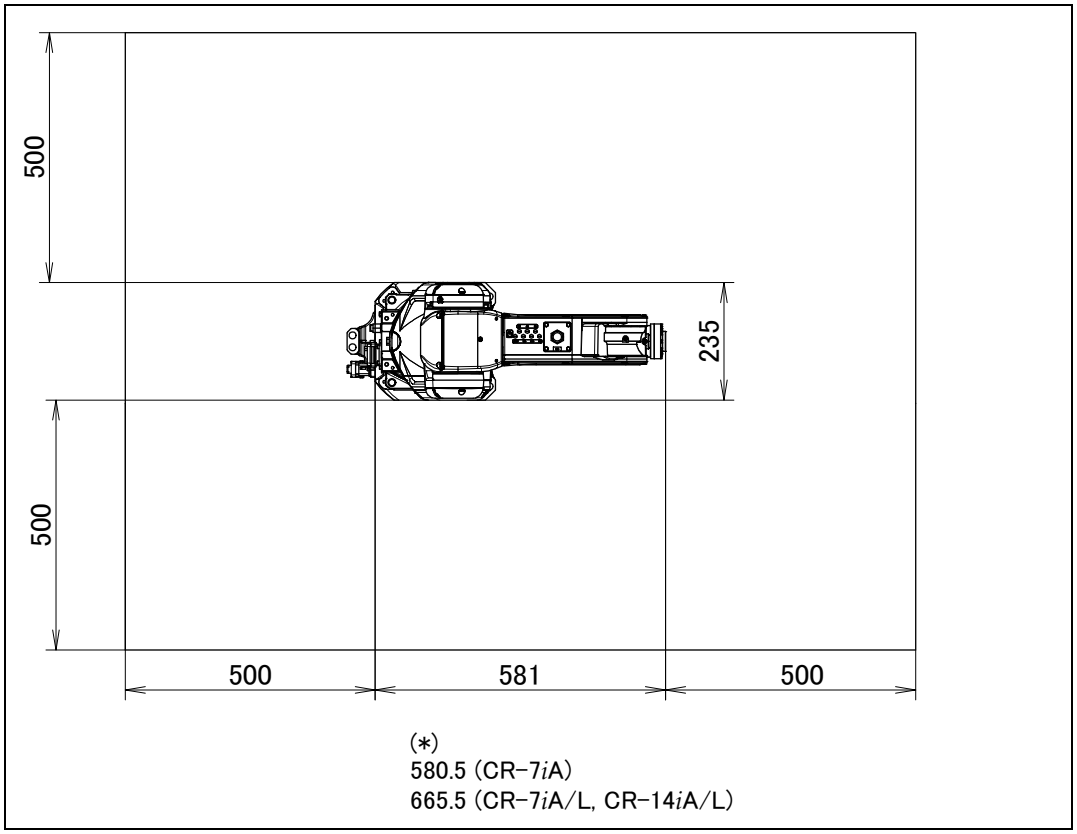


Fig. 1.3 (b) Maintenance area (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

1.4 INSTALLATION CONDITIONS

Refer to caution below about installation conditions.
Refer to specifications of Section 3.1 and Section 3.2 too.

> ⚠ **CAUTION**
> The damage of coating of robot connection cable and external battery cable causes the flood. Please note handling enough when setting it up, and exchange it when damaging.

2 CONNECTION WITH THE CONTROLLER

2.1 CONNECTION WITH THE CONTROLLER

The robot is connected with the controller via the power cable, signal cable, force sensor cable and earth line. Connect these cables to the connectors on the back of the robot base.
Please be sure to connect the earth cable.
For details on air and option cables, see Chapter 5.

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

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

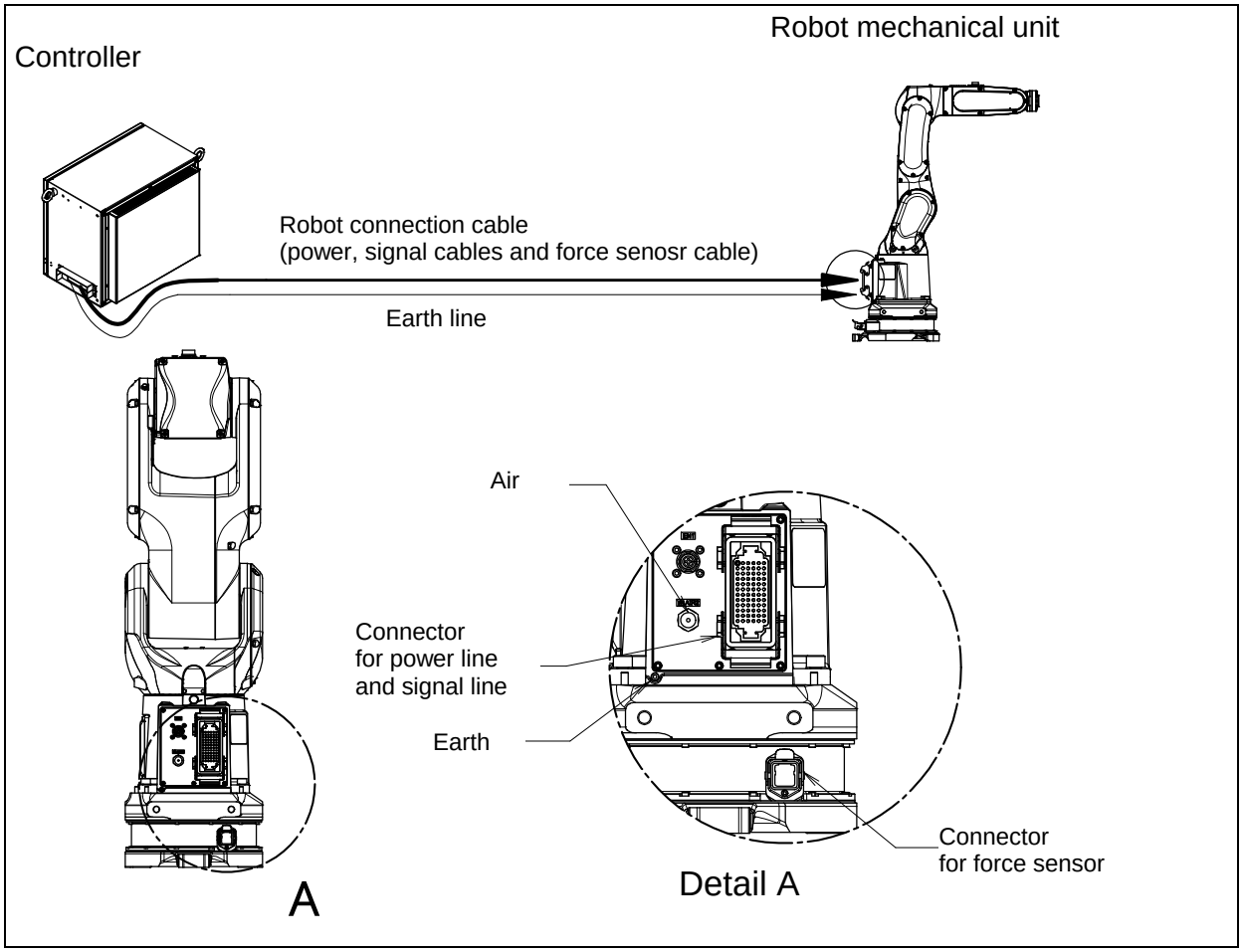


Fig. 2.1 (a) Cable connection

3 BASIC SPECIFICATIONS

3.1 ROBOT CONFIGURATION

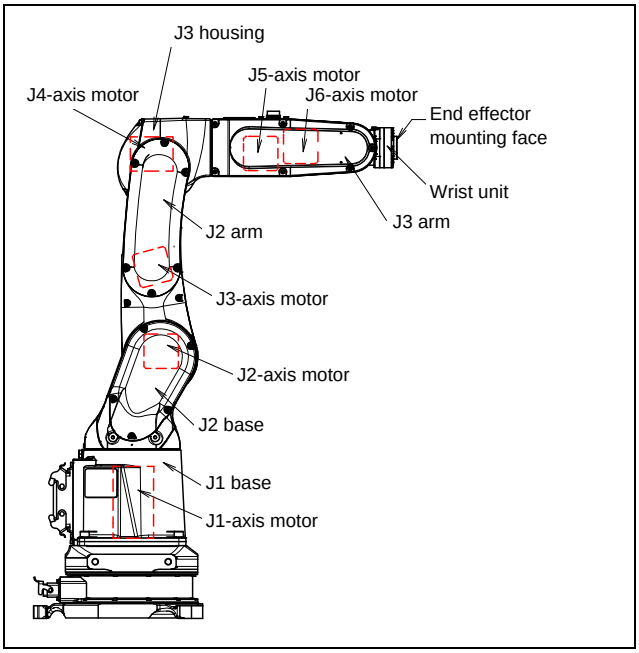


Fig. 3.1 (a) Mechanical unit configuration

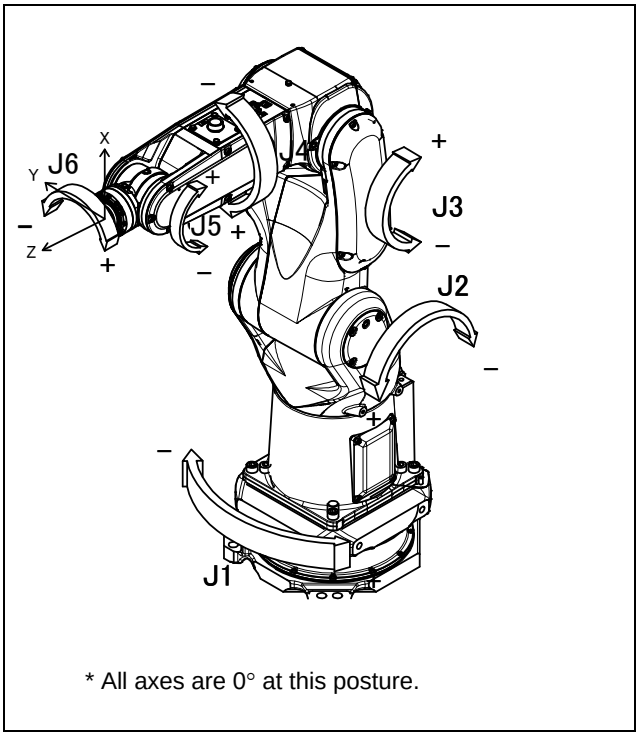


Fig. 3.1 (b) Each axis coordinates and mechanical interface coordinates

NOTE
The end effector mounting face center is 0, 0, 0 of the mechanical interface coordinates.

Specifications (NOTE 1) (1/2)

Item		Specification	
Model		CR-4*i*A	CR-7*i*A
Type		Articulated Type	
Controlled axis		6-axis (J1, J2, J3, J4, J5, J6)	
Reach		550mm	717mm
Installation (NOTE 2)		Floor, Upside-down, Angle mount	
Motion range	J1-axis	340°/360° (option) 5.93rad/6.28rad (option)	340°/360° (option) 5.93rad/6.28rad (option)
	J2-axis	150° 2.61rad	166° 2.90rad
	J3-axis	354° 6.17rad	374° 6.52rad
	J4-axis	380° 6.63rad	380° 6.63rad
	J5-axis	200° 3.49rad	240° 4.18rad
	J6-axis	720° 12.57rad	720° 12.57rad
Max. speed (NOTE 3, NOTE 4)		1000mm/s	
Max. load capacity (NOTE 5)	Wrist	Max. 4 kg	Max.7 kg
Allowable load moment at wrist	J4-axis	8.86Nm	16.6Nm
	J5-axis	8.86Nm	16.6Nm
	J6-axis	4.90Nm	9.4Nm
Allowable load inertia at wrist	J4-axis	0.20 kg·m^2	0.47 kg·m^2
	J5-axis	0.20 kg·m^2	0.47 kg·m^2
	J6-axis	0.067 kg·m^2	0.15 kg·m^2
Drive method		Electric servo drive by AC servo motor	
Repeatability (NOTE 6)		±0.01mm	
Mass (NOTE 7)		48kg	53kg
Dust proof and drip proof mechanism (NOTE 8)		Conform to IP67	
Acoustic noise level		64.7dB (NOTE 9)	
Installation environment		Ambient temperature:0 to 45°C (NOTE 10) 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 required, no particular provision for posture. Free of corrosive gases (NOTE 11) Vibration acceleration : 4.9m/s^2 (0.5G) or less (NOTE 12) Environment without fire	

NOTE 1) Even if the robot is used according to the defined specifications, motion programs might shorten reducer life or cause the robot to overheat. Use ROBOGUIDE for further evaluation before running production.

NOTE 2) For CR-7*i*A, in case of wall mount, the operating space is restricted depending on the payload. Please refer to Section 3.6. There is no restriction for CR-4*i*A.

NOTE 3) During short distance motions, the axis speed may not reach the maximum value stated.

NOTE 4) It is necessary to set a motion speed according to risk assessment of system considering pinching with the surroundings.

NOTE 5) The mass including the equipment and connection cables and its swing must not exceed this value when you install the equipment. Refer to Section 3.5.

NOTE 6) Compliant with ISO9283.

NOTE 7) It doesn't contain the mass of the control part.

NOTE 8) Any liquid that might deteriorate the seal material such as Organic solvent, acid, any alkali and chlorine system, or a cutting liquid cannot be used.(See Section 3.1.1.)

NOTE 9) This value is the equivalent continuous A-weighted sound pressure level that applied with ISO11201 (EN31201). This value is measured with the following conditions.
- Maximum load and speed
- Operating mode is AUTO

NOTE 10) When robot is used in low temperature environment that is near to 0ºC, or robot is not operated for a long time in the environment that is less than 0ºC in a holiday or the night, because viscous resistance of the drive train is so big that may cause occurrence of collision detect alarm (SRVO –050) etc. In this case, we recommend performing the warm up operation for several minutes.

NOTE 11) 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.

NOTE 12) Depending on the vibration of the floor or the hand, the robot may stop when vibration is less than this value.

Specifications (NOTE 1) (2/2)

Item		Specification	
Model		CR-7*i*A/L	CR-14*i*A/L
Type		Articulated Type	
Controlled axis		6-axis (J1, J2, J3, J4, J5, J6)	
Reach		911mm	911mm (load capacity < 12kg) 820mm (load capacity ≧12kg)
Installation (NOTE 2)		Floor, Upside-down, Angle mount	
Motion range	J1-axis	340°/360° (option) 5.93rad/6.28rad (option)	
	J2-axis	166° 4.28rad	
	J3-axis	383° 6.70rad	
	J4-axis	380° 6.63rad	
	J5-axis	240° 4.18rad	
	J6-axis	720° 12.57rad	
Max. speed (NOTE 3, NOTE 4)		1000mm/s	500mm/s
Max. load capacity (NOTE 5)	Wrist	Max.7 kg	Max. 14 kg
Allowable load moment at wrist	J4-axis	16.6Nm	31.0Nm
	J5-axis	16.6Nm	31.0Nm
	J6-axis	9.4Nm	13.4Nm
Allowable load inertia at wrist	J4-axis	0.47 kg·m^2	0.66 kg·m^2
	J5-axis	0.47 kg·m^2	0.66 kg·m^2
	J6-axis	0.15 kg·m^2	0.30 kg·m^2
Drive method		Electric servo drive by AC servo motor	
Repeatability (NOTE 6)		±0.01mm	
Mass (NOTE 7)		55kg	
Dust proof and drip proof mechanism (NOTE 8)		Conform to IP67	
Acoustic noise level		64.7dB (NOTE 9)	
Installation environment		Ambient temperature:0 to 45°C (NOTE 10) 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 required, no particular provision for posture. Free of corrosive gases (NOTE 11) Vibration acceleration : 4.9m/s^2 (0.5G) or less (NOTE 12) Environment without fire	

NOTE 1) Even if the robot is used according to the defined specifications, motion programs might shorten reducer life or cause the robot to overheat. Use ROBOGUIDE for further evaluation before running production.

NOTE 2) For CR-7*i*A/L, CR-14*i*A/L, in case of wall mount, the operating space is restricted depending on the payload. Please refer to Section 3.6.

NOTE 3) During short distance motions, the axis speed may not reach the maximum value stated.

NOTE 4) It is necessary to set a motion speed according to risk assessment of system considering pinching with the surroundings.

NOTE 5) The mass including the equipment and connection cables and its swing must not exceed this value when you install the equipment. Refer to Section 3.5.

NOTE 6) Compliant with ISO9283.

NOTE 7) It doesn't contain the mass of the control part.

NOTE 8) Any liquid that might deteriorate the seal material such as Organic solvent, acid, any alkali and chlorine system, or a cutting liquid cannot be used.(See Section 3.1.1.)

NOTE 9) This value is the equivalent continuous A-weighted sound pressure level that applied with ISO11201 (EN31201). This value is measured with the following conditions.
- Maximum load and speed
- Operating mode is AUTO

NOTE 10) When robot is used in low temperature environment that is near to 0ºC, or robot is not operated for a long time in the environment that is less than 0ºC in a holiday or the night, because viscous resistance of the drive train is so big that may cause occurrence of collision detect alarm (SRVO –050) etc. In this case, we recommend performing the warm up operation for several minutes.

NOTE 11) 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.

NOTE 12) Depending on the vibration of the floor or the hand, the robot may stop when vibration is less than this value.

3.1.1 Note of Severe Dust /Liquid Specification

1 The liquids below cannot be applied because they may cause deterioration or corrosion of the rubber parts (such as gaskets, oil seals, and O-rings) used in the robot. (As exception to this only liquids tested and approved by FANUC can be used with the robot.)
   (a) Organic solvent
   (b) Chlorine-based cutting fluid
   (c) Amine-based cleaning fluid
   (d) Liquid or solution that includes a corrosive such as an acid or alkali or causes rust
   (e) Some other liquid or solution to which nitrile rubber (NBR) does not have resistance
2 When the robot is used in an environment where a liquid such as water is splashed over the robot, great attention should be given to drainage under the J1 base. A failure might occur if the J1 base is kept immersed in water due to poor drainage.
3 Please replace any gasket, which is removed during the component replacement and the check, with a new one.
4 If a liquid is unknown, do not use it on the robot.

3.2 MECHANICAL UNIT OPERATION AREA AND INTERFERENCE AREA

Fig. 3.2 (a) to (d) show the robot interference area. When installing peripheral devices, be careful not to interfere with the robot and its operating space.

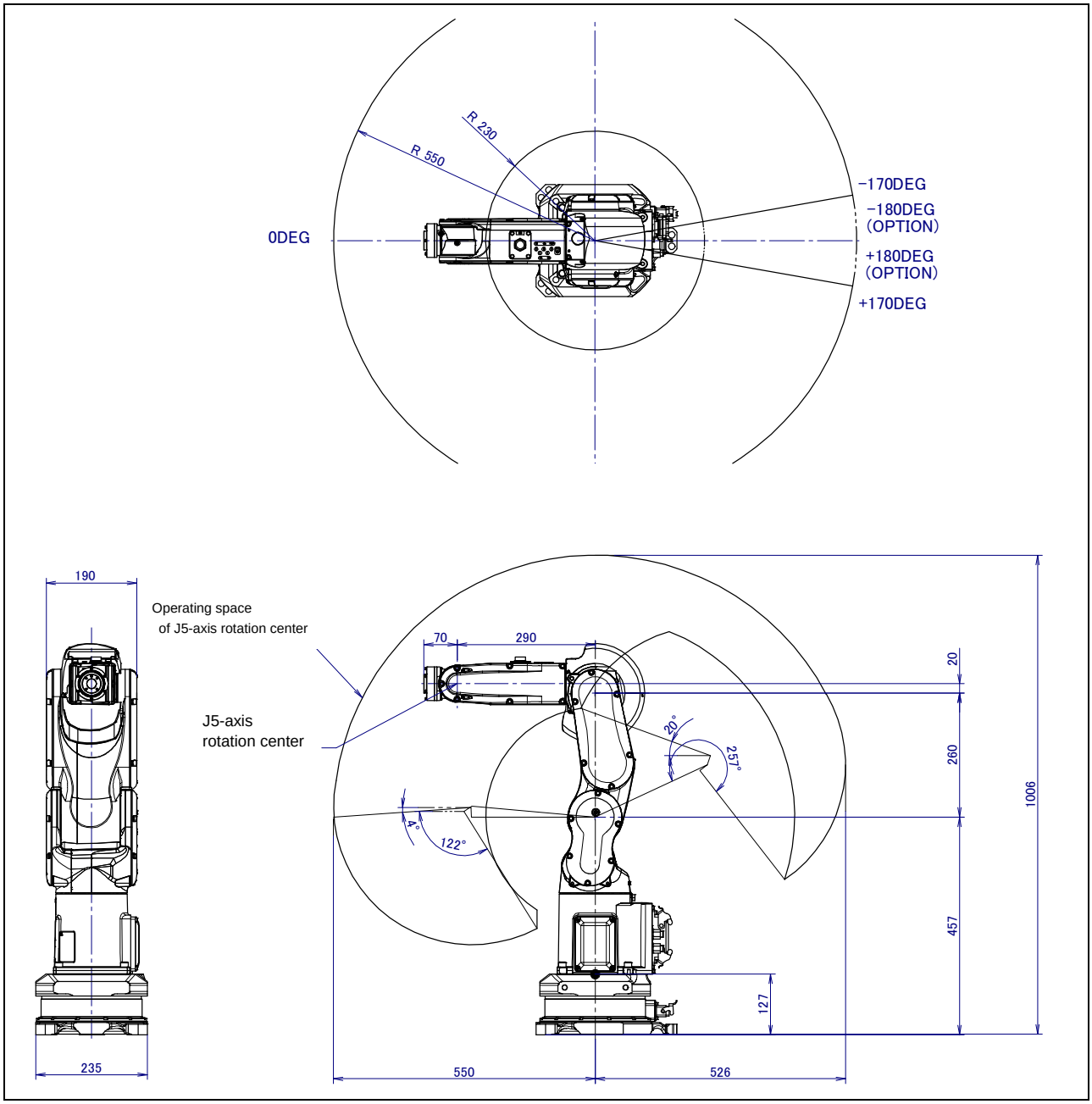


Fig. 3.2 (a) Operating space (CR-4*i*A)

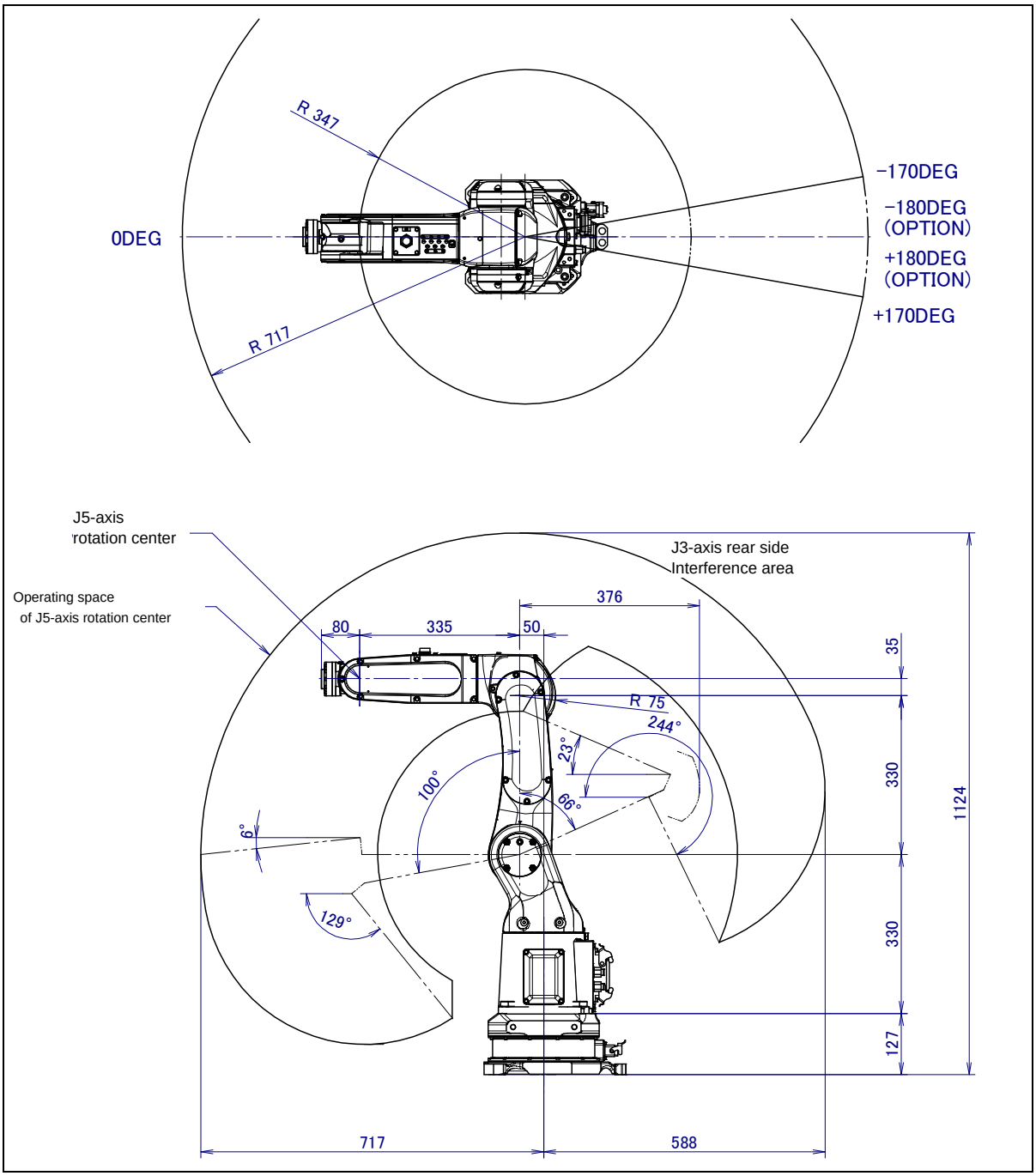


Fig. 3.2 (b) Operating space (CR-7*i*A)

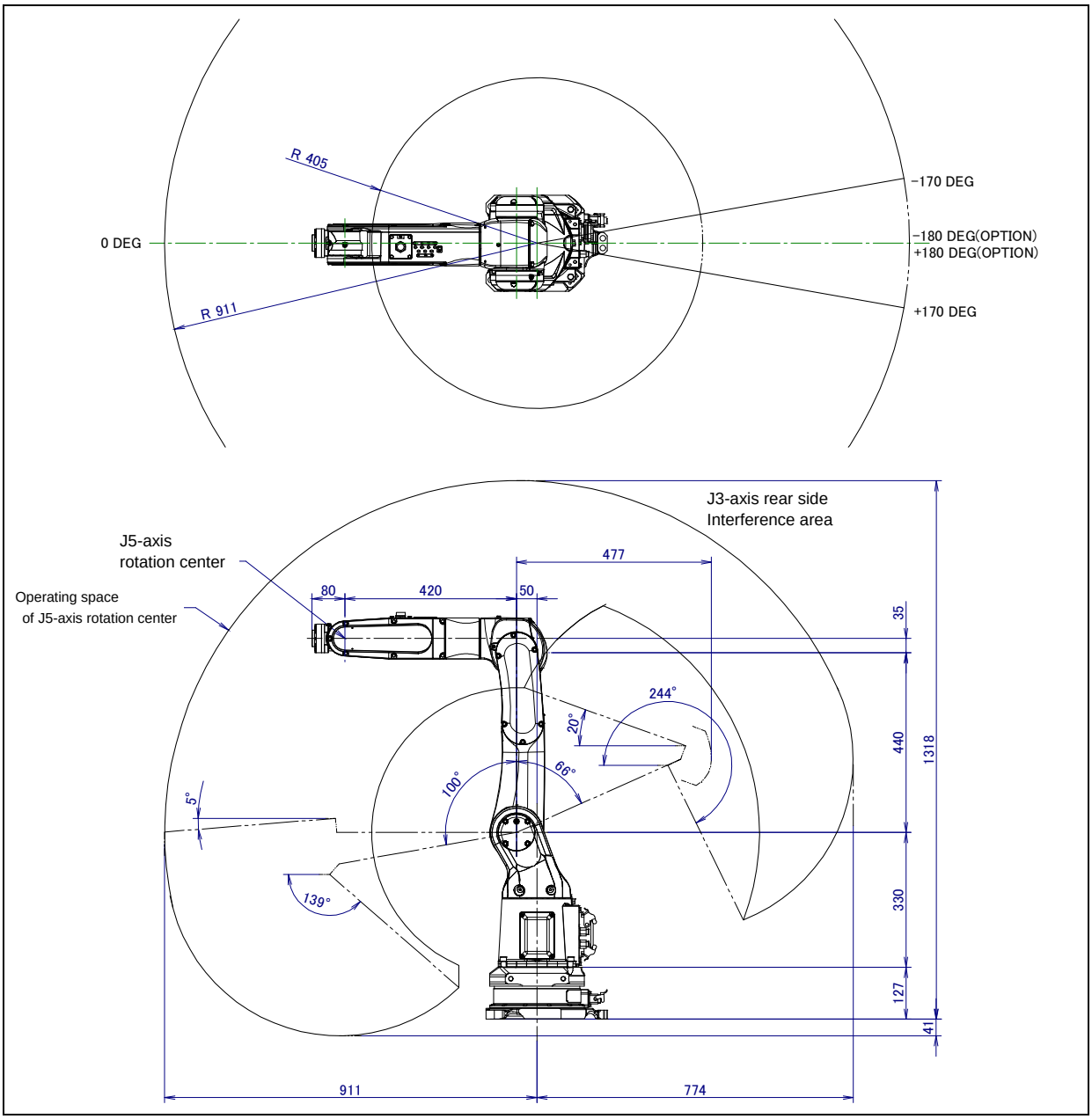


Fig. 3.2 (c) Operating space (CR-7*i*A/L)

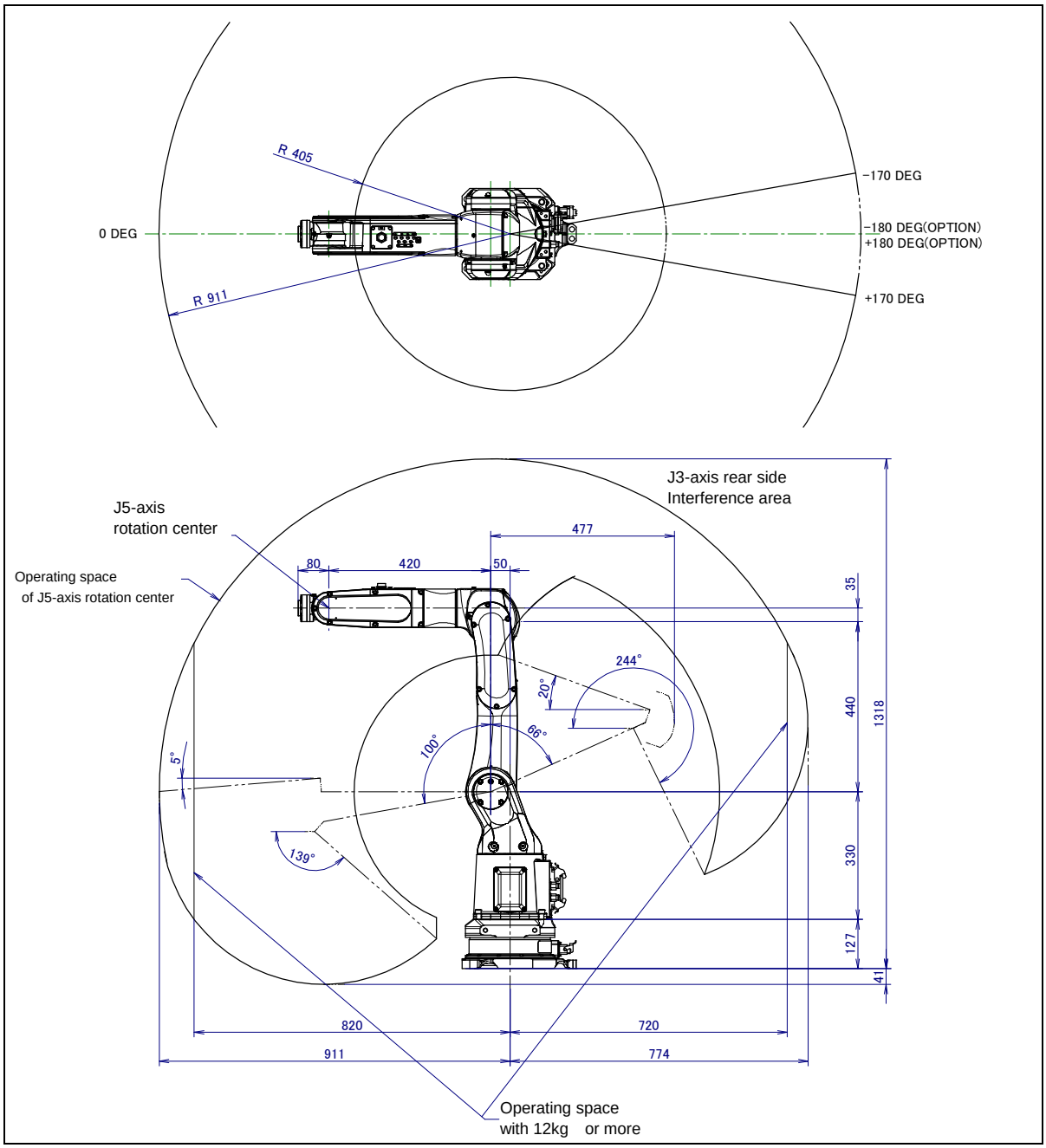


Fig. 3.2 (d) Operating space (CR-14*i*A/L)

3.3 ZERO POINT POSITION AND MOTION LIMIT

A zero point and motion range are provided for each controlled axis. Exceeding the software motion limit of a controlled axis is called overtravel (OT). Overtravel is detected at both ends of the motion limit for each axis. The robot cannot exceed the motion range unless there is a loss of the zero point position due to abnormalities in servo system or a system error. In addition, a mechanical stopper is also used to limit maximum motion and to improve safety.

Fig. 3.3 (a), (b) shows the position of the mechanical stopper. Don't reconstruct the mechanical stopper. If you do, there is a possibility that the robot will not stop normally.

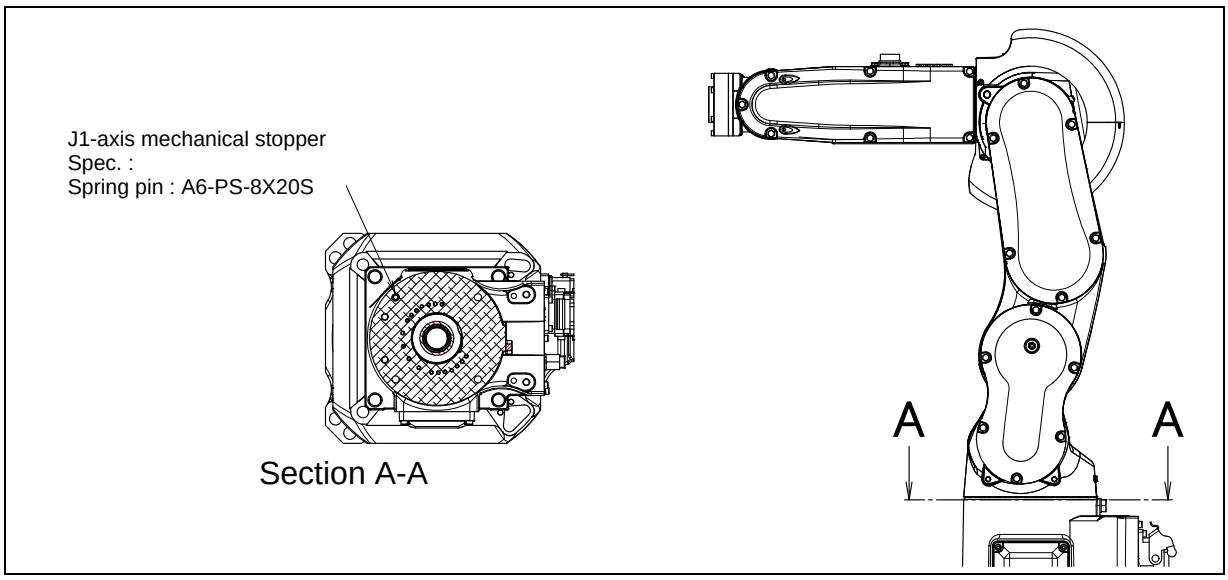


Fig. 3.3 (a) Position of mechanical stopper (CR-4*i*A)

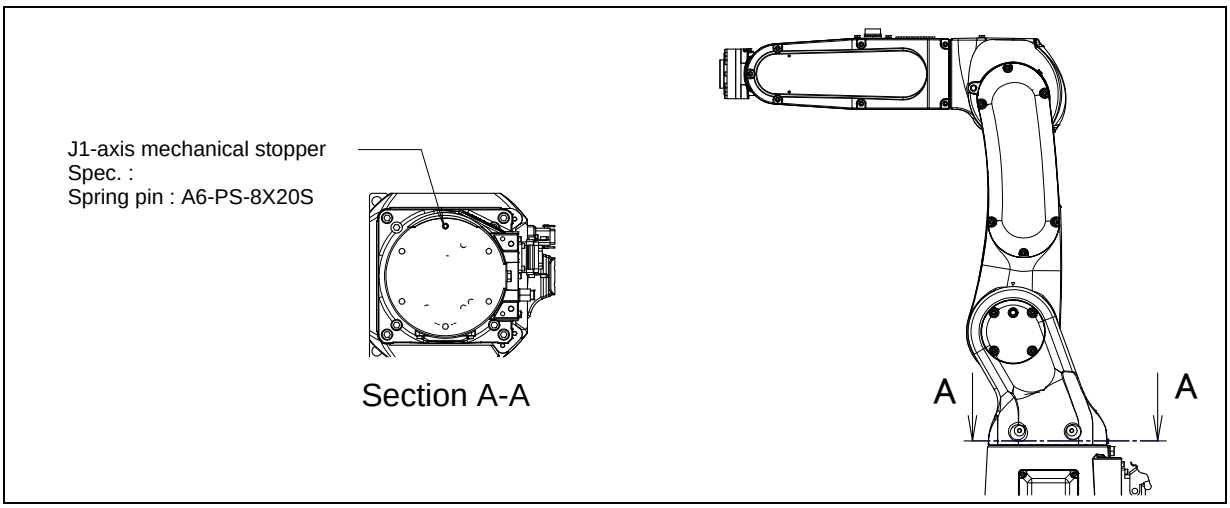


Fig. 3.3 (b) Position of mechanical stopper (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

Fig. 3.3 (c) to (l) show the zero point, motion limit and maximum stopping distance (stopping distance in condition of max speed and max load) of each axis.

Only in case of J1-axis, robot stops by transforming mechanical stopper. When the mechanical stopper is transformed, the exchange is needed. Contact FANUC about replacing J1-axis mechanical stopper.

* The motion range can be changed. For information on how to change the motion range, see Chapter 6, "AXIS LIMIT SETUP".

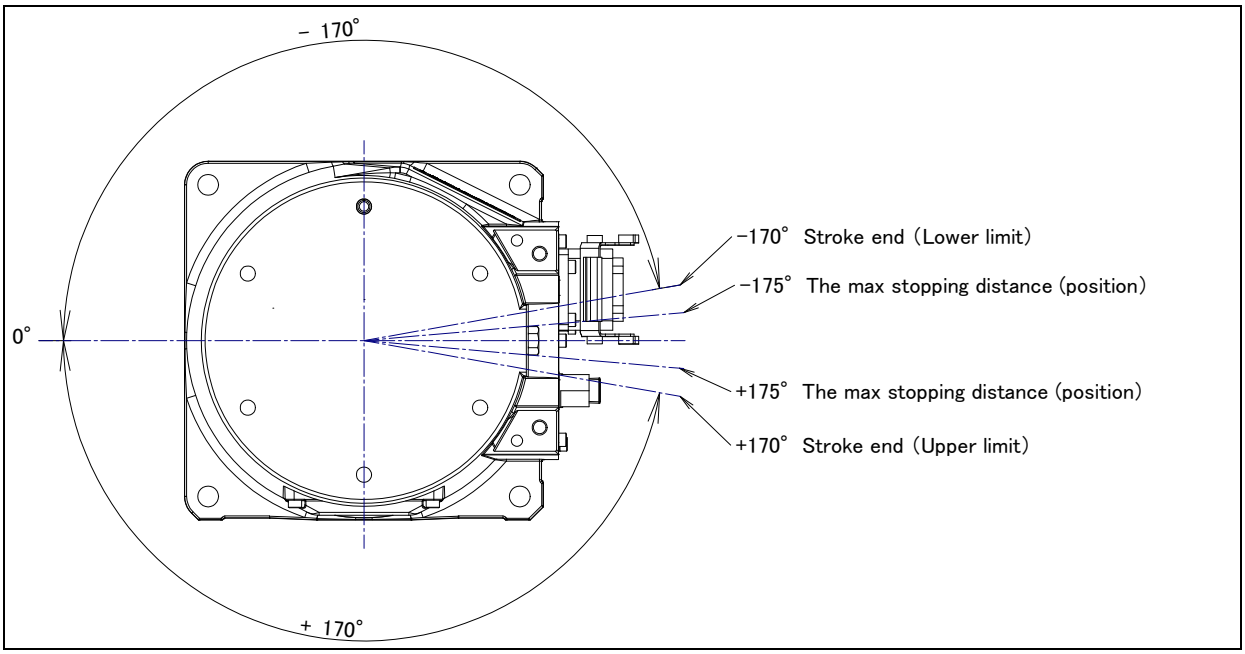


Fig. 3.3 (c) J1-axis motion limit (J1-axis 340° turn specification)

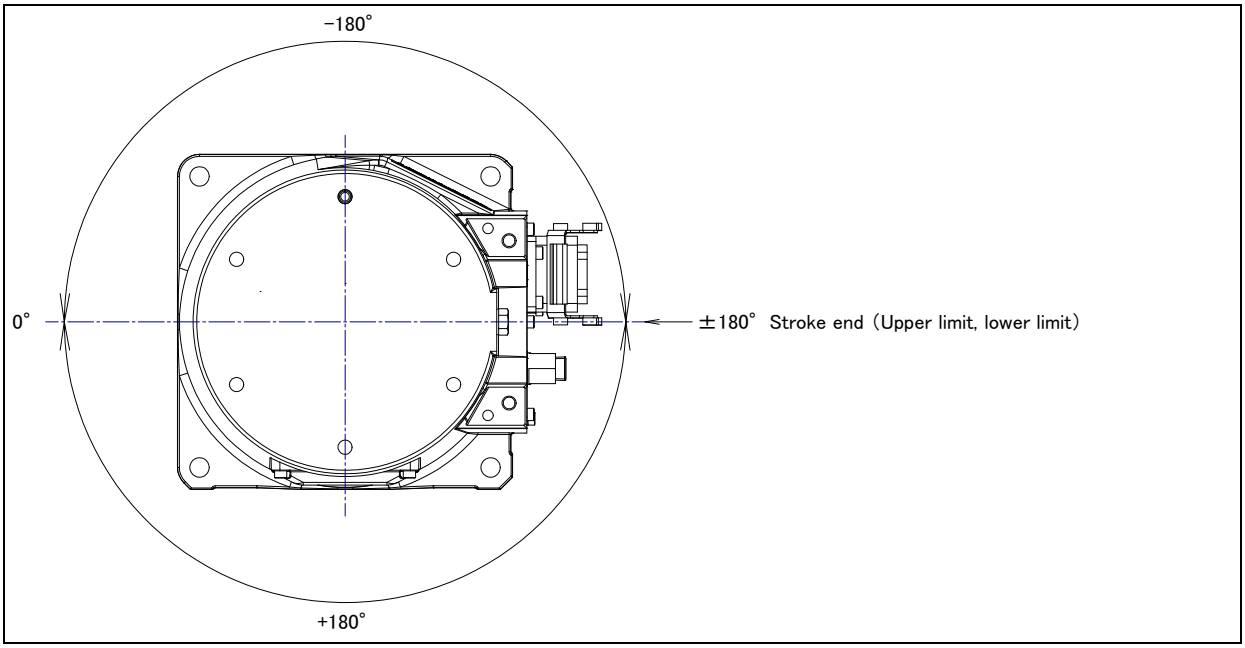


Fig. 3.3 (d) J1-axis motion limit (J1-axis 360° turn specification)

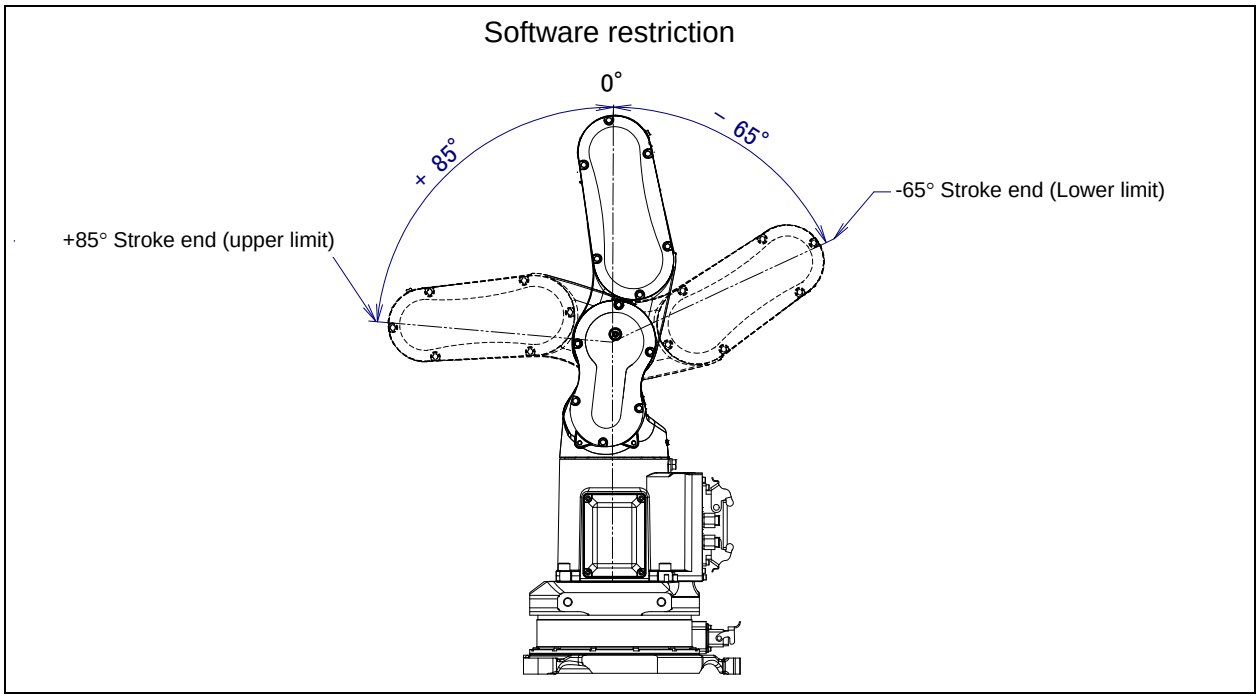


Fig. 3.3 (e) J2-axis motion limit (CR-4*i*A)

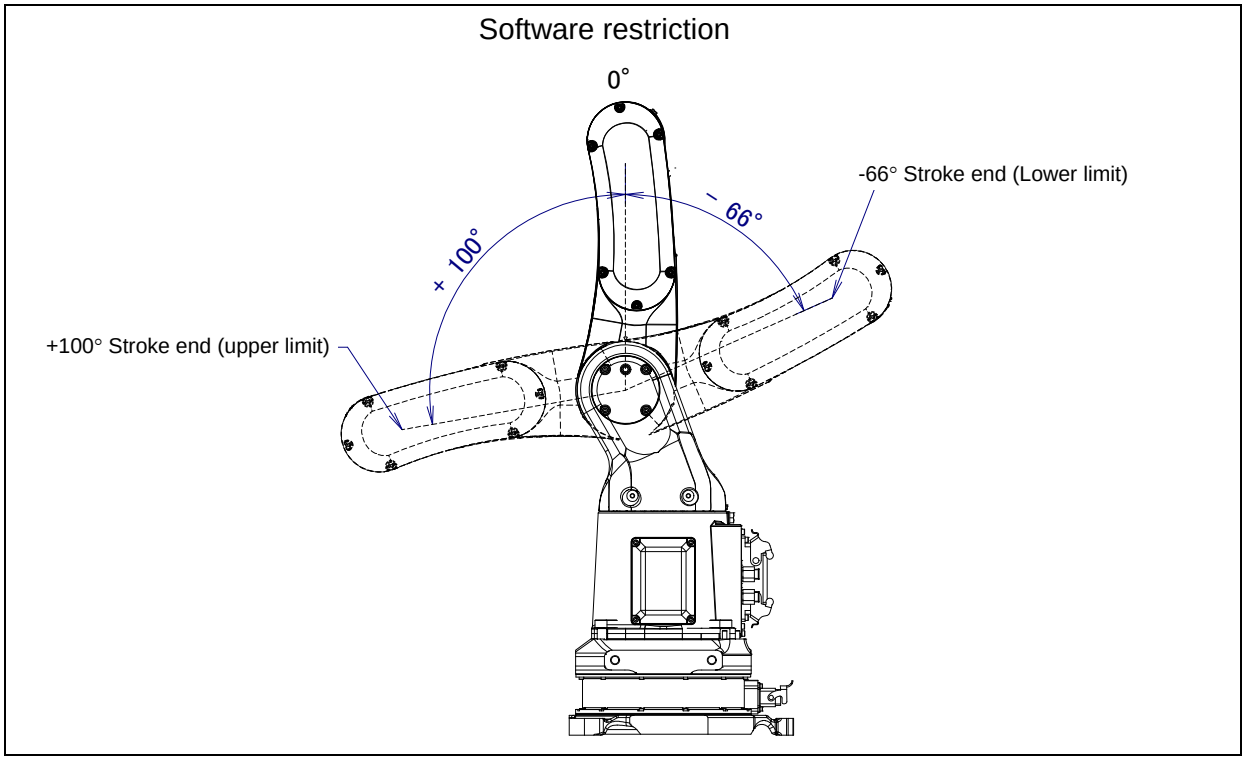


Fig. 3.3 (f) J2-axis motion limit (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

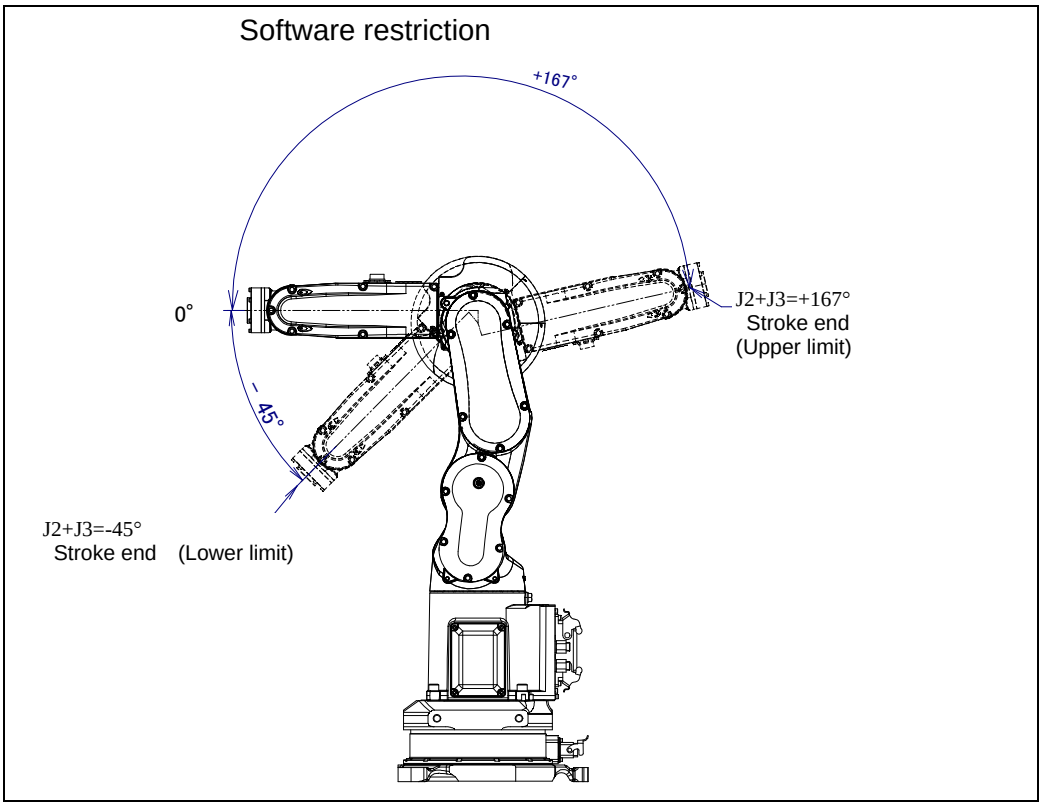


Fig. 3.3 (g) J3-axis motion limit (CR-4*i*A)

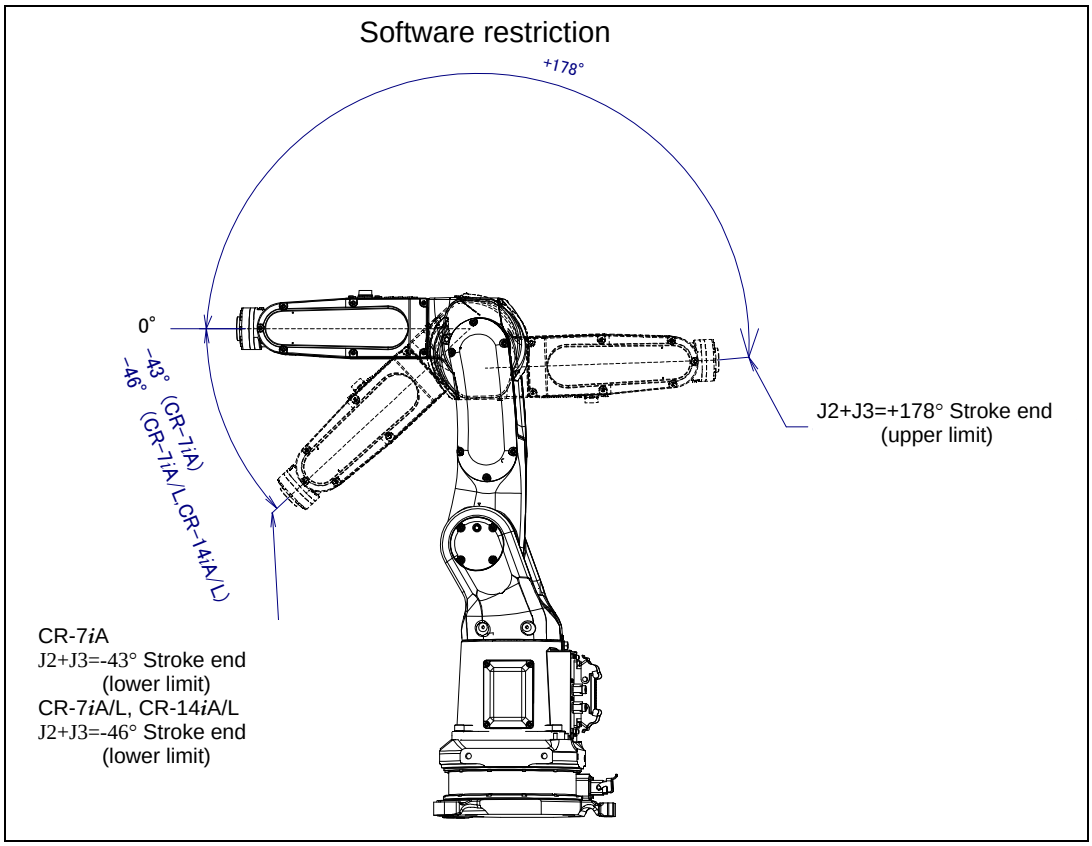


Fig. 3.3 (h) J3-axis motion limit (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

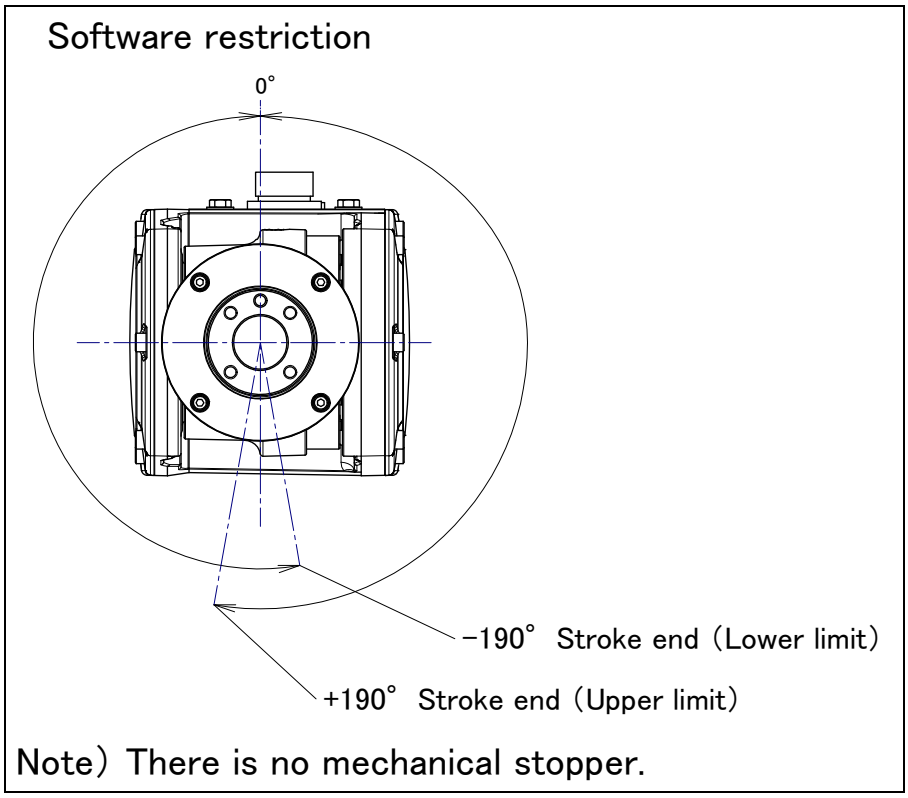


Fig. 3.3 (i) J4-axis motion limit

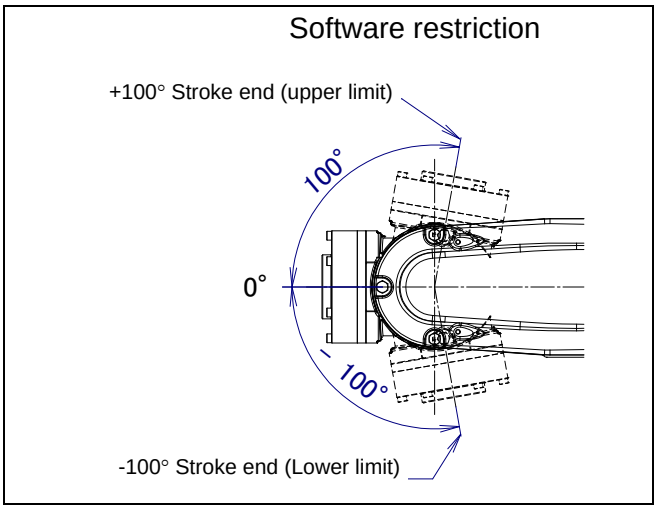


Fig. 3.3 (j) J5-axis motion limit (CR-4*i*A)

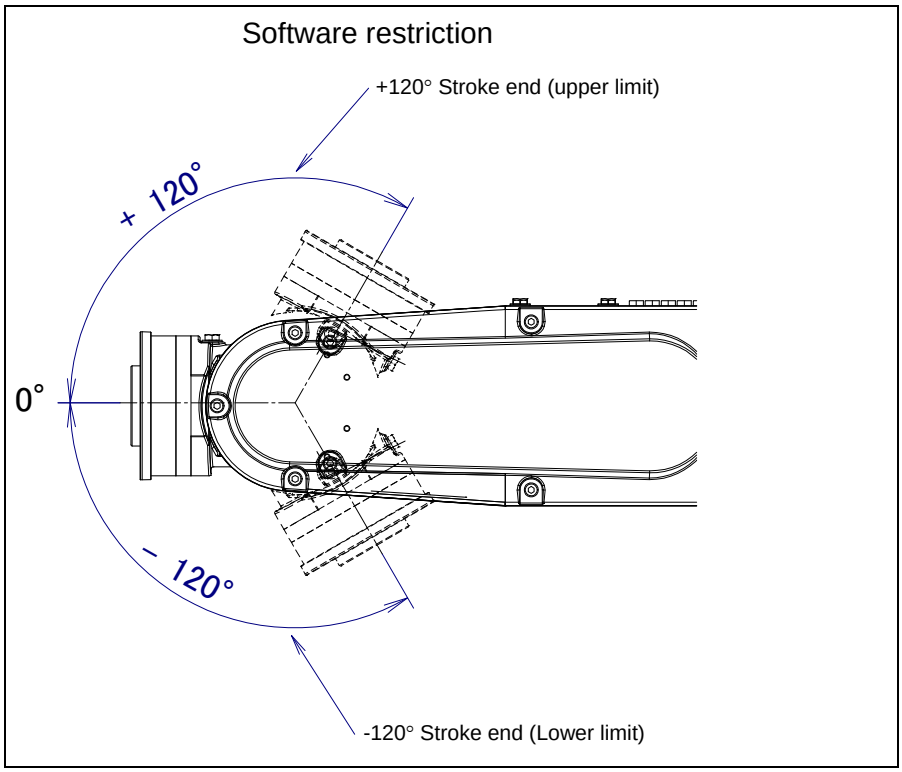


Fig. 3.3 (k) J5-axis motion limit (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

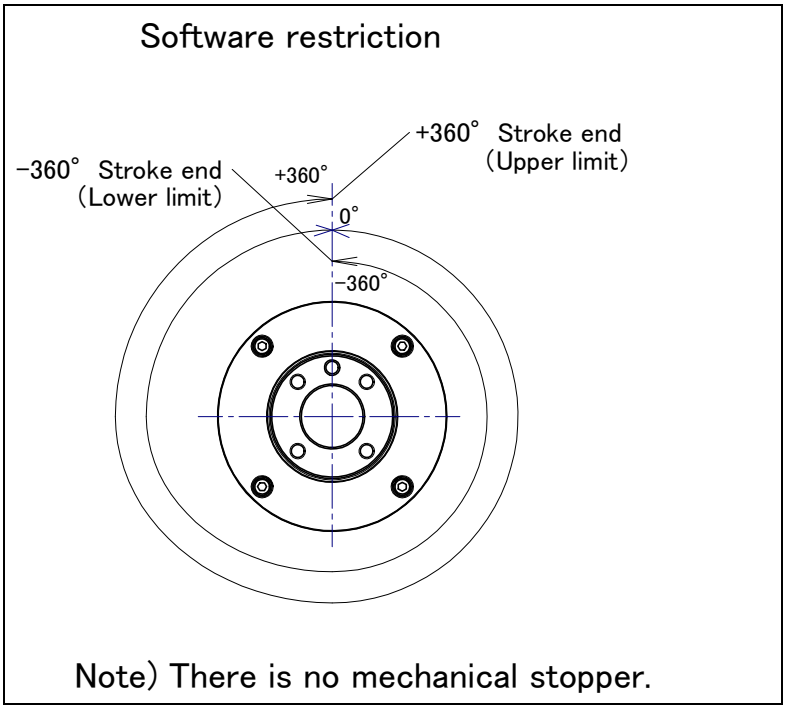


Fig. 3.3 (l) J6-axis motion limit

3.4 WRIST LOAD CONDITIONS

Fig. 3.4 (a) to (c) are diagrams to limit loads applied to the wrist.

- Apply a load within the region indicated in the graph.
- Apply the conditions of the allowable load moment and the allowable load inertia. See Section 3.1 about the allowable load moment and the allowable load inertia.
- See Section 4.1 about the mounting of an end effector.

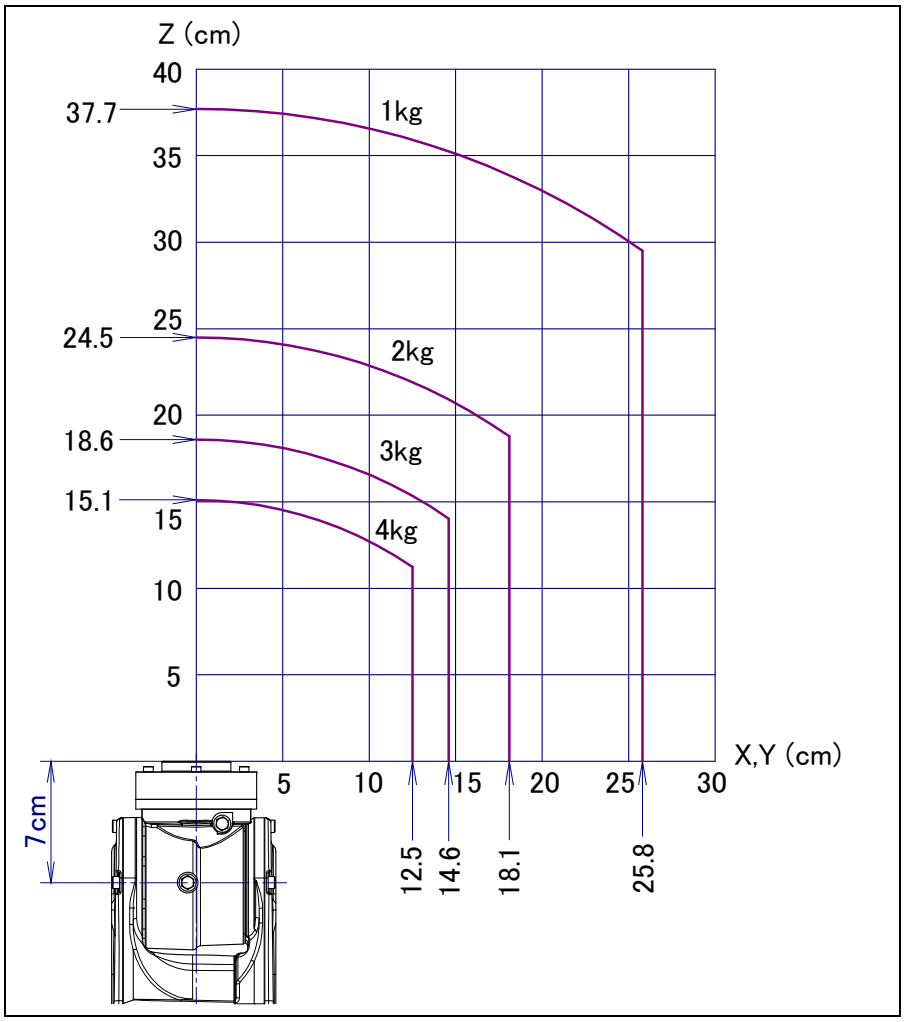


Fig. 3.4 (a) Wrist load diagram (CR-4*i*A)

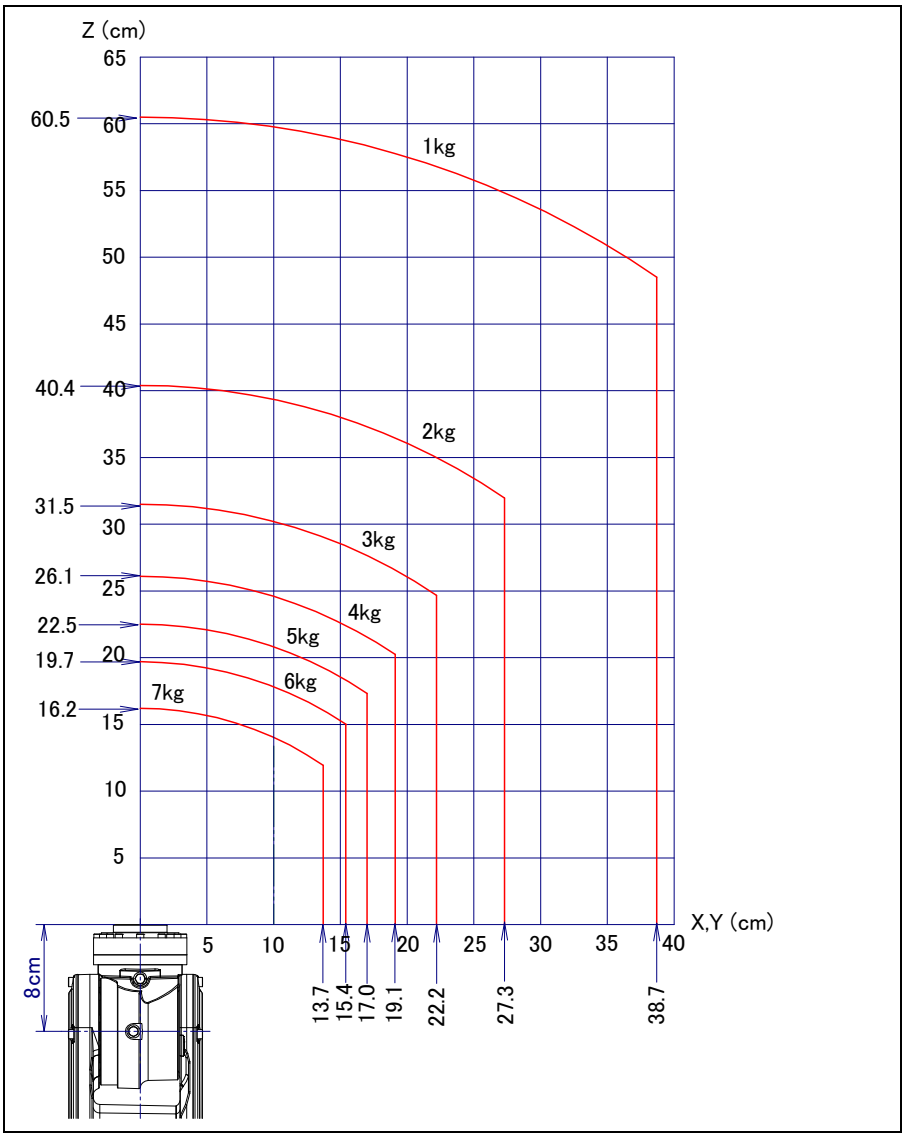


Fig. 3.4 (b) Wrist load diagram (CR-7*i*A, CR-7*i*A/L)

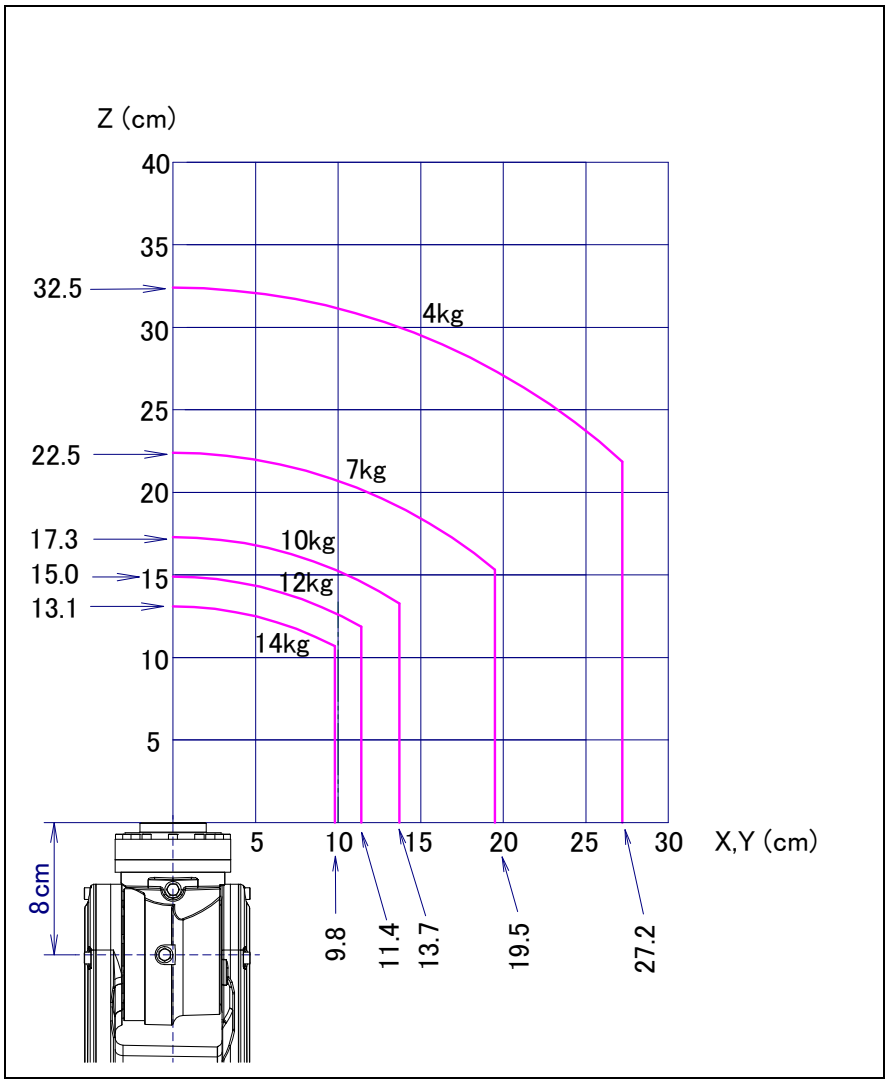


Fig. 3.4 (c) Wrist load diagram (CR-14*i*A/L)

3.5 LOAD CONDITION ON EQUIPMENT MOUNTING FACE

The equipment can be installed as shown in Fig.3.5 (a), (b).When the equipment is installed, in case of CR-4*i*A the total weight of the installed equipment, hand and work, must not exceed 4kg. In case of CR-7*i*A or CR-7*i*A/L, the total weight of the installed equipment, hand and work, must not exceed 7kg. In case of CR-14*i*A/L, the total weight of the installed equipment, hand and work, must not exceed 14kg.

Please refer to Chapter 4 for the size on the equipment installation side.

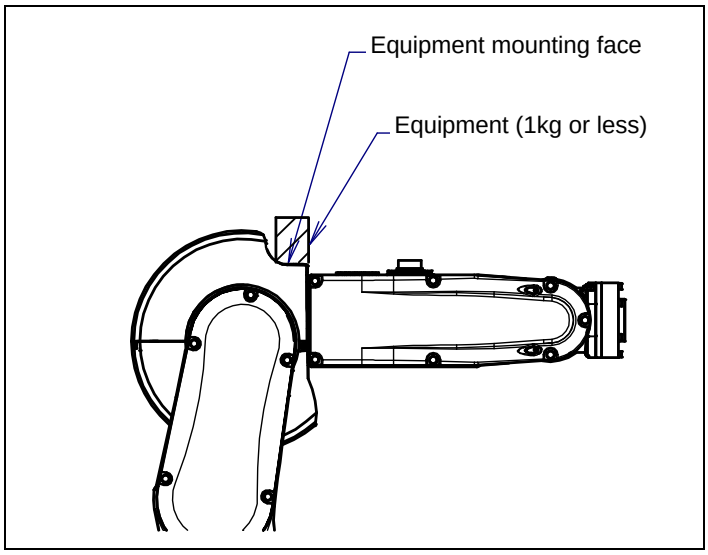


Fig. 3.5 (a) Load condition of equipment mounting face (CR-4*i*A)

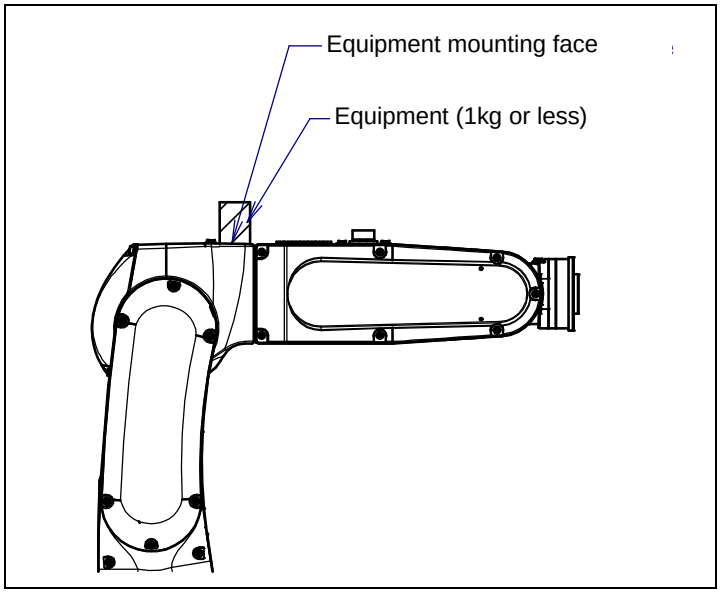


Fig. 3.5 (b) Load condition of equipment mounting face (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

3.6 OPERATING AREA FOR WALL MOUNT INSTALLATION

If applied load on the CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L exceeds the constant value (CR-7*i*A, CR-7*i*A/L:5kg, CR-14*i*A/L:7kg) when the robot is wall mount, the operating space is limited. The robot can't stop except for the ranges that are shown in the Fig. 3.6 (a) to (d). If payload is less than constant value, there is no restriction of the operating space. There is no restriction for CR-4*i*A.

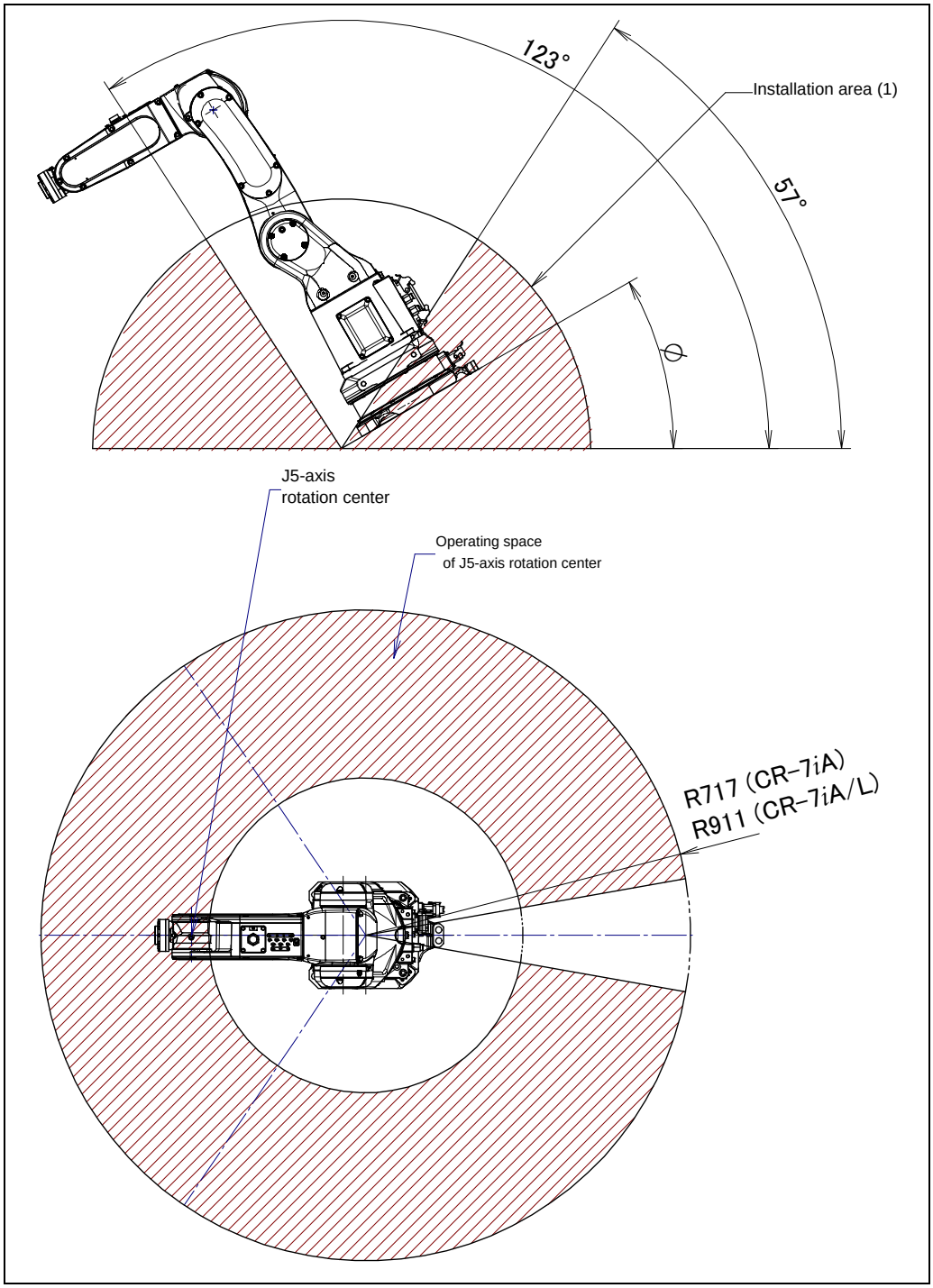


Fig. 3.6 (a) Installation area (1) Operation area (CR-7*i*A, CR-7*i*A/L)
(0°≦ϕ≦57°, 123°≦ϕ≦180°)

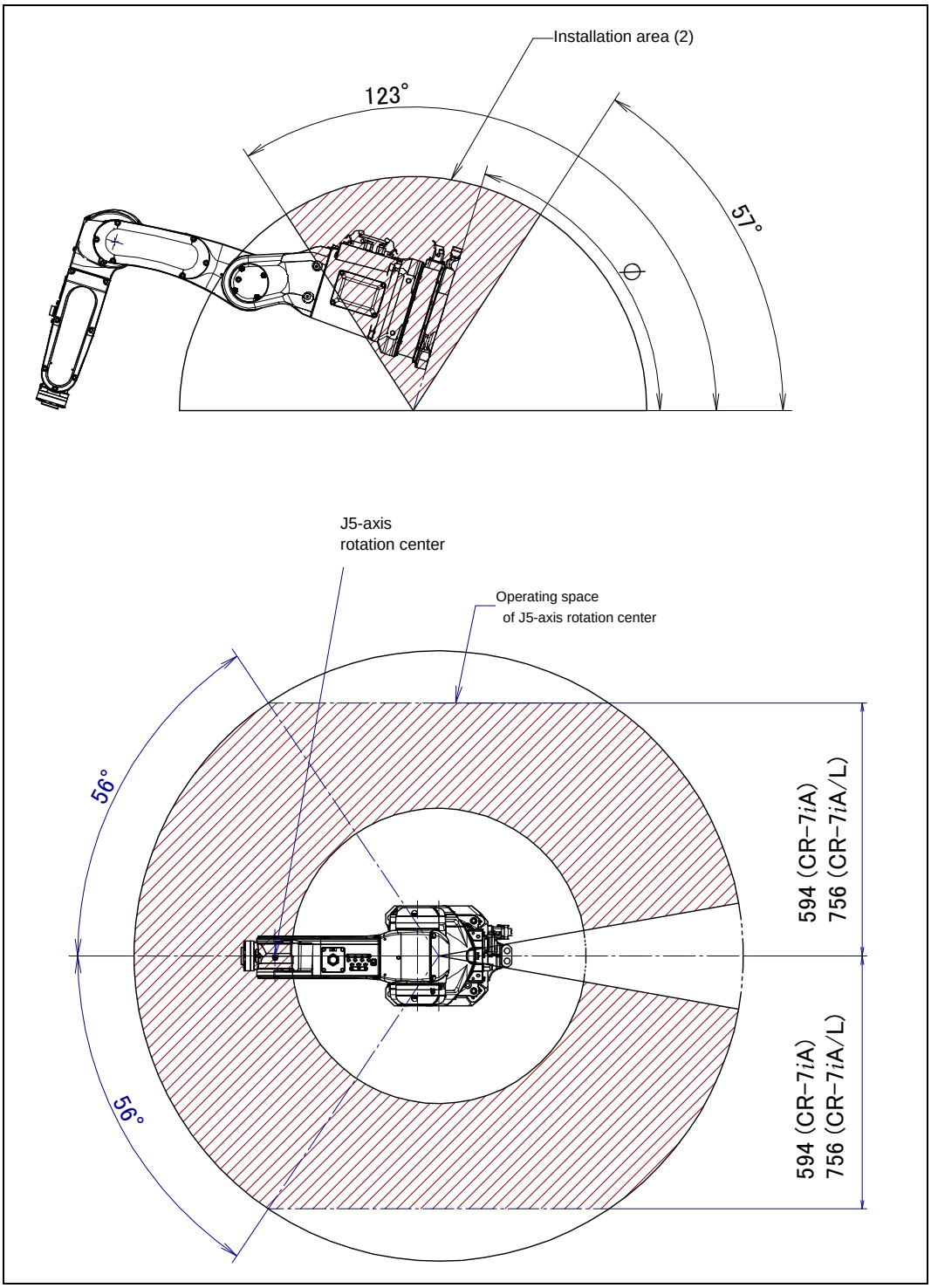


Fig. 3.6 (b) Installation area (2) Operation area (CR-7*i*A, CR-7*i*A/L) (57°<ϕ<123°)

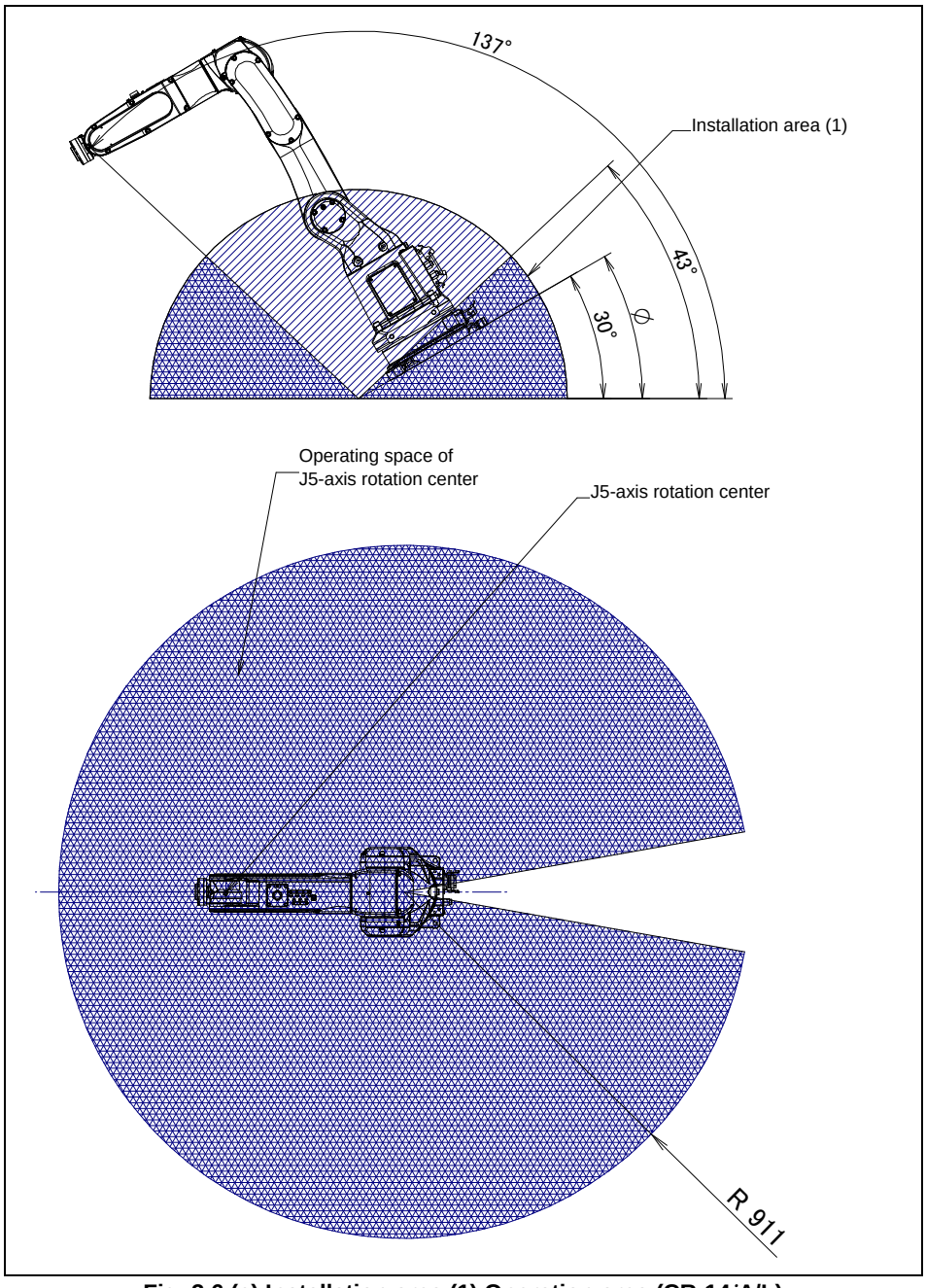


Fig. 3.6 (c) Installation area (1) Operation area (CR-14*i*A/L)
(0°≦ϕ≦57°, 123°≦ϕ≦180°)

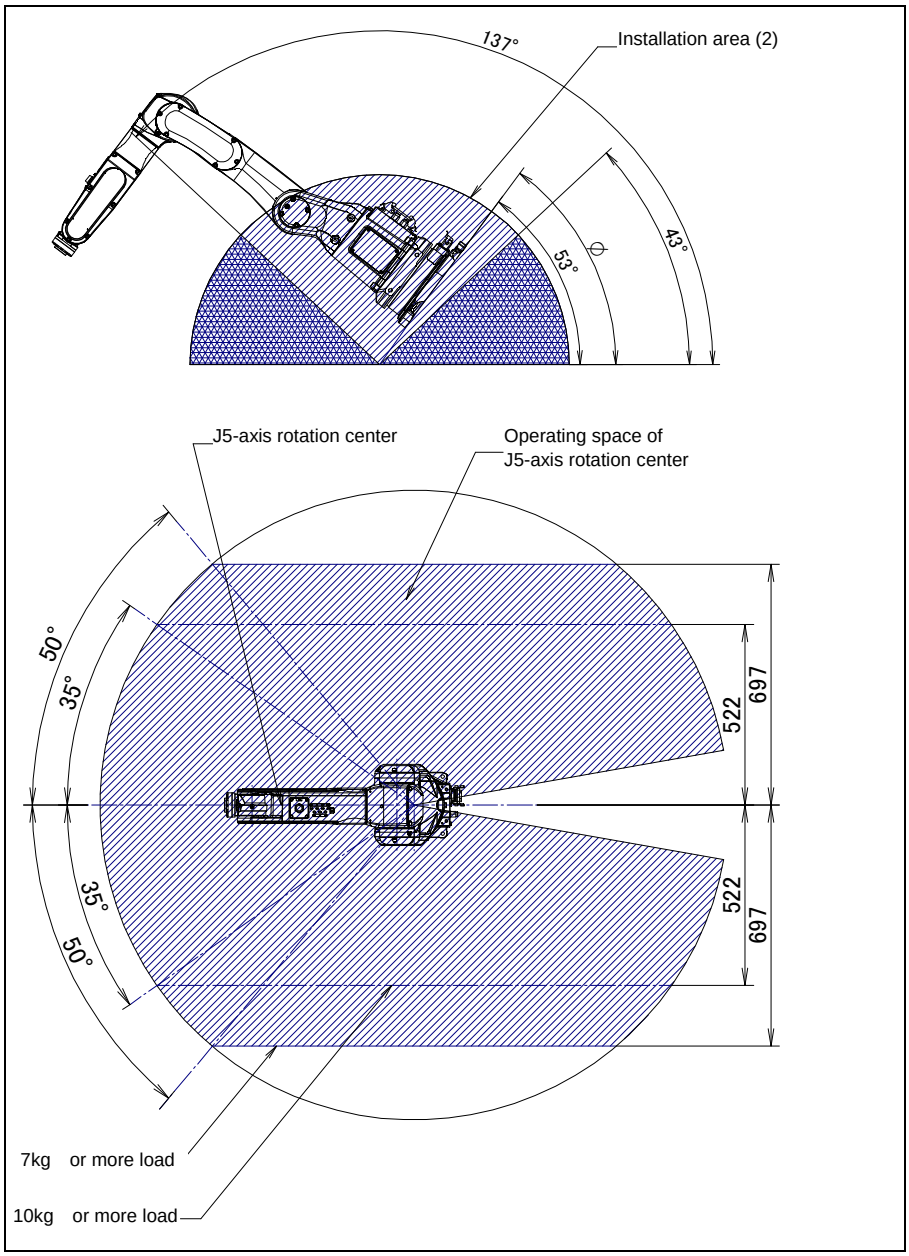


Fig. 3.6 (d) Installation area (2) Operation area (CR-14*i*A/L)
(57°<ϕ<123°)

3.7 RESTRICTION FOR OPERATION

Arc motion and Circle Arc motion are not supported on the collaborative robot series.

4 EQUIPMENT INSTALLATION TO THE ROBOT

4.1 END EFFECTOR INSTALLATION TO WRIST

Fig. 4.1 (a) to (c) are the diagrams for installing end effectors on the wrist. Select screws and positioning pins of a length that matches the depth of the tapped and pin holes. Fasten the bolt for attaching the end effector, referring to Appendix B for the tightening torque.

⚠ CAUTION
1 Notice the tooling coupling depth to wrist flange should be shorter than the flange coupling length.
2 Don't use a pin without tap for removal at wrist flange.

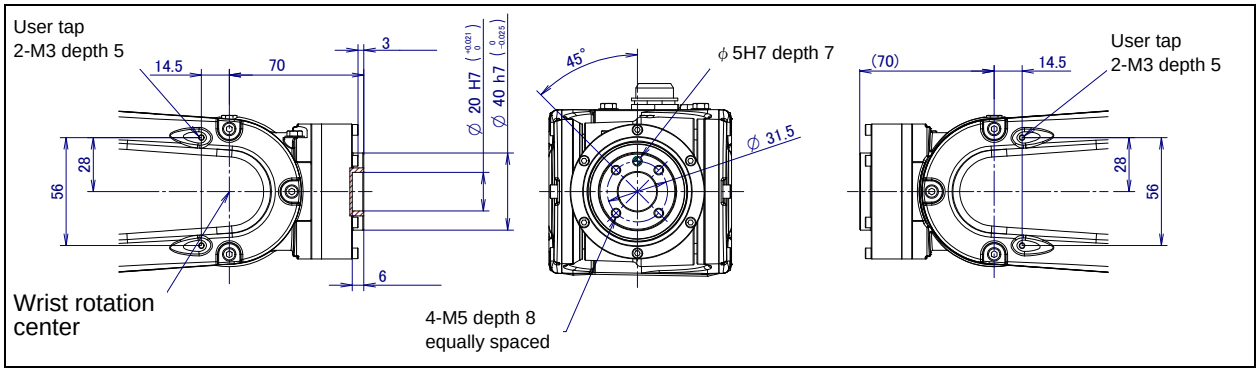


Fig. 4.1 (a) Surface for installing the end effector (CR-4*i*A)

NOTE : User tap (2-M3) is for piping and wiring to the end effector

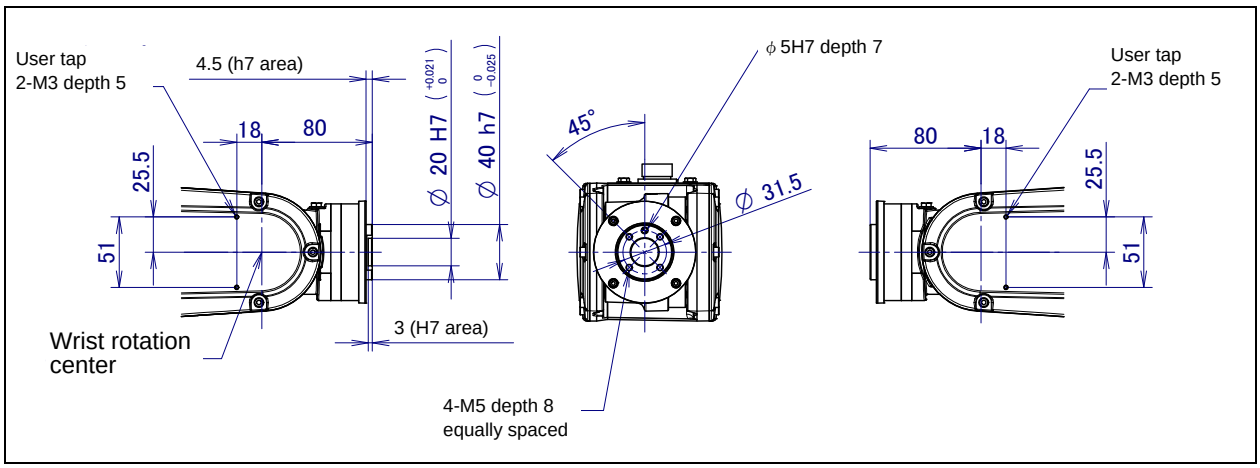


Fig. 4.1 (b) Surface for installing the end effector (CR-7*i*A, CR-7*i*A/L)

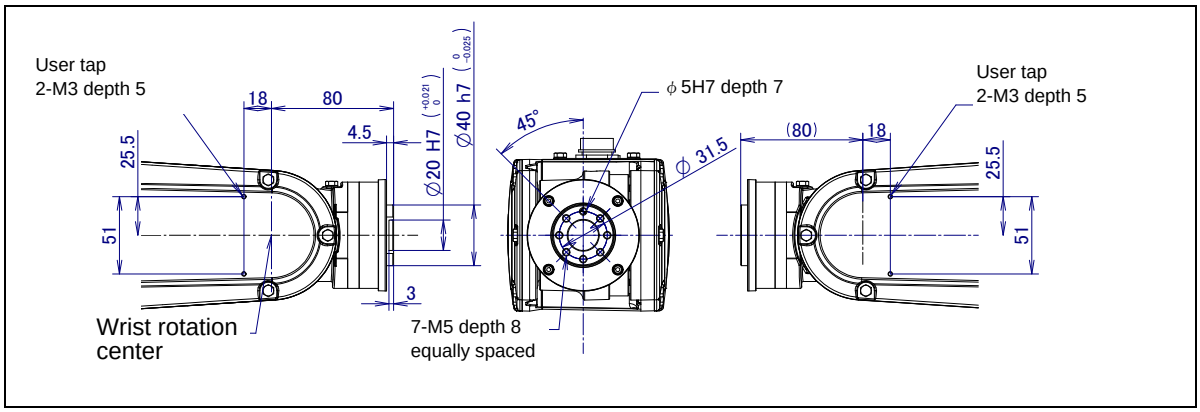


Fig. 4.1 (c) Surface for installing the end effector (CR-14*i*A/L)

NOTE : Figure is example with J6-axis reducer bolt cover (A05B-1142-J001)
User tap (2-M3) is for piping and wiring to the end effector

4.2 EQUIPMENT MOUNTING FACE

As shown in Fig. 4.2 (a), (b) tapped holes are provided to install equipment to the robot.

⚠ 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 interfere, the mechanical unit cable might be disconnected, and unexpected troubles might occur.

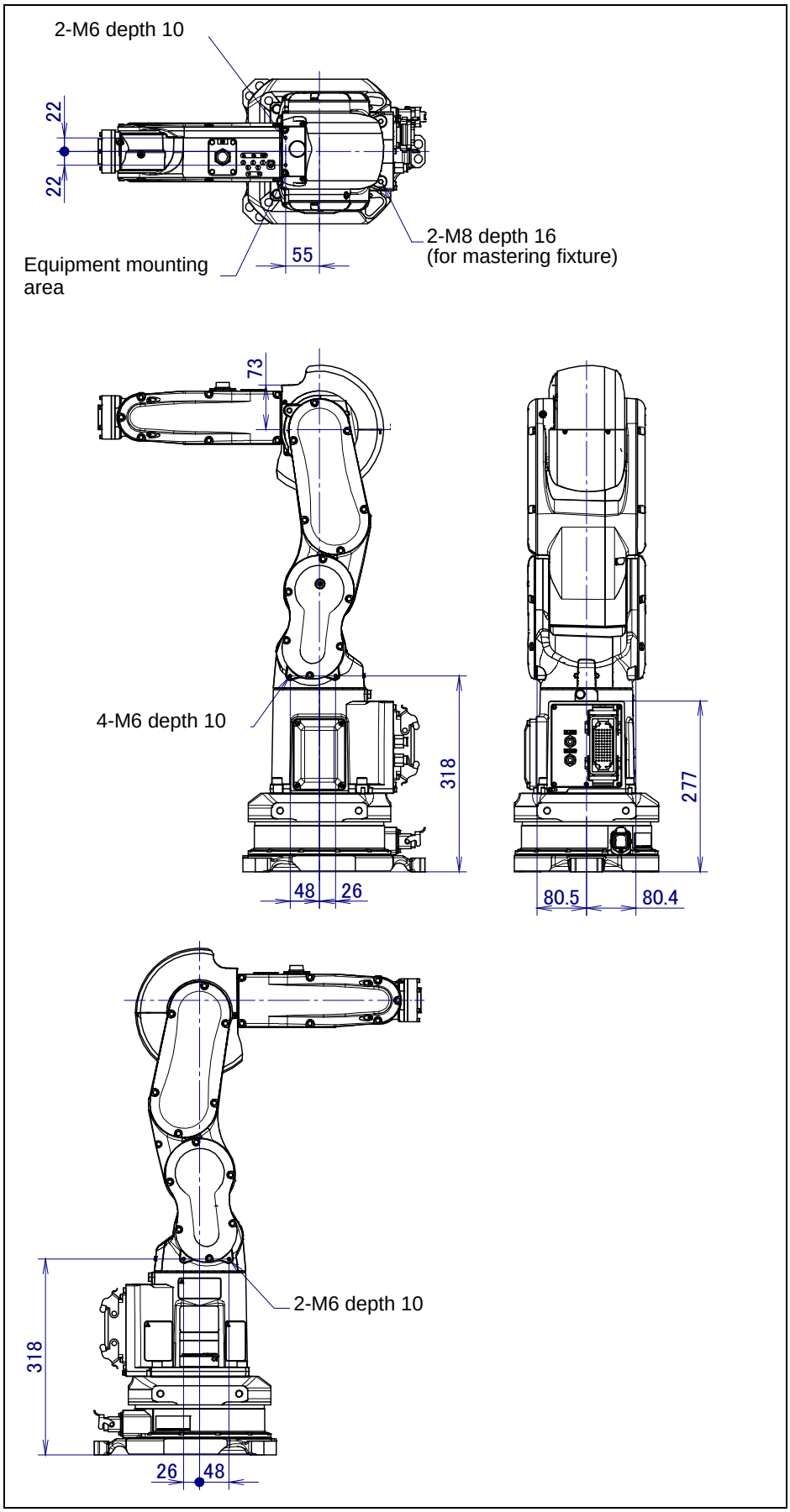


Fig. 4.2 (a) Equipment mounting faces (CR-4*i*A)

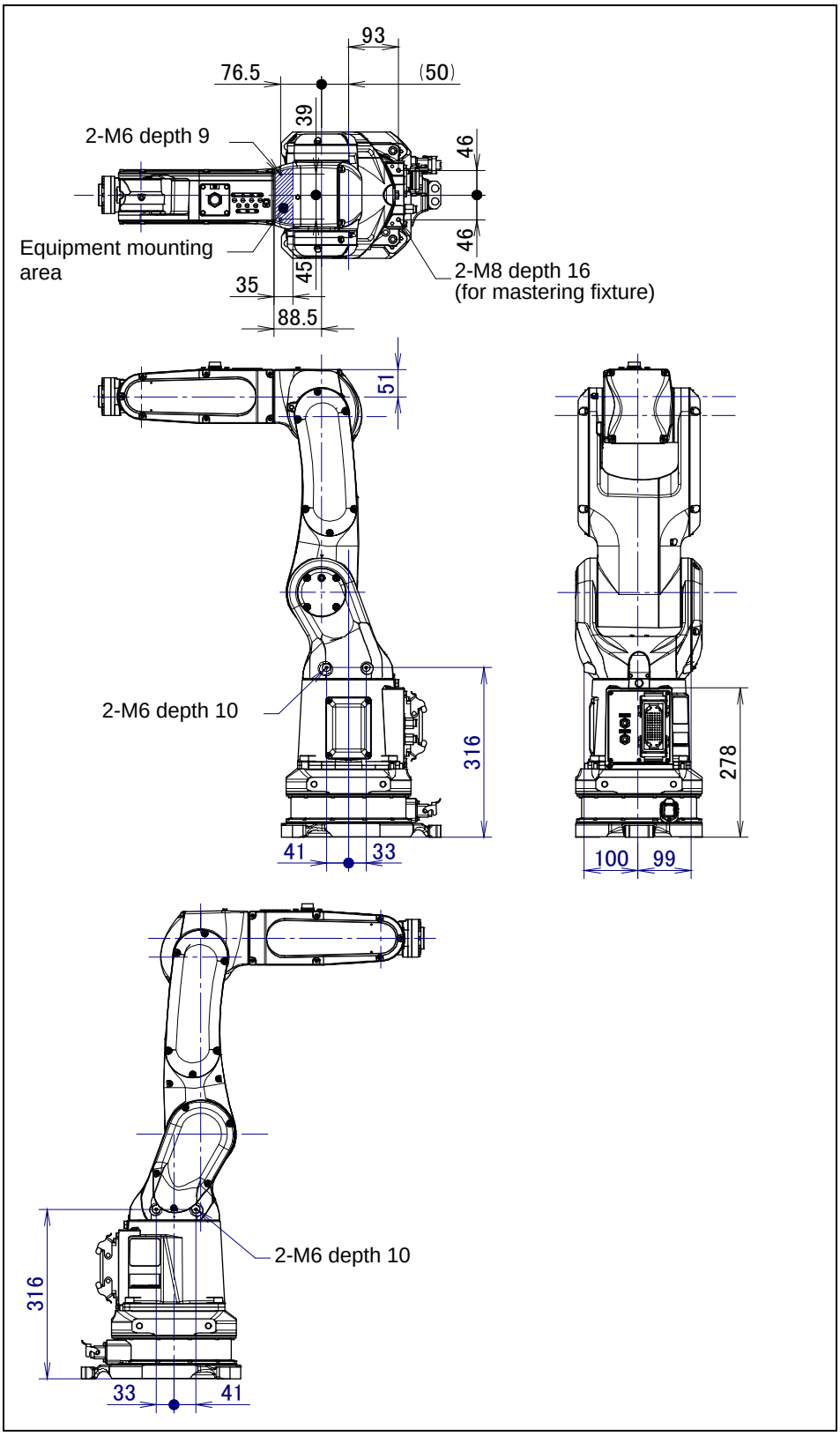


Fig. 4.2 (b) Equipment mounting faces (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

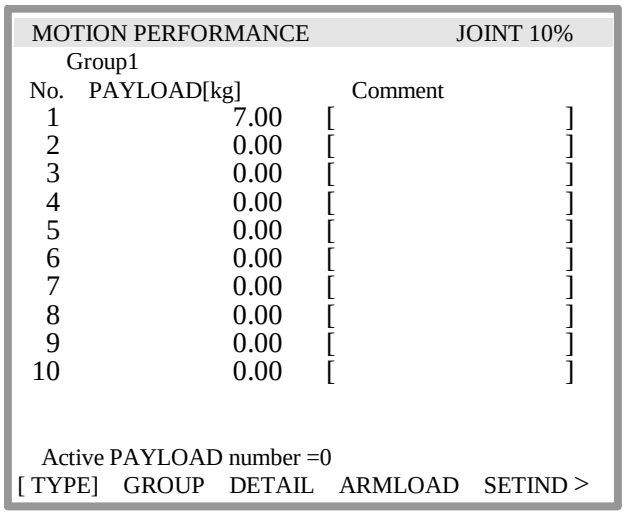
4.3 LOAD SETTING

> ⚠ **WARNING**
> If the load setting is wrong, safety functions may be lost, and it may cause personnel injury . If the load setting is changed, confirm the value and perform testing again.

> ⚠ **CAUTION**
> 1 Perform load setting (payload, payload center and inertia) correctly. If load setting is not correct, the sensitivity of the contact stop may getting worse. In addition, collaborative robot always check the load is correct or not during operations. If the robot detect the actual load does not match the load setting, robot stops for safety. So if load setting is incorrect, you cannot operate the robot.
> 2 Set the correct load condition parameter before the robot runs. Do not operate the robot in over when its payload is exceeded or incorrect. Do not exceed the allowable payload including connection cables. Operation in with the robot over payload may result in troubles such as reducer life reduction.

The operation motion performance screens include the MOTION PERFORMANCE screen, MOTION PAYLOAD SET screen, and 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.



5 Ten different pieces of payload information can be set using condition Nos. 1 to 10 on this screen. Place the cursor on one of the numbers, and click F3 (DETAIL). The MOTION PAYLOAD SET screen appears.

```
MOTION PAYLOAD SET                    JOINT 10%

   Group 1
 1 Schedule No[          1]:[Comment          ]
 2 PAYLOAD                 [kg]          7.00
 3 PAYLOAD CENTER  X [cm]               -13.72
 4 PAYLOAD CENTER  Y [cm]                0.00
 5 PAYLOAD CENTER  Z [cm]               11.954
 6 PAYLOAD INERTIA X [kgfcms^2]        138.974
 7 PAYLOAD INERTIA Y [kgfcms^2]        169.538
 8 PAYLOAD INERTIA Z [kgfcms^2]        102.039

 [TYPE] GROUP NUMBER   DEFAULT   HELP
```

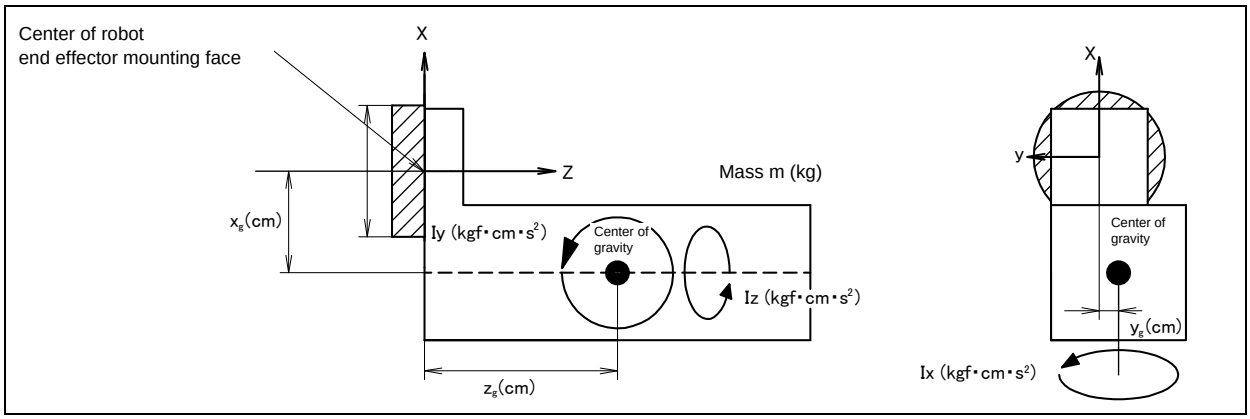


Fig. 4.3 (a) Standard tool coordinate

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 Cycletime will change. Set it?” Respond to the message with 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, clicking 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. Click F5 ([SETIND]), and enter the desired payload setting condition number.

9 On the list screen, pressing F4 ARMLOAD brings you to the device-setting screen.

```
MOTION ARMLOAD SET                    JOINT   100%

   Group 1
 1 ARM LOAD AXIS #1 [kg]                  0.00
 2 ARM LOAD AXIS #3 [kg]                  1.00

[  TYPE  ]     GROUP          DEFAULT   HELP
```

10 Specify the mass of the loads on the J2 base and J3 housing. When you enter
ARMLOAD AXIS #1[kg] : Mass of the load on the J2 base
ARMLOAD AXIS #3[kg] : Mass of the load on the J3 housing (wrist side),
the confirmation message “Path and Cycle time will change. Set it?” appears. Select F4 YES or F5 NO. Once the mass of a device is entered, it is put in effect by turning the power off and on again.

5 PIPING AND WIRING TO THE END EFFECTOR

⚠ 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 when cables are added to the outside of the mechanical unit.
- Please do not perform remodeling (adding a protective cover, or secure an additional outside cable) that obstructs the behavior of the cable.
- When external equipment is installed on the robot, make sure that it does not interfere with other parts of the robot.
- Cut and discard any unnecessary length of wire strand of the end effector (hand) cable. Insulate the cable with seal tape. (See Fig. 5 (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 user cable 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 the end effector, robot faults, or damage to robot electrical hardware. In addition, electric shock could occur when touching the power cables.

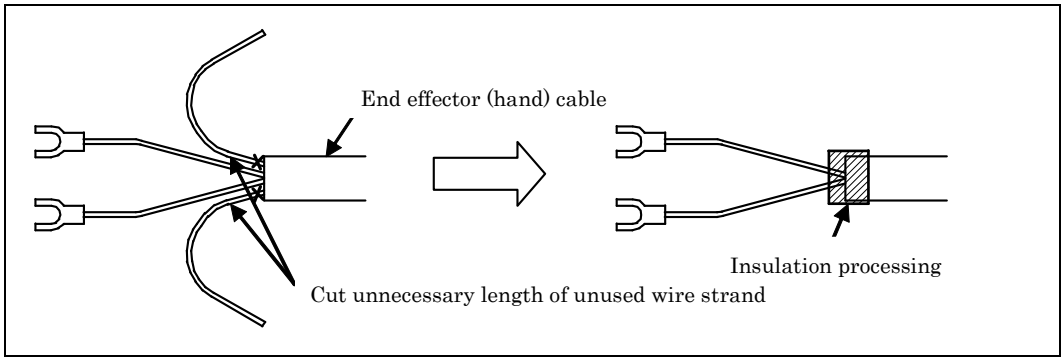


Fig. 5 (a) Treatment method of end effector (hand) cable

5.1 AIR SUPPLY

Air supply holes (Rc1/4) are prepared on the J1–axis connector panel for end effector as shown in Fig.5.1 (a), (b).
Optional solenoid valves can be mounted as shown in Table 5.1 (a). Plugs are inserted in all of the ports used for supplying air before the robot is shipped. To use the air circuit, you must remove the plugs and connect couplings to the ports.
When the solenoid valve is replaced, the entire manifold should be replaced.

Table 5.1 (a) Optional solenoid valves

Option spec.	Model	Description	Solenoid (Manifold) spec.	Remarks	RO
A05B-1143-H002	CR-4*i*A	Double solenoids x 1	A97L-0218-0130#D1 (manufactured by SMC)	2 position x 1	RO1 to 2
A05B-1142-H092#B	CR-7*i*A	Double solenoids x 1	A97L-0218-0130#D1 (manufactured by SMC)	2 position x 1	RO1 to 2
A05B-1142-H092#L	CR-7*i*A/L CR-14*i*A/L	Double solenoids x 1	A97L-0218-0130#D1 (manufactured by SMC)	2 position x 1	RO1 to 2
A05B-1142-H093#B	CR-7*i*A	Double solenoids x 2	A97L-0218-0130#D2 (manufactured by SMC)	2 position x 2	RO1 to 4
A05B-1142-H093#L	CR-7*i*A/L CR-14*i*A/L	Double solenoids x 2	A97L-0218-0130#D2 (manufactured by SMC)	2 position x 2	RO1 to 4
A05B-1142-H094#B	CR-7*i*A	Double solenoids x 3	A97L-0218-0130#D3 (manufactured by SMC)	2 position x 3	RO1 to 6
A05B-1142-H094#L	CR-7*i*A/L CR-14*i*A/L	Double solenoids x 3	A97L-0218-0130#D3 (manufactured by SMC)	2 position x 3	RO1 to 6
A05B-1142-H095#B	CR-7*i*A	Double solenoids x 3	A97L-0218-0130#D3B (manufactured by SMC)	3 position (closed center) x 3	RO1 to 6
A05B-1142-H095#L	CR-7*i*A/L CR-14*i*A/L	Double solenoids x 3	A97L-0218-0130#D3B (manufactured by SMC)	3 position (closed center) x 3	RO1 to 6
A05B-1142-H096#B	CR-7*i*A	Double solenoids x 3	A97L-0218-0130#D3R (manufactured by SMC)	3 position (exhausted center) x 3	RO1 to 6
A05B-1142-H096#L	CR-7*i*A/L CR-14*i*A/L	Double solenoids x 3	A97L-0218-0130#D3R (manufactured by SMC)	3 position (exhausted center) x 3	RO1 to 6

Available section area of the solenoid valve : $1.98mm^2$ (CV value : 0.11)

NOTE
1 When the air circuit is not used, reinstall the plugs as originally installed for the purpose of dust and water protection.
2 Attach an air filter with a mesh size of 5μm or better on the upstream side near the robot. Compressed air including much drainage causes valve malfunctions. Take action to prevent the entry of drainage, and also drain the air filter periodically.

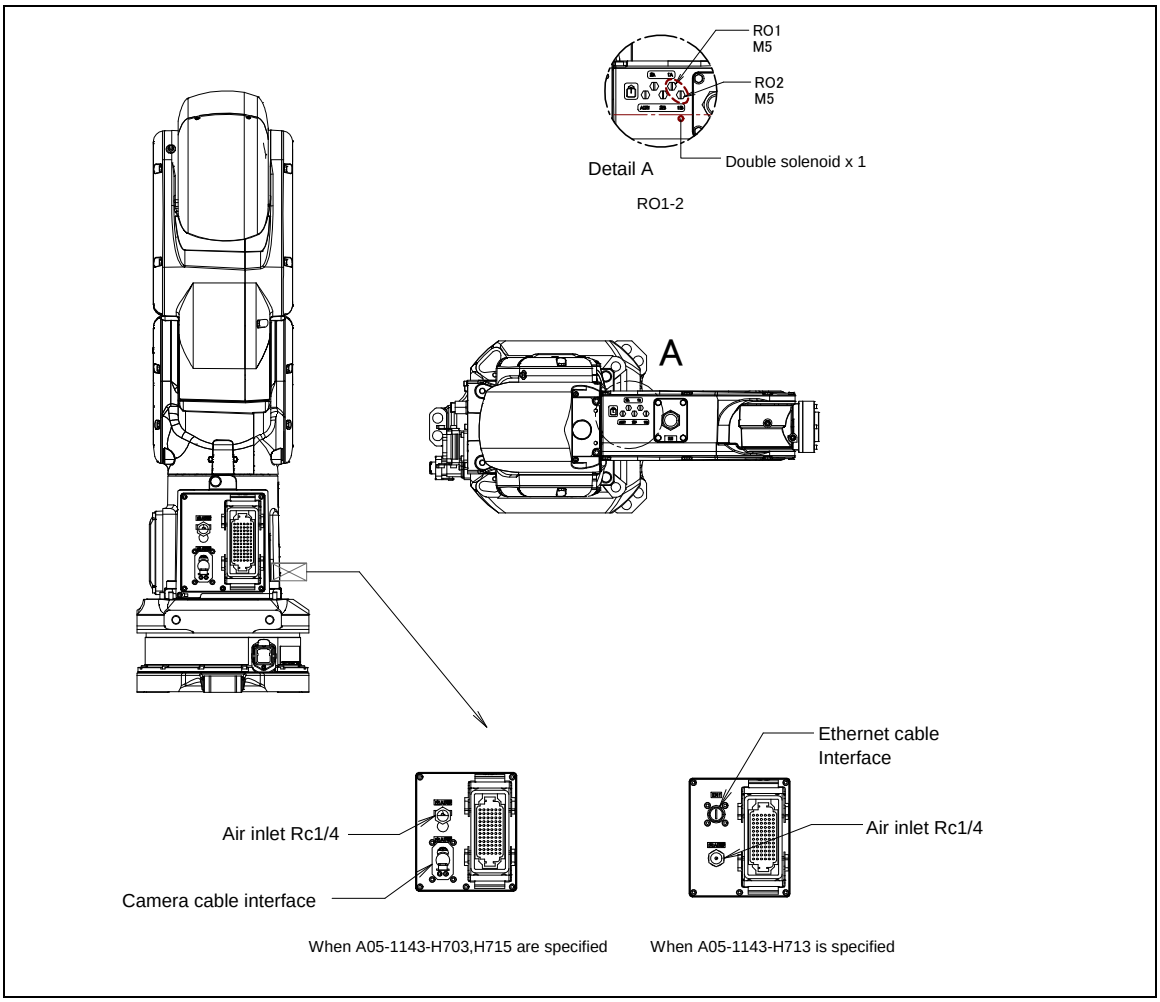


Fig. 5.1 (a) Air supply (CR-4*i*A)

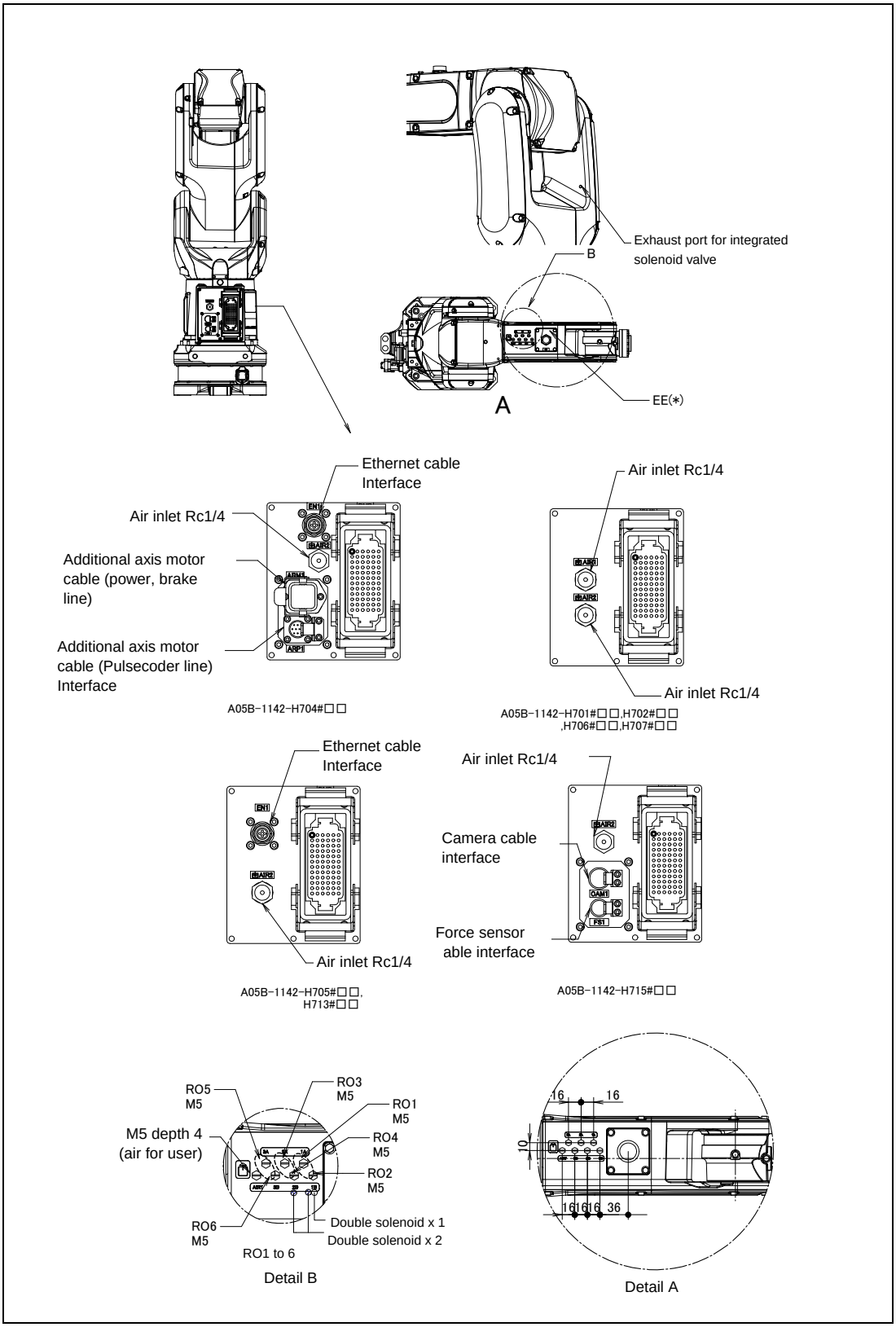


Fig. 5.1 (b) Air supply (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

Air pressure	Supply air pressure	0.49 to 0.69MPa(5 to 7kgf/cm^2), Setting: 0.49MPa(5kgf/cm^2)
	Amount of consumption	Maximum instantaneous amount 120N//min (0.12Nm^3/min)

* The air should be dry. Do not use oiled compressed air.

5.2 INTERFACE FOR OPTION CABLE (OPTION)

⚠ CAUTION

1 The connector to be plugged into the interface and the cable attached to that connector should be supplied by the customer.
2 Please cover the unused connector and air port reliably by a metal cap (option) and a plug. If the covering is loose, unexpected substances will enter into the robot and cause any troubles. At ex-factory, the interfaces are covered by easy caps in order to avoid dust during transportation. Please keep in mind that the cap doesn't work enough as a protect means in factory environment.
3 Please do the waterproof processing of the hand cable surely to prevent the flood in the mechanism.
Moreover, the damage of the cover of the cable causes the flood so exchange it, please when it is damaged.

Fig. 5.2 (a) shows the pin layout for the EE interface (RI/RO signal).

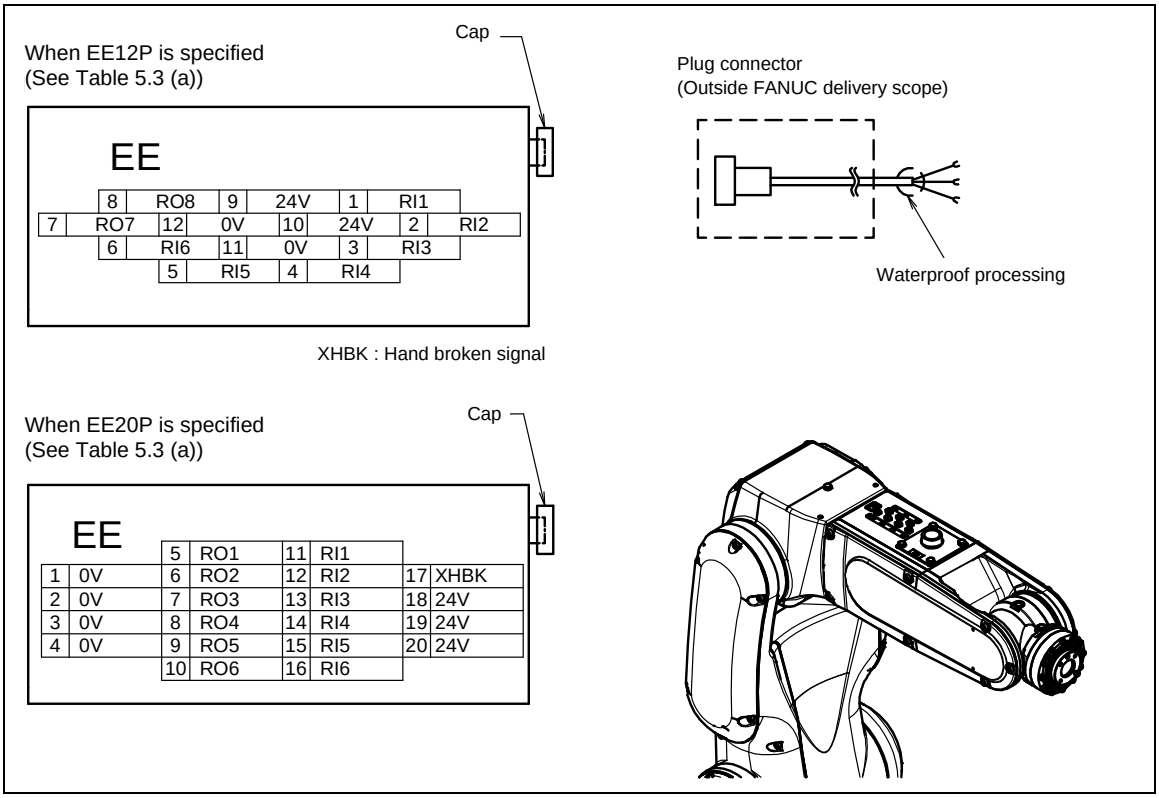


Fig. 5.2 (a) Pin layout of the EE interface (RI/RO signal)

Table 5.2 (a) Correspondence table for mechanical unit cable

EE Type	Spec. of mechanical unit cable
EE12P	A05B-1143-H713,H715 A05B-1142-H701#☐☐, H706#☐☐, H713#☐☐, H715#☐☐
EE20P	A05B-1142-H702#☐☐, H705#☐☐, H707#☐☐

Fig. 5.2 (b) shows the connector position of the J3 arm connector panel.

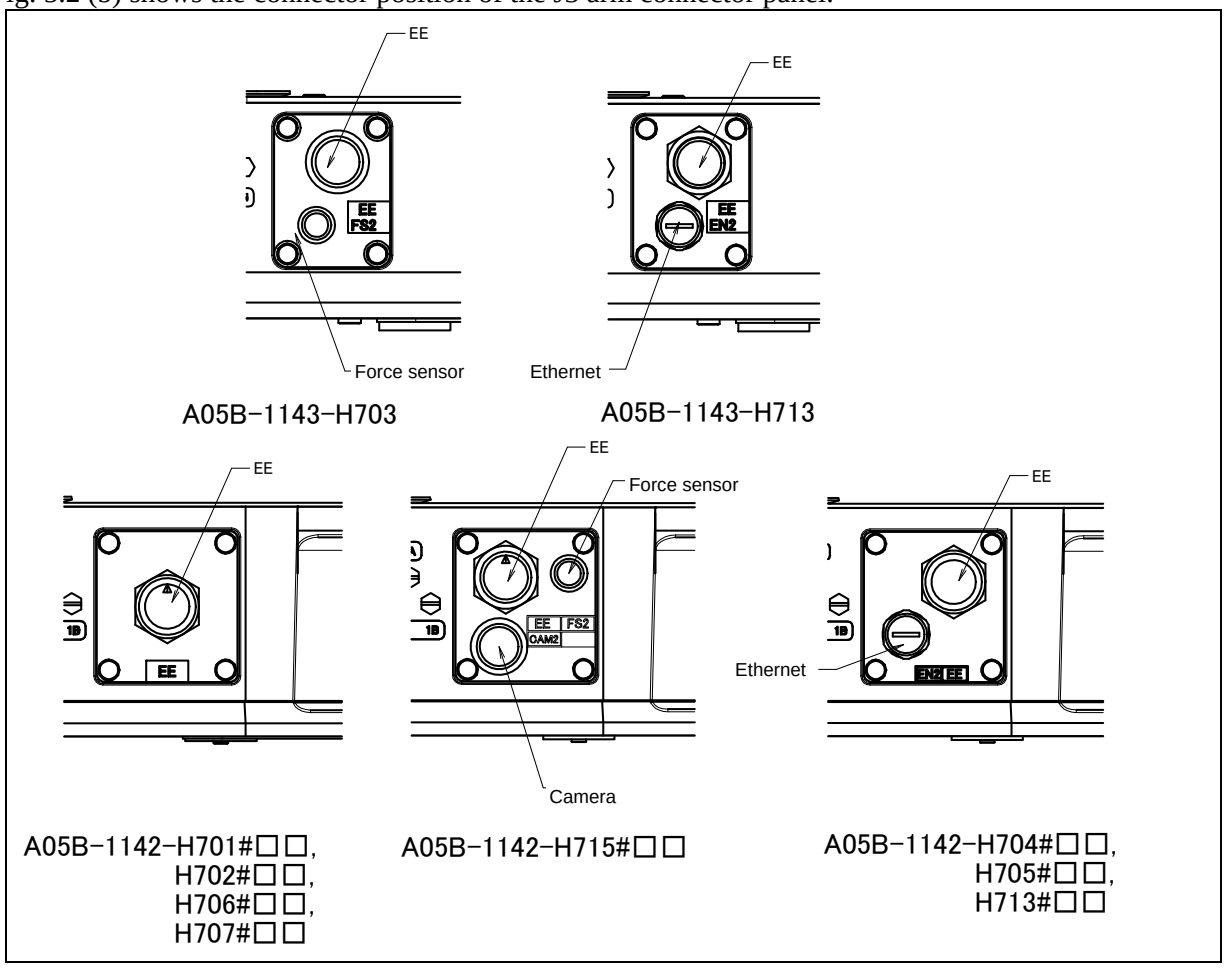


Fig. 5.2 (b) Option cable interface on the J3 arm

> ⚠ **CAUTION**
> For wiring of the peripheral device to the EE interface, refer to the Chapter "ELECTRICAL CONNECTIONS" in the following manual.
> CONTROLLER MAINTENANCE MANUAL (B-83525EN)

Connector specifications

Table 5.2 (b) show the connector parts supported by the end effector interface. Some of these parts are available as an option from FANUC. (Table 5.2 (c))

Table 5.2 (b) Supported connector (user side)

Maker	Manufacturer specification	Remarks
Hirose Electric Co. Ltd.	Plug : RM15WTPZ-12P(71) Clamp : JR13WCC-*(72)	Straight type connector (12 pins) * indicates an applicable cable diameter selected from the following: * : ϕ5, 6, 7, 8, 9, 10mm
	Plug : RM15WTLP-12P(71) Clamp : JR13WCC-*(72)	Elbow type connector (12 pins) * indicates an applicable cable diameter selected from the following: * : ϕ5, 6, 7, 8, 9, 10mm

> **NOTE**
> For details, such as the dimensions, refer to the related catalogs offered by the respective manufacturers, or contact your local FANUC representative.

Table 5.2 (c) Supported option

Option specification	Remarks
A05B-1137-J057	Straight type connector (12-pins) Applicable cable diameter : 8mm
A05B-1137-J058	Elbow type connector (12-pins) Applicable cable diameter : 9mm
A05B-1142-K052	Cable with elbow type connector (12-pins) Length : 300mm

Table 5.2 (d) shows the connector parts supported by the Eternet cable (ES) interface.

Table 5.2 (d) Connector specifications（user side）

Cable name	Input side (J1 base)	Maker/ dealer	Output side（J3 arm）	Maker/ dealer
ES	2103 881 1405 2103 881 1415 2103 281 1405 2103 282 1405 Many other types are available.	HARTING K.K	←The same	HARTING K.K

Table 5.2 (e) shows additional axis cable (ARP, ARM) interface.

Table 5.2 (e) Connector specifications（mechanical unit side）

Cable name	Input side (J1 base)		Maker/ dealer	Output side（J3 arm）		Maker/ dealer
ARP	Connector	JN2AS10ML1-R	日本航空電子㈱	Connector	LF10WBR-12S	Hirose Electric Co. Ltd.
ARM	Housing Insert Contact	09 20 003 0301 09 12 007 3001 09 15 000 6104	HARTING K.K	Connector	RM15WTRZ-8S(71)	

NOTE
See Appendix C, "OPTIONAL CONNECTOR WIRING PROCEDURE" for explanations about how to wire optional connectors.

5.3 PROTECTION AGAINST THE END EFFECTOR

⚠ WARNING
Please add protection (for example, a cover) to the end effector part to prevent personnel injury.

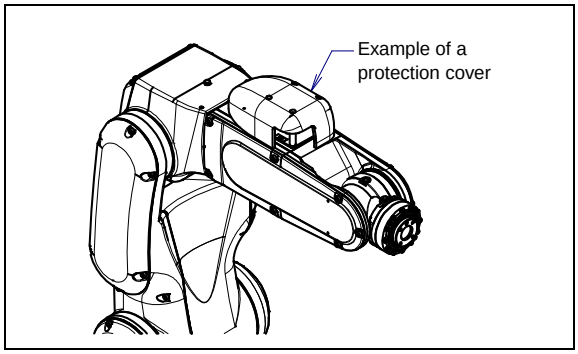


Fig. 5.3 (a) Example of a protection cover

6 AXIS LIMIT SETUP

By setting the motion range of each axes, you can change the robot's motion range from the standard values. Changing the motion range of the robot is effective under following circumstances:

- Used motion range of the robot is limited.
- There's an area where tool and peripheral devices interfere with the robot.
- The length of cables and hoses attached for application is limited.

The software method used to prevent the robot from going beyond the necessary motion range.

- Axis limit by DCS (All axes)

> ⚠ **WARNING**
> Changing the motion range of any axis affects the operating range of the robot. To avoid trouble, carefully consider any possible effect of the change to the movable range of each axis in advance. Otherwise, it is likely that an unexpected condition will occur; for example, an alarm may occur in a previously taught position.

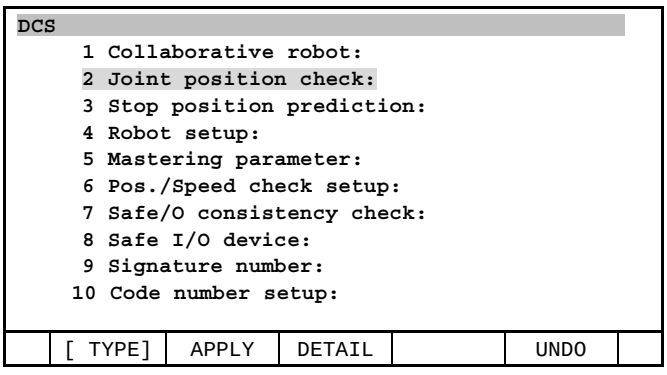
6.1 CHANGE AXIS LIMIT BY DCS

The robot motion can be restricted with DCS (Dual check safety) function by using the following software. For J2/J3-axis, the same effect as adjustable mechanical stopper can be obtained.
The robot motion can be restricted at any angle and position if it is in robot motion area. DCS functions are certified to meet the requirements of International Standard ISO13849-1 and IEC61508 approved by certificate authority. If only the operating space is set using Joint Position Check, the robot stops after it goes beyond the workspace. When the motor power is shut down, the robot's momentum causes it to move some distance before it completely stops. The actual "Robot Stop Position" will be beyond the workspace. To stop the robot within the robot workspace, use the DCS Stop Position Prediction function (option). The stop position prediction is disabled by default.

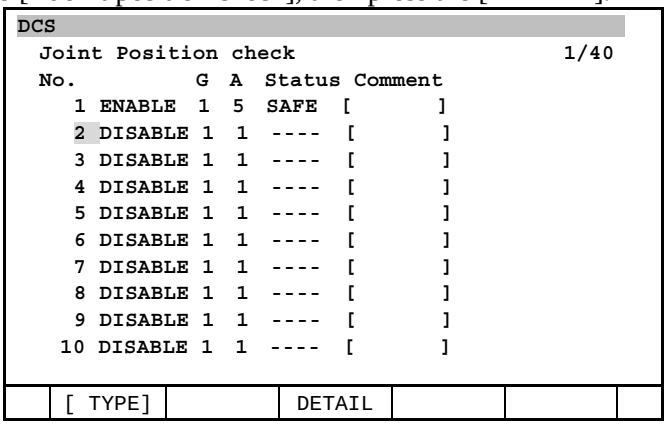
As an example, we shows the procedure to set $\pm 30^{o}$ for J2-axis in here. Refer to Controller Dual check safety function Operator's Manual (B-83184EN) for details of other setting, function and DCS stop position prediction.

Setting procedure

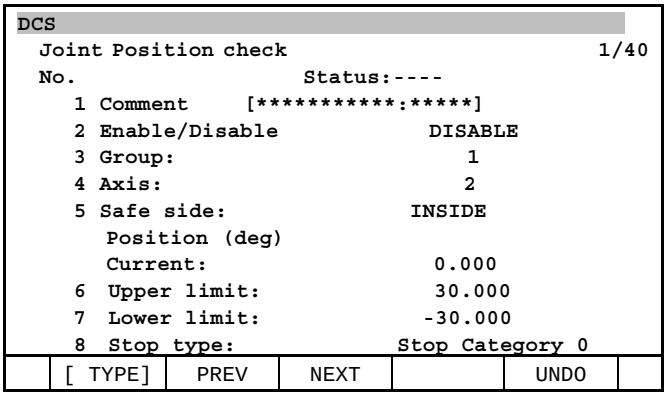
1 Press the [MENU] key to display the screen menu.
2 Press [0 NEXT] and press [6 SYSTEM].
3 Press the F1 ([TYPE]).
4 Select [DCS]. The following screen will be displayed.



5 Move the cursor to [2 Joint position check], then press the [DETAIL].

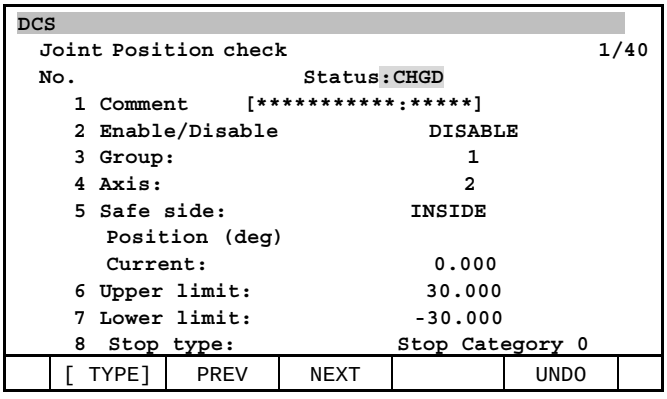


6 Move the cursor to [2], then press the [DETAIL].

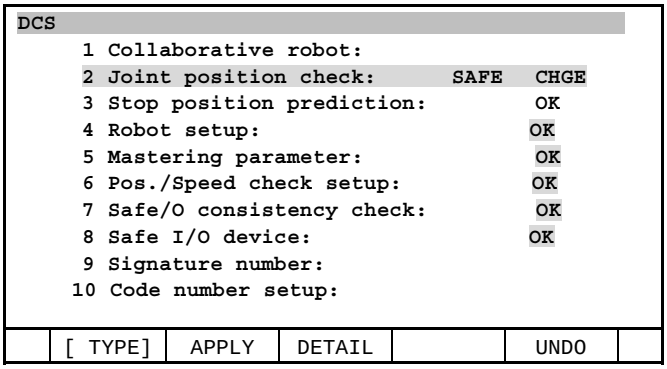


7 Move the cursor to [DISABLE], then press [CHOICE], set the status to [ENABLE].
8 Move the cursor to [Group], then input the robot group number, then press the [ENTER] key.
9 Move the cursor to [Axis], then input “2”, then press the [ENTER] key.
10 Move the cursor to [Upper limit] right side, then input “30”, then press the [ENTER] key.
11 Move the cursor to [Lower limit] right side, then input “-30”, then press the [ENTER] key.

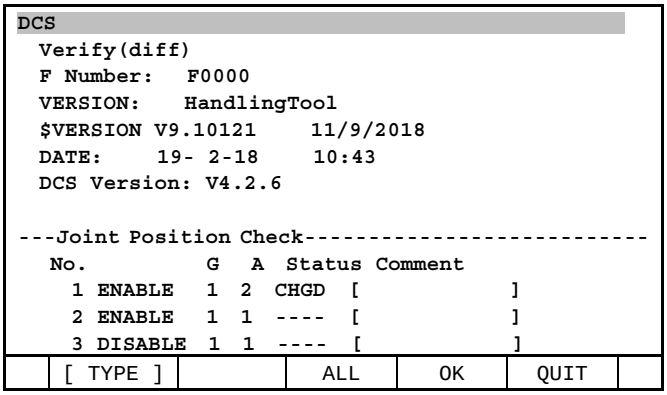
> ⚠ **WARNING**
> If only the operating space is set using Joint Position Check, the robot stops after it goes beyond the workspace. When the motor power is shut down, the robot’s momentum causes it to move some distance before it completely stops. The actual "Robot Stop Position" will be beyond the workspace. To stop the robot within the robot workspace, use the DCS Stop Position Prediction function. The stop position prediction is disabled by default.



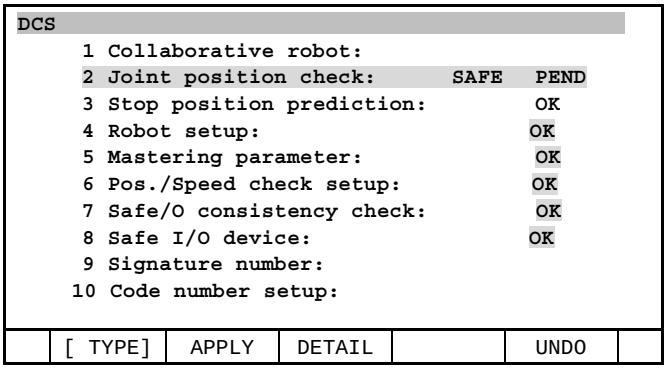
12 Press the [PREV] key two times, back to the first screen.



13 Press the [APPLY].
14 Input 4-digit password, then press the [ENTER] key. (Password default setting is “1111”.)
15 The following screen will be displayed, then press the [OK].



[CHGD] on the right side of [2 Joint position check] will change to [PEND].



16 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.

6.2 RISK ASSESSMENT FOR J5-AXIS MOTION RANGE

Perform the setting of the J5-axis motion range after performing the risk assessment for the robot system including an end effector.

> ⚠ **WARNING**
> When the motion range is performed without a risk assessment, it might cause danger such as pinching fingers.

Setting procedure

1 Change the J5-axis motion range referring to Section 6.1.
2 Change the upper limit and the lower limit of the J5-axis DCS axis position check. Refer to Chapter 3 of the DUAL CHECK SAFETY FUNCTION OPERATOR'S MANUAL (B-83184EN). Set a 1° margin against the motion range (example : motion range ±120°, DCS each axis position check upper limit =121°, lower limit =-121°)
3 Turn off the controller and then turn it back on again in the cold start mode so the new information can be used.

7 CHECKS AND MAINTENANCE

Optimum performance of the robot can be maintained by performing the checks and maintenance procedures presented in this chapter. (See APPENDIX A PERIODIC MAINTENANCE TABLE.)

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 operation 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 with a recommended maintenance interval of 3 years or 11520 hours, use the following calculation to determine the maintenance frequency: 3 years / 2 = perform maintenance every 1.5 years.

7.1 CHECKS AND MAINTENANCE

7.1.1 Daily Checks

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

Check items	Check points and management
Oil seepage	Check to see if there is oil on the sealed part of each joint. If there is an oil seepage, clean it. **⇒"7.2.1 Confirmation of Oil Seepage"**
Air control set Air purge kit	(When air control set or air purge kit is used) **⇒"7.2.2 Confirmation of the Air Control Set"**
Vibration, abnormal noises	Check whether vibration or abnormal noises occur. When vibration or abnormal noises occur, perform measures referring to the following section: **⇒"9.1 TROUBLESHOOTING" (symptom : Vibration, Noise)**
Positioning accuracy	Check that the taught positions of the robot have not deviated from the previously taught positions. If displacement occurs, perform the measures as described in the following section: **⇒"9.1 TROUBLESHOOTING" (Symptom : Displacement)**
Peripheral equipment for proper operation	Check whether the peripheral equipment operate properly according to commands from the robot and the peripheral equipment.
Brakes for each axis	Check that the end effector drops 2 mm or less when servo power is turned off. If the end effector (hand) drops, perform the measures as described in the following section: **⇒"9.1 TROUBLESHOOTING" (symptom : Dropping axis)**
Warnings	Check whether unexpected warnings occur in the alarm screen on the teach pendant. If unexpected warnings occur, perform the measures as described in the following manual: **⇒" CONTROLLER OPERATOR'S MANUAL (Alarm Code List)(B-83284EN-1)"**

7.1.2 Periodic Check and Maintenance

Check the following items at the intervals recommended below based on the period or the accumulated operating time, whichever comes first. (○ : Item needs to be performed.)

Check and maintenance intervals (Period, Accumulated operating time)						Check and maintenance item	Check points, management and maintenance method	Periodic maintenance No.
1 month 320h	3 months 960h	1 year 3840h	2 years 7680h	4 years 15360h	8 years 30720h			
○ Only 1st check	○					Cleaning the controller ventilation system	Confirm that the controller ventilation system is not dusty. If dust has accumulated, remove it.	14
○						Check the force sensor	Confirm sensor performance referring to Chapter 6 of the Collaborative Robot Function OPERATOR'S MANUAL (B-83744EN). If abnormality is found, replace the sensor.	3
	○					Check for external damage or peeling paint	Check whether the robot has external damage or peeling paint due to the interference with the peripheral devices. If an interference occurs, eliminate the cause. Also, if the external damage is serious, and causes a problem in which the robot will not operate, replace the damaged parts.	1
	○					Check for water	Check whether the robot is subjected to water or cutting oils. If water is found, remove the cause and wipe off the liquid.	2
	○ Only 1st check	○				Check for damages to the teach pendant cable, the operation box connection cable or the robot connection cable	Check whether the cable connected to the teach pendant, operation box and robot are unevenly twisted or damaged. If damage is found, replace the damaged cables.	13
	○ Only 1st Check	○				Check for damage to the end effector (hand) cable and external batteries cable	Check whether the end effector cables and external batteries cable are unevenly twisted or damaged. If damage is found, replace the damaged cables.	9
	○ Only 1st check	○				Check the exposed connectors	Check the exposed connectors. **⇒"7.2.3 Check the Connectors"**	4
	○ Only 1st check	○				Retightening the end effector mounting bolts	Retighten the end effector mounting bolts. Refer to the following section for tightening torque information: **⇒"4.1 END EFFECTOR INSTALLATION TO WRIST"**	5

Check and maintenance intervals (Period, Accumulated operating time)						Check and maintenance item	Check points, management and maintenance method	Periodic maintenance No.
1 month 320h	3 months 960h	1 year 3840h	2 years 7680h	4 years 15360h	8 years 30720h			
	○ Only 1st check	○				Retightening the external main bolts	Retighten the robot installation bolts, bolts that have been removed for inspection, and bolts exposed to the outside. Refer to the recommended bolt tightening torque guidelines at the end of the manual. An adhesive to prevent bolts from loosening is applied to some bolts. If the bolts are tightened with greater than the recommended torque, the adhesive might be removed. Therefore, follow the recommended bolt tightening torque guidelines when retightening the bolts.	6
	○ Only 1st check	○				Check the mechanical stopper	Check that the spring pin of J1/J3-axis mechanical stopper is not deformed, if it is deformed, replace it with a new one. **⇒"7.2.4 Check of the Mechanical Stopper "**	7
	○ Only 1st check	○				Clean spatters, sawdust and dust	Check that spatters, sawdust, or dust does not exist on the robot main body. If dust has accumulated, remove it. Especially, clean the robot movable parts well (each joint). For an arc welding robot, insulation failure might occur when spatter has collected around the wrist flange or welding torch, and there is a possibility of damaging the robot mechanism by the welding current. (See APPENDIX D)	8
		○				Replacing the mechanical unit batteries	Replace the mechanical unit batteries. Regardless of operating time, replace batteries at 1 year. **⇒"7.3.1 Replacing the Batteries"**	10
				○		Replenish grease to each axis reducer	Replenish grease to each axis reducer **⇒"7.3.2 Replenish the Grease of the Drive Mechanism"**	11
				○		Replacing the mechanical unit cable	Replace the mechanical unit cable Contact your local FANUC representative for information regarding replacing the cable.	12
					○	Replacing the Force sensor	Replace the force sensor Contact your local FANUC representative for information regarding replacing the cable.	13
				○		Replacing the controller batteries	Replace the controller batteries. Regardless of operating time, replace batteries at 4 years. **⇒Chapter 7 Replacing batteries of R-30*i*B MATE/ R-30*i*B MATE Plus CONTROLLER MAINTENANCE MANUAL (B-83525EN)"**	16

⚠ WARNING
Never loosen the bolts shown in Fig. 7.1.2 (a). Otherwise, the robot's safety functionality may be compromised causing personnel injury or equipment damage.

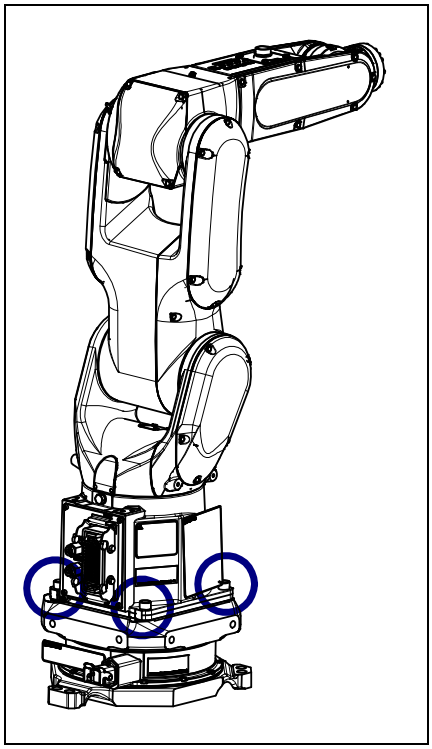


Fig. 7.1.2 (a) Check points

7.2 CHECK POINTS

7.2.1 Confirmation of Oil Seepage

Check items

Check to see whether there is an oil seepage on the rotating parts of each joint axis.

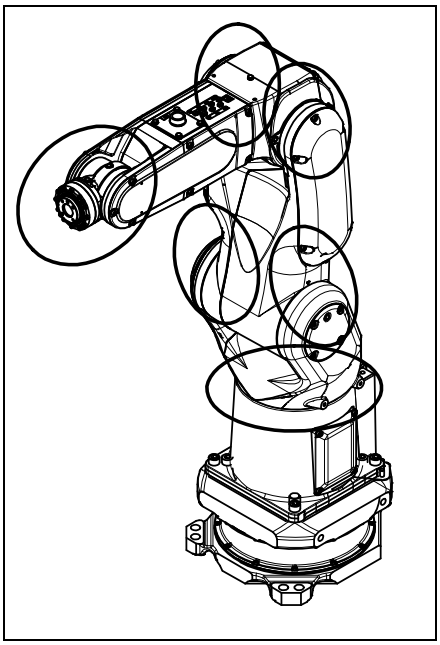


Fig. 7.2.1 (a) Check points of oil seepage

Management

- Oil might accumulate on the outside of the seal lip depending on the movement condition or environment of the axis. If the oil changes to a state of liquid, the oil might fall depending on the axis movement. To prevent oil spots, be sure to wipe away any accumulated oil under the axis components before you operate the robot.
- Also, motors might become hot and the internal pressure of the grease bath might rise by frequent repetitive movement and use in high temperature environments. In these cases, normal internal can be restored by venting the grease inlet. (When opening the grease inlet, refer to Subsection 7.3.2 and ensure that grease is not expelled onto the machine or tooling.)
- If you must wipe oil frequently, and opening the grease outlet does not stop the seepage, perform the measures below.

  ⇒"9.1 TROUBLESHOOTING" (symptom : Grease leakage)

7.2.2 Confirmation of the Air Control Set (option)

When an air control set is used, check the items below.

Item	Check items	Check points
1	Air pressure	Check air pressure using the pressure gauge on the air control set as shown in Fig.7.2.2 (a). If it does not meet the specified pressure of 0.49MPa (5 kgf/cm^2), adjust it using the regulator pressure setting handle.
2	Leakage from hose	Check the joints, tubes, etc. for leaks. Repair leaks, or replace parts, as required.
3	Drain	Check the drain and empty it. When the quantity of liquid in the drain is excessive, examine the setting of the air dryer on the air supply side.

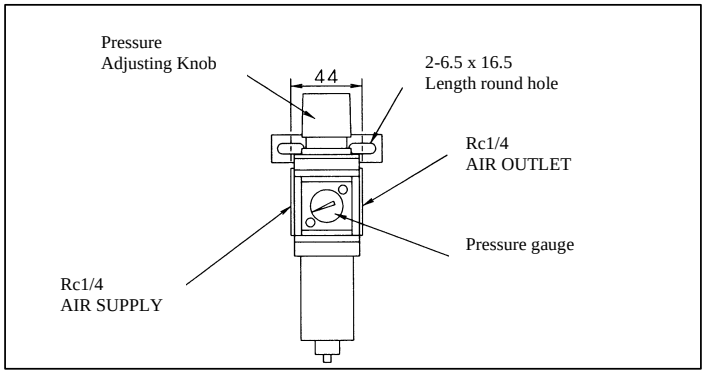


Fig. 7.2.2 (a) Air control set (option)

7.2.3 Check the Connectors

Inspection points of the connectors

- Robot connection cables, earth terminal and user cables

Check items

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

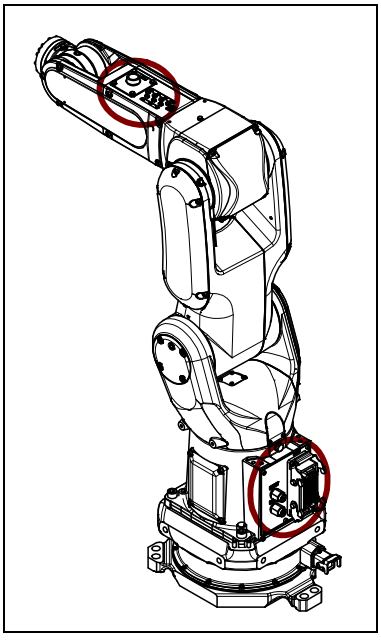


Fig. 7.2.3 (a) Connector Inspection points

7.2.4 Check of Mechanical Stopper

- Check that the spring pin of the J1 -axis mechanical stopper is not deformed, if it is deformed, replace it with a new one.

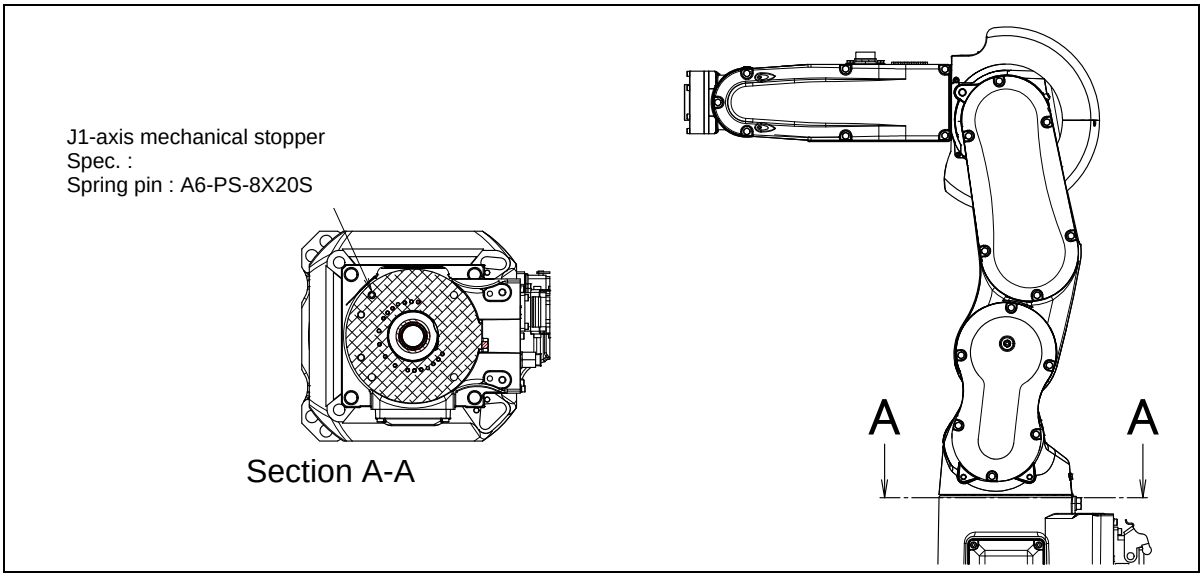


Fig. 7.2.4 (a) Check of the mechanical stopper (CR-4*i*A)

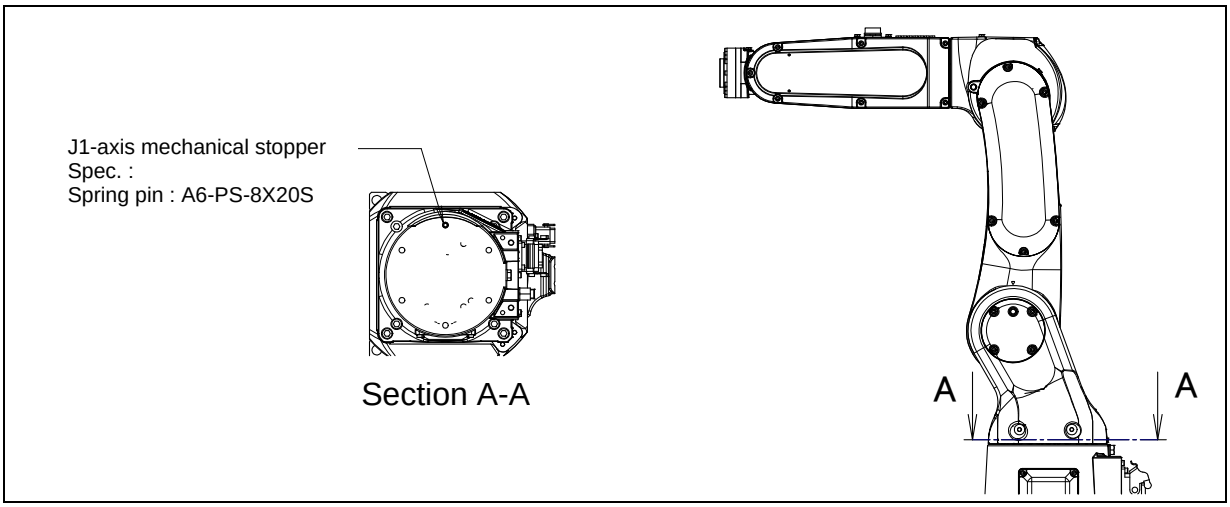


Fig. 7.2.4 (b) Check of the mechanical stopper (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

7.3 MAINTENANCE

7.3.1 Replacing the Batteries (1-Year (3840 hours) Periodic Inspection)

The position data of each axis is preserved by the backup batteries. Replace them every year. Also use the following procedure to replace them when the backup battery voltage drop alarm occurs.

1 Press the EMERGENCY STOP button to prohibit the robot motion.

> **⚠ CAUTION**
> Be sure to keep the power supply turned on. Replacing the batteries with the power supply turned off causes all current position data to be lost. If this occurs, mastering will be required again.

2 Remove the battery case cap. (Fig. 7.3.1 (a)) If it cannot be removed, tap it on the side with a plastic hammer.
3 Loosen the plate screw and take off the lid of the battery box and replace the battery. The battery can be taken out by pulling the stick which is in the center of the battery box.
4 Assemble them by reversing the sequence. Pay attention to the direction of batteries.
It is necessary to replace the gasket.

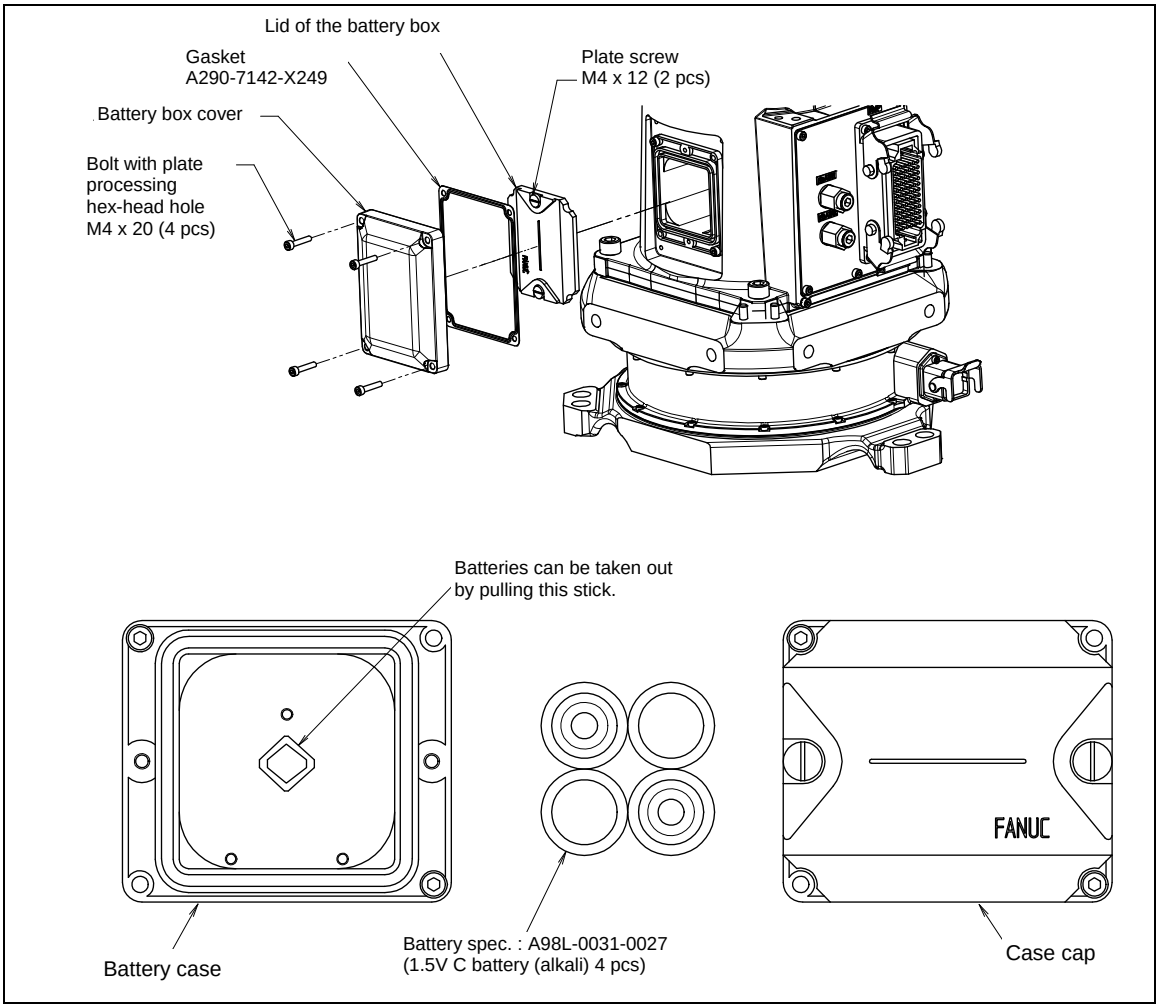


Fig. 7.3.1 (a) Replacing the battery

7.3.2 Replenish the Grease of the Drive Mechanism (4 years (15360 hours) checks)

Supply reducer grease every four years or 15360 hours by using the following procedures.

For the grease name and quantity, see the Table 7.3.2 (a).

Table 7.3.2 (a) Grease for 4-year (15360 hours) periodical greasing

Greasing points	Greasing amount	Specified grease
J1-axis reducer	2.7g (3ml)	Harmonic grease 4BNo.2 Spec: A98L-0040-0230
J2-axis reducer	2.7g (3ml)	
J3-axis reducer	1.8g (2ml)	
J4-axis reducer	1.8g (2ml)	
J5-axis reducer	1.8g (2ml)	
J6-axis reducer	1.8g (2ml)	

For grease replacement, use the arbitrary postures.

⚠ CAUTION

1 The following maintenance kits are prepared for the greasing.
   - Greasing kit: A05B-1142-K021
     (This set of greasing syringe and grease in tube. (80g))
   - Grease in tube: A05B-1139-K022 (grease in tube. (80g))

2 Failure to follow proper lubrication procedures may cause the suddenly increase of the grease bath internal pressure and the damage to the seal, which could lead to grease leakage and abnormal operation. When greasing, observe the following cautions.
   (1) Use specified grease. Use of non-approved grease may damage the reducer or lead to other problems. Do not use Harmonic grease SK-3
   (2) To prevent slipping accidents and catching fire, completely remove any excess grease from the floor or robot.
   (3) Please fill a necessary amount to the injection syringe after softening grease in the tube massaging it by the hand when you use the grease greasing kit. Please install the nozzle in the point of the injection syringe. Please remove the nozzle and do the cap when you do not use the injection syringe.

1 Turn off controller power.
2 Remove the seal bolts from the grease inlet.
3 Supply a regulated amount of grease by using the injection syringe. Please note that grease might come out immediately after the grease has been supplied, or during the greasing. Even in this case, please do not supply grease beyond the regulated amount specified.
4 Replace the seal bolts with new ones. When reusing a seal bolt, be sure to seal it with seal tape.

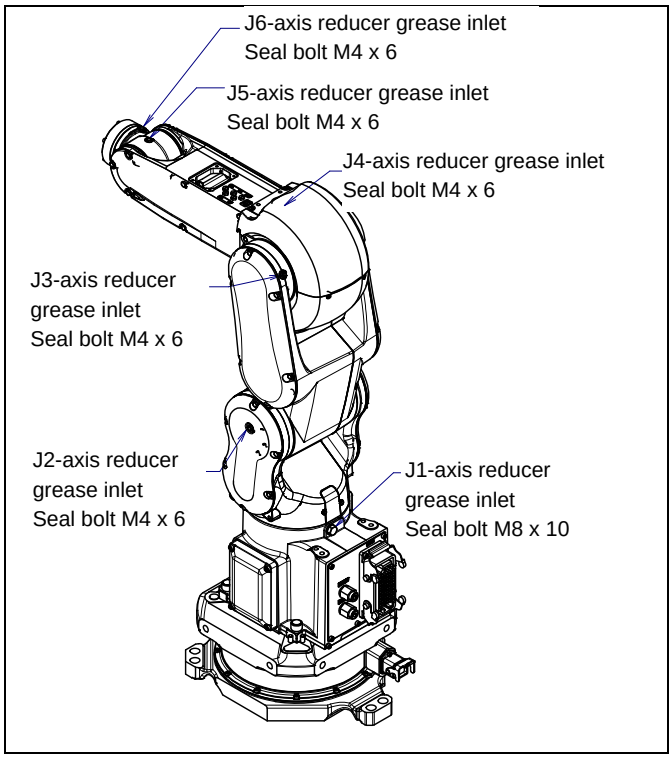


Fig. 7.3.2 (a) Applying grease of the reducer (CR-4*i*A)

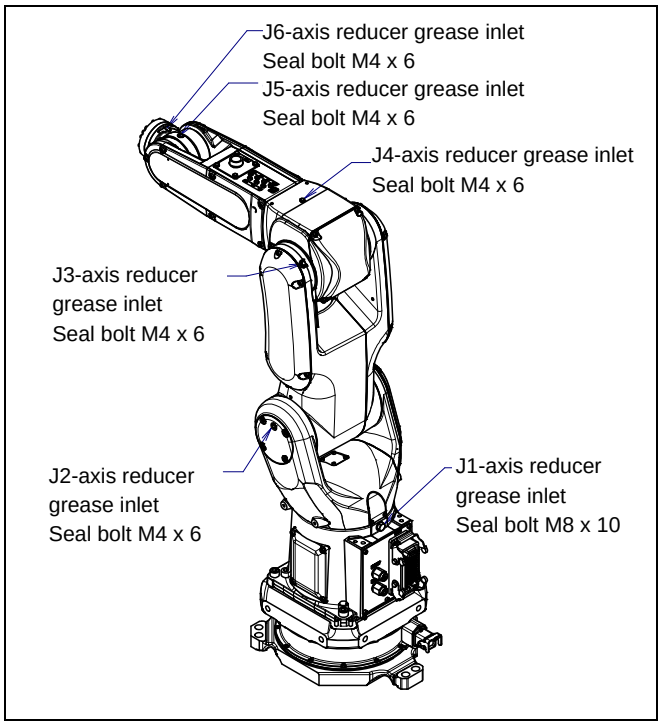


Fig. 7.3.2 (b) Applying grease of the reducer (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

Table 7.3.2 (b) Spec. of seal bolts

Parts name	Specifications	Remarks
Seal bolt	A97L-0318-0410#040606EN	J2 to J6-axis grease inlet 5 pcs/1 robot
Seal bolt	A97L-0318-0410#081010S	J1-axis grease inlet

7.4 STORAGE

When storing the robot, place it on a level surface with the same posture that was used for transportation. (See Section 1.1.)

8 MASTERING

Mastering associates 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.

8.1 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 die. Replace the batteries in the controller and mechanical units periodically. An alarm will alert you when battery voltage is low.

Types of Mastering

Table 8.1 describes the following mastering methods.

Table 8.1 (a) Type 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, you must carry out positioning (calibration). Positioning is an operation in which the controller reads the 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 detailed 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. So, 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 reset to 0 automatically, thus hiding the Master/Cal screen.
2 It is recommended that the current mastering data be backed up before mastering is performed.
3 When the motion range is mechanically 360 degrees or more, if any of the axes (J1-axis and J4-axis) to which the cables are connected is turned one turn beyond the correct mastering position when mastering occurs, the cables in the mechanical unit may be damaged. If the correct rotation position is not clear because the axis is moved too much during mastering, remove the connector panel or cover, check the states of the internal cables, and perform mastering in the correct position. For the checking procedure, see Fig. 8.1 (a) to 8.1 (c).

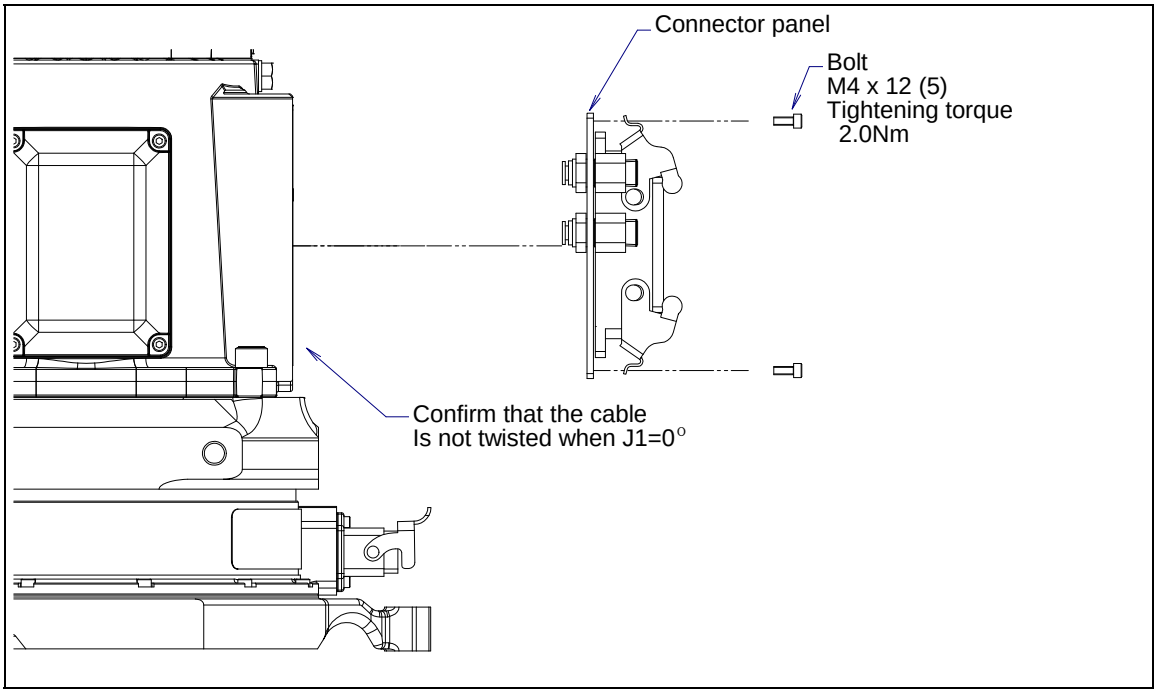


Fig. 8.1 (a) Confirming the state of cable (J1-axis)

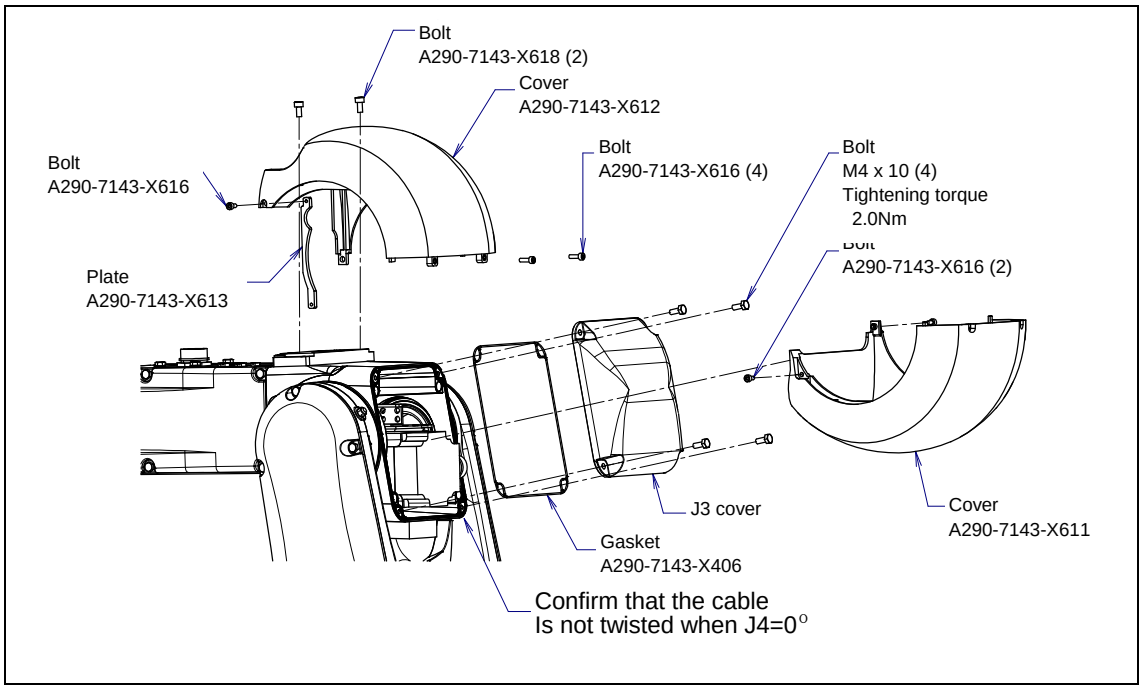


Fig. 8.1 (b) Confirming the state of cable (J4-axis) (CR-4*i*A)

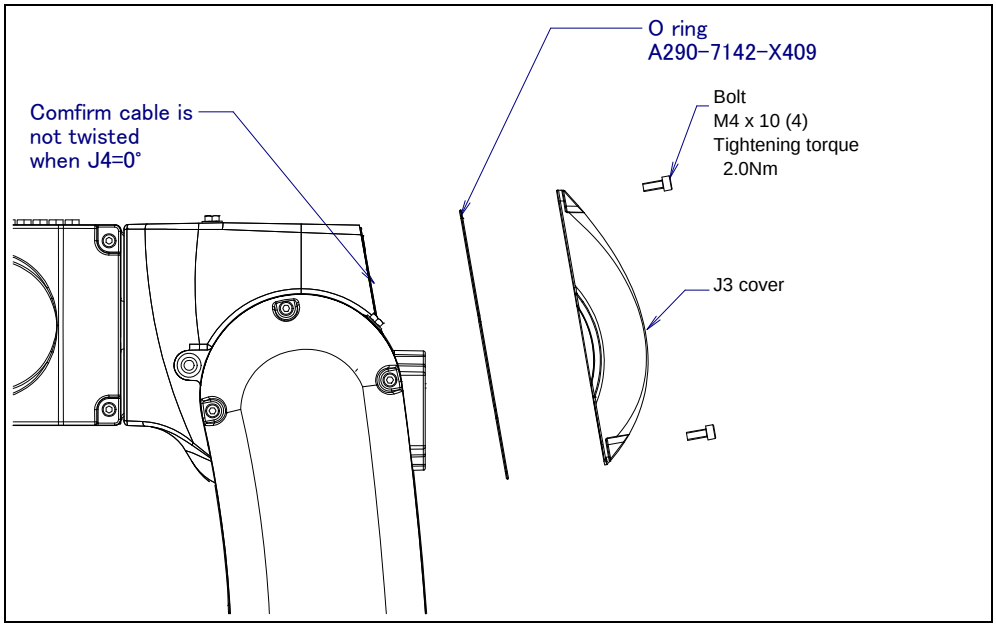


Fig. 8.1 (c) Confirming the state of cable (J4-axis) (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

8.2 RESETTING ALARMS AND PREPARING FOR MASTERING

Before performing mastering because a motor has been replaced, it is necessary to 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 the steps 1 to 6.
   1 Press the [MENU] key.
   2 Press [0 NEXT] and select [6 SYSTEM].
   3 Press F1 ([TYPE]), and select [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 Press [0 NEXT] and select [6 SYSTEM].
   3 Press F1 ([TYPE]), and select [Master/Cal] from the menu.
   4 Press F3 ([RES_PCA]), then press F4 ([YES]).
   5 Cycle power of the controller.

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

8.3 ZERO POSITION 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.8.3 (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], display the screen change menu.
4 Select [Master/Cal]. The positioning screen will be displayed.

```
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, turn off the controller power and on again.

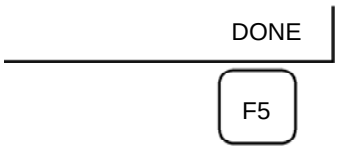
6 Select [2 Zero Position Master]. Press F4 [YES].

```
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.

```
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 Calibrated! Cur Jnt Ang(deg):
   <    0.0000> <    0.0000> <    0.0000>
   <    0.0000> <    0.0000> <    0.0000>
```

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



9 Return brake control to original setting, and turn off the controller power and on again.

Table 8.3 (a) Posture with position marks aligned

Axis	Position
J1-axis	0 deg
J2-axis	0 deg
J3-axis	0 deg (When J2-axis is 0 deg.)
J4-axis	0 deg
J5-axis	0 deg
J6-axis	0 deg

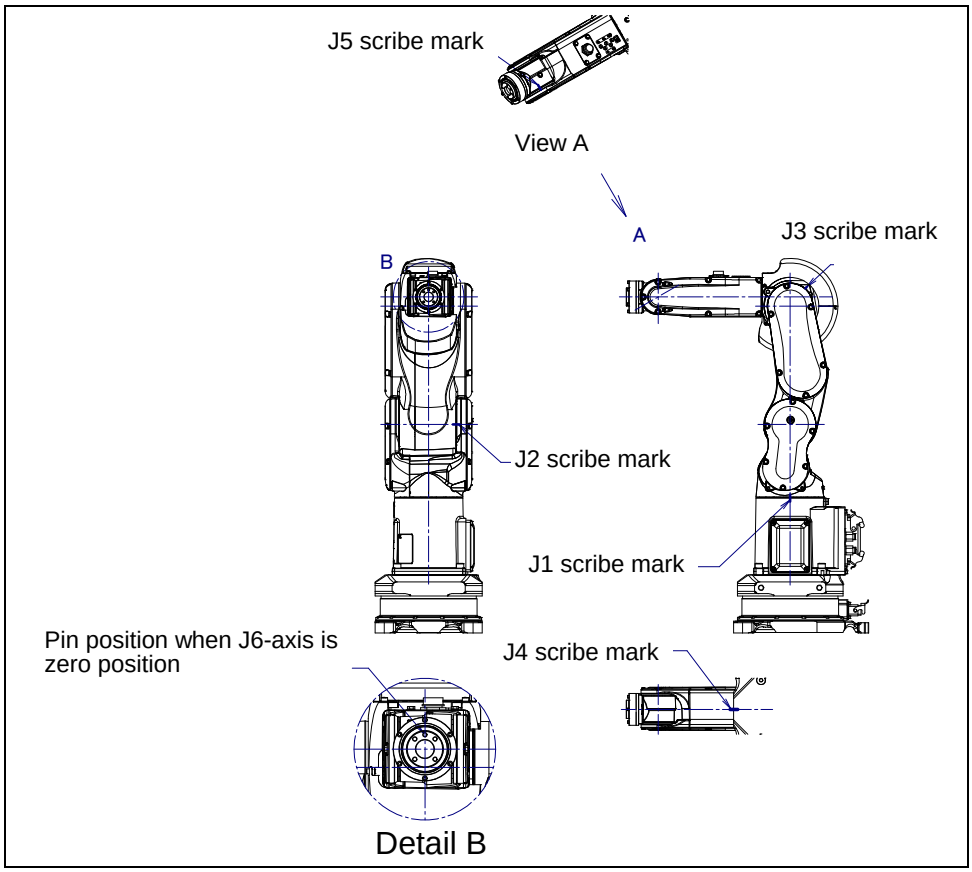


Fig. 8.3 (a) Marking position (CR-4*i*A)

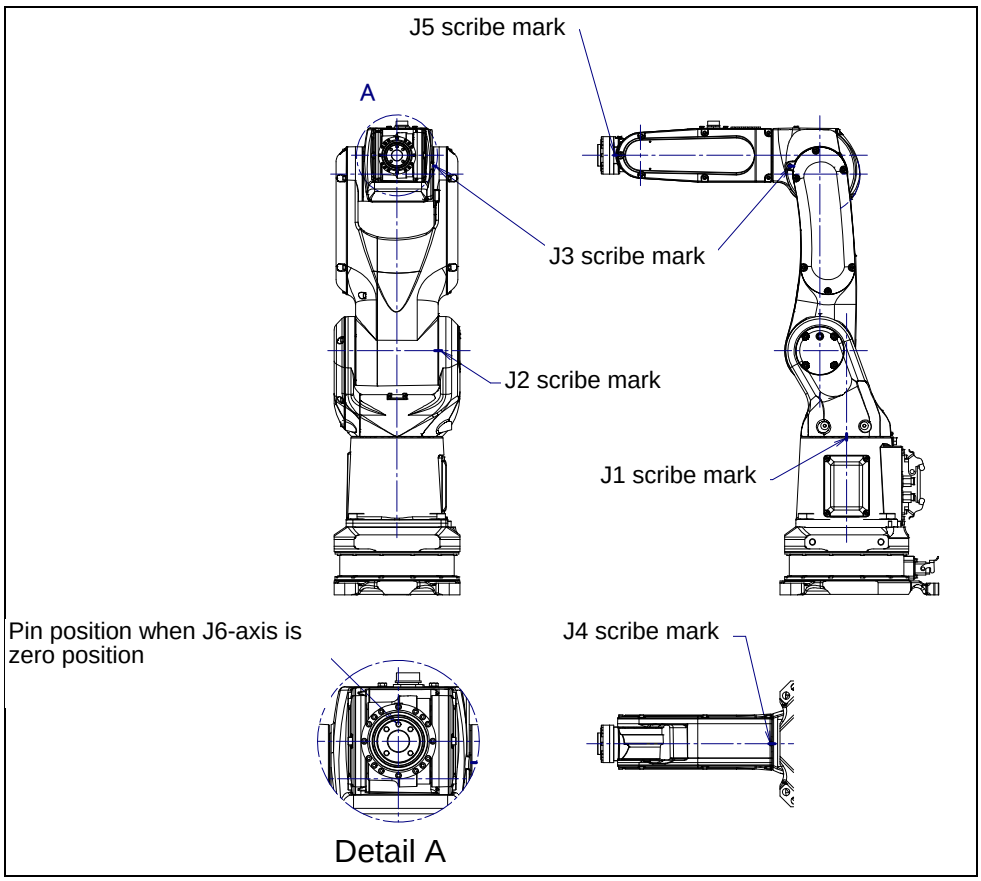


Fig. 8.3 (b) Marking position (CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L)

8.4 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.

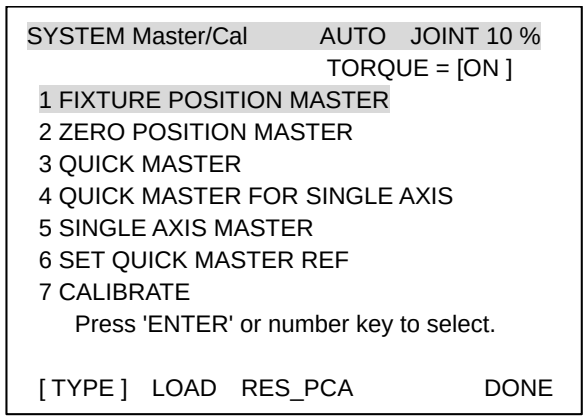
Quick mastering is factory-performed at the position indicated in Table 8.3 (a). If possible, do not change the setting.

If it is impossible to set the robot at the position mentioned above, it is necessary to 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.)

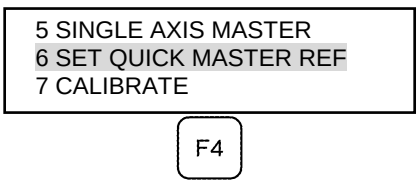
> **⚠ CAUTION**
> 1 Quick mastering can be used, if the pulse count value is lost, for example, because a low voltage has been detected on the backup battery for the pulse counter.
> 2 Quick mastering cannot be used, after the Pulsecoder is replaced or after the mastering data is lost from the robot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

Procedure Recording the Quick Mastering Reference Position

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



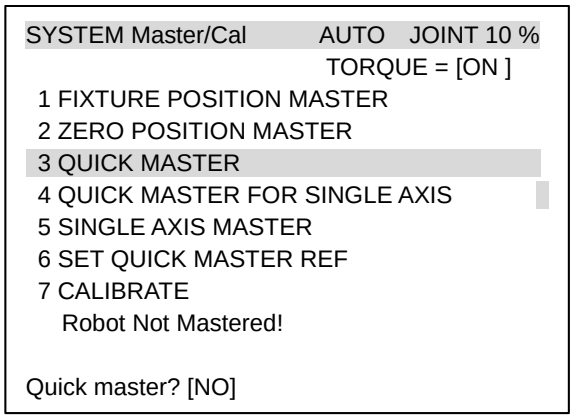
3 Release brake control, and jog the robot to the quick mastering reference position.
4 Select [6 SET QUICK MASTER REF] and press F4 [YES]. Quick mastering reference position is saved.



> **⚠ 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.

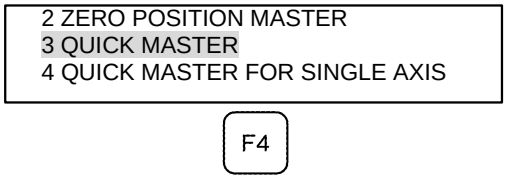
Procedure of Quick Mastering

1 Display the Master/Cal screen.



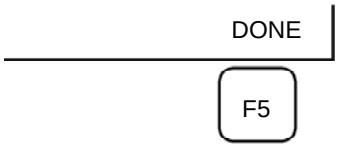
2 Release brake control, and jog the robot to the quick mastering reference position.

3 Move the cursor to [3 QUICK MASTER] and press [ENTER]. Press F4 [YES]. Quick mastering data is memorized.



4 Move the cursor to [7 CALIBRATE] and press ENTER. Calibration is executed. Calibration is executed by power on again.

5 After completing the calibration, press F5 Done.



6 Return brake control to original setting, and turn off the controller power and on again.

8.5 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 8.3 (a). 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.

```
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
```

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 is saved.

```
 5 SINGLE AXIS MASTER
 6 SET QUICK MASTER REF
 7 CALIBRATE
```

F4

⚠ 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
   Robot Not Mastered!

Quick master? [NO]
```

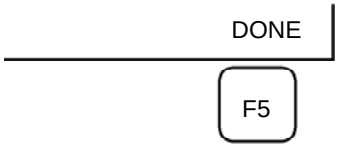
2 Select [4 QUICK MASTER FOR SINGLE AXIS]. You will see the quick master for single axis screen.

```
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
```

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.

```
SINGLE AXIS MASTER              AUTO    JOINT 10%
                                                1/9
    ACTUAL   POS    (MSTR POS)      (SEL)   [ST]
J5          0.000   (      0.000)   (0)     [2]
J6          0.000   (      0.000)   (0)     [0]

                                                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 Move the cursor to [7 CALIBRATE] and press ENTER. Calibration is executed. Calibration is executed by power on again.
7 After completing the calibration, press F5 Done.



8 Return brake control to original setting, and turn off the controller power and on again.

8.6 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.

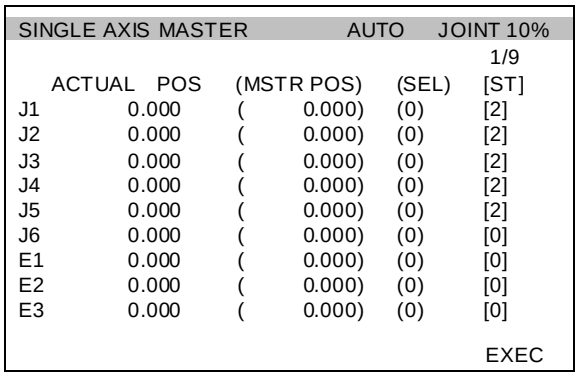
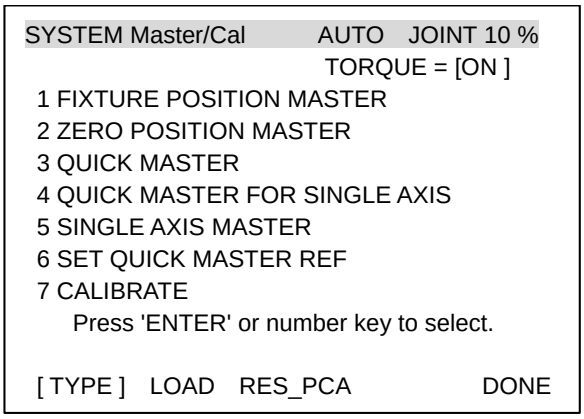


Table 8.6 (a) Items set in single axis mastering

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 to set to it to the 0_ 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 appears.



3 Select [5 SINGLE AXIS MASTER]. You will see a screen similar to the following.

```
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
```

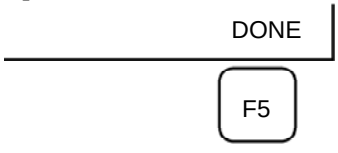
4 Move the cursor to the [SEL] column for the unmastered axis and press the numeric key [1]. Setting of [SEL] is available for one or more axes.
5 Turn off brake control, then jog the robot to the mastering position.
6 Enter axis data for the mastering position.
7 Press F5 [EXEC]. Mastering is performed. So, [SEL] is reset to 0, and [ST] is re-set to 2 or 1.

```
SINGLE AXIS MASTER          AUTO    JOINT 10%
                                            6/9
   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         90.000 (      0.000) (1)     [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.

```
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
```

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].



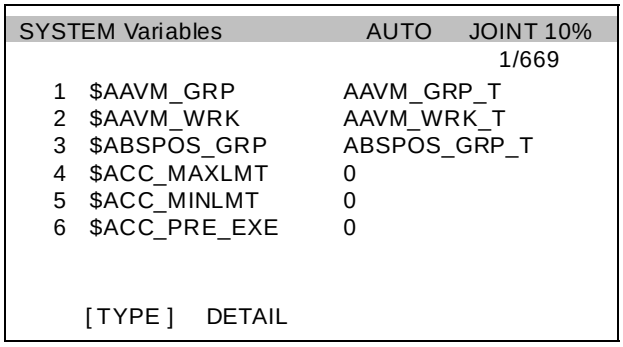
11 Return brake control to original setting, and turn off the controller power and on again.

8.7 MASTERING DATA ENTRY

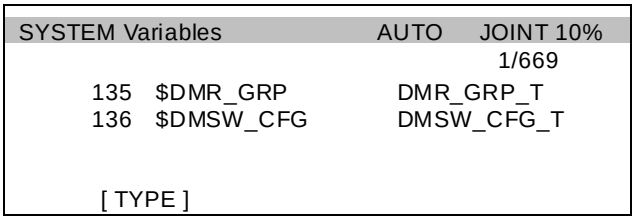
This function enables mastering data values to be assigned directly to a system variable. It can be used if mastering data has been lost but the pulse count is preserved.

Mastering data entry method

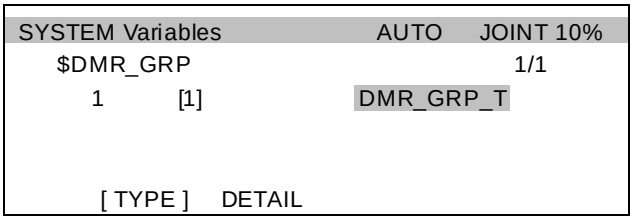
1 Press [MENU] key, then press [0 NEXT] and select [6 SYSTEM].
2 Press F1 [TYPE]. Select [Variables]. The system variable screen appears.

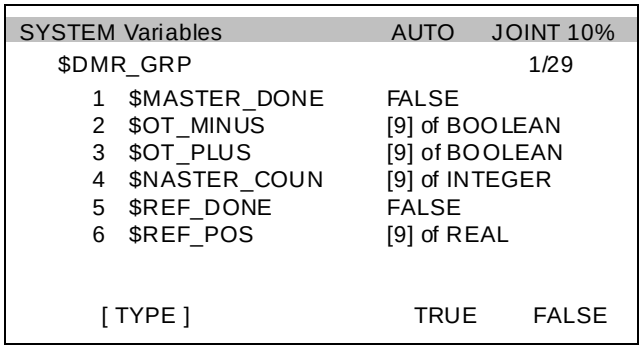


3 Change the mastering data.
The mastering data is saved to the $DMR_GRP.$MASTER_COUN system variable.

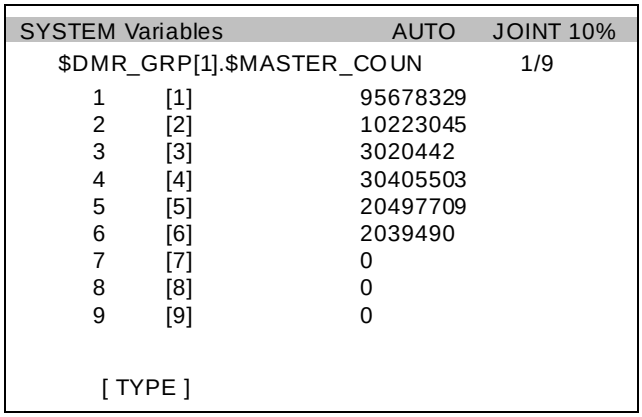


4 Select $DMR_GRP.

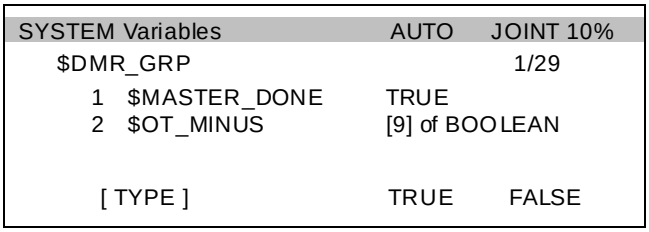




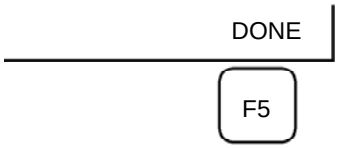
5 Select $MASTER_COUN, and enter the mastering data you have recorded.



6 Press the 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].



8.8 CHECKING THE MASTERING

1 How to check the robot mastered properly.
Usually, positioning is performed automatically at the power on. To check whether mastering has been performed correctly, examine if the current displayed position meets the actual robot position by using 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 Section 8.3 of OPERATOR'S MANUAL are aligned. No need of any visual aid.

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 in 2. 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 Alarm type displayed during mastering and their Solution methodology
(1) BZAL alarm
This alarm is alert if the Pulsecoder's backup battery voltage decreases to 0 V while the power to the controller is disconnected. Furthermore, if Pulsecoder connector is removed for replacing cables etc. this alarm is output as the voltage decreased to 0. Confirm if the alarm will disappear by performing pulse reset (See Section 8.2.). And then cycle power of the controller to check if the alarm disappears or not.
The battery may be drained if the alarm is still displayed. Perform pulse reset, turn off and on the controller power after replacing the battery. Note that, if this alarm displayed, all the original data held by the Pulsecoder will be lost. Mastering is required.
(2) BLAL alarm
Warn 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.
(3) Alarm notification like CKAL, RCAL, PHAL, CSAL, DTERR, CRCERR, STBERR, and SPHAL may have trouble with Pulsecoder, contact your local FANUC representative.

9 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.

9.1 TROUBLESHOOTING

Table 9.1 (a) shows the problems that may occur in the mechanical unit and their probable causes. If you cannot pinpoint the cause of a failure or which measures to take, contact your local FANUC representative. For troubleshooting except the mechanical unit, refer to "CONTROLLER MAINTENANCE MANUAL (B-83195EN etc.)" and Alarm Code List (B-83284EN-1).

Table 9.1 (a) Troubleshooting

Symptom	Description	Cause	Measure
Vibration Noise	- The J1 base lifts off the floor plate as the robot operates. - There is a gap bfetween 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 cause is a loose bolt, an insuffcient degree of surface flatness, or foreign material caught between the robot 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 wihich, in turn, leads to vibration.	- If a bolt is loose, apply LOCTITE and tighten it with the appropriate torque. - Adjust the floor plate surface flatness to within the specified tolenrance. - If there is any foreign material between the J1 base and floor plate, remove it.
	- The rack or floor plate vibrates during operation of the robot.	[Rack or floor] - It is likely that the rack or floor is not rigid enough. - If they are not rigid enough, counterforce deforms the rack or floor, and responsible for the 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 once more. If the robot is found to be overloaded, reduce the load, or modify the robot control program. - Vibration in a specific portion can be reduced by modifying the robot control program while slowig the robot and reducing its acceleration (to minimize the influenece on the entire cycle time).

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- Vibration was first noticed after the robot collided with an object or the robot was overloaded for a long period. - The grease of the vibrating axis has not been replenished for a long period. - Cyclical vibration and noise occur.	[Gear, bearing, or reducer] - It is likely that collision or overload applied an excessive force on the drive mechanism, thus damaging the geartooth surface or rolling surface of a bearing, or reducer. - Prolonged overloaded use may cause fretting fatigue on the gear tooth surface or the rolling surface of bearing and reducer - It is likely that foreign material 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 foreign material caught in a gear, bearing, or within a reducer cause vibration. - It is likely that, because the grease has not been changed 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 FANUC. - Using the robot within its maximum rating prevents problems with the drive mechanism. - Using the specified grease at the recommended interval will prevent problems.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- The cause of 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. - Pulse coder defect may be the cause of the vibration as the motor cannot propagate the accurate position. - 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 connection cable between them has an intermittent break, vibration might occur. - If the power cable between them has an intermittent break, vibration might occur. - If the power source voltage drops below the rating, vibration might occur. - It may vibrate when the invalid value parameter was set. - If the noise occurs at belt driving axis, damage of the bel may cause the noise.	- Refer to the 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 the cable in the mechanical unit is broken. - Check whether the cable jacket connecting the mechanical unit and controller 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 them. Contact your local FANUC representative for further information if necessary. - Contact your local FANUC representative if performing the belt check.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- There is some 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 is 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 leading to vibration.	- Connect the grounding wire firmly to ensure a reliable ground potential and prevent extraneous electrical noise.
Rattling	- While the robot is not supplied with power, pushing it with the hand causes part of the mechanical unit to wobble. - There is a gap on the mounting face of the mechanical unit.	[Mechanical unit coupling bolt] - It is likely that overloading or a collision has loosened a mounting bolt in the robot mechanical unit.	- Check that the following bolts for each axis are tight. If any of these bolts is loose, apply LOCTITE and tighten it to the appropriate torque. - Motor retaining bolt - Reducer retaining bolt - Base retaining bolt - Arm retaining bolt - Casting retaining bolt - End effector retaining bolt
Motor overheating	- The ambient temperature of the installation location increases, causing the motor to overheat. - After the robot control program or the load was changed, the motor overheated.	[Ambient temperature] - It is likely that a rise in the ambient temperature prevented the motor from releasing heat efficiently, thus leading to overheating. [Operating condition] - It is likely that the robot was operated with the maximum average current exceeded.	- Reducing the ambient temperature is the most effective means of preventing overheating. - 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 conditions can reduce the average current, thus preventing overheating. - The teach pendant can be used to monitor the average current. Check the average current when the robot control program is running.
	- After a control parameter (load setting etc.) was changed, the motor overheated.	[Parameter] - If data input for a workpiece is invalid, the robot cannot be accelerated or decelerated normally, so the average current increases, leading to overheating.	- As for load setting, Input an appropriate parameter referring to Section 4.3.

Symptom	Description	Cause	Measure
Motor overheating	- Symptom other than stated above	[Mechanical unit 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 while 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. - If the average current falls after the motor is replaced, it indicates that the first motor was faulty.

Grease leakage	- Grease is leaking from the mechanical unit.	[Poor sealing]
		- Probable causes are a crack in the casting, a broken O-ring, a damaged oil seal, or a loose seal bolt.
		- A crack in a casting can occur due to excessive force that might be caused in collision.
		- An O-ring can be damaged if it is trapped or cut during disassembling or re-assembling.
		- An oil seal might be damaged if extraneous dust scratches the lip of the oil seal.
		- A loose seal bolt might allow grease to leak along the threads.
			- If a crack develops in the casting, sealant can be used as a quick-fix to prevent further grease leakage. However, the component should be replaced as soon as possible, because the crack might extend.
			- O-rings are used in the locations listed below.
			  - Motor coupling section
			  - Reducer 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 inlet and outlet

Symptom	Description	Cause	Measure
Dropping axis	- An axis drops because the brake does not function. - An axis drops gradually when it should be at rest.	[Brake drive relay and motor] - It is likely that brake drive relay contacts are stuck to each other to keep the brake current flowing, thus preventing the brake from operating when the motor is deenergized. - 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 has entered the motor, causing the brake to slip.	- Check whether the brake drive relay contacts are stuck to each other. If they are found to be stuck, replace the relay. - If the brake shoe is worn out, if the brake main body is damaged, or if oil or grease has entered the motor, replace the motor.
Displacement	- The robot operates at a point other than the taught position. - The repeatability is not within the tolerance.	[Mechanical unit problems] - If the repeatability is unstable, probable cause is a failure in the drive mechanism or a loose bolt. - If the repeatability becomes stable it is likely that a collision imposed an excessive load, leading to slipping on the base surface or the mating surface of an arm or reducer. - It is likely that the Pulsecoder is faulty.	- If the repeatability is unstable, repair the mechanical unit by referring to the above descriptions of vibration, noise, and rattling. - If the repeatability is stable, correct the taught program. The problem will not reoccur unless another collision occurs. - If the Pulsecoder is faulty, replace the motor or the Pulsecoder.
	- 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 setting of the peripheral equipment position. - Correct the taught program.
	- Displacement occurred after a parameter was changed.	[Parameter] - It is likely that the mastering data was rewritten in such a way that the robot origin was shifted.	- Re-enter the previous mastering data, which is known to be correct. - If correct mastering data is unavailable, perform mastering again.

Symptom	Description	Cause	Measure
CLALM alarm occurred. Move error excess alarm occurred.	- Ambient temperature of the robot installation location is low, CLALM alarm is displayed on the teach pendant screen. - Ambient temperature of the robot installation position is low, “Move error excess” alarm is displayed on the teach pendant screen.	[Peripheral temperature] - When the robot is used in a low temperature environment that is near to 0ºC, or the robot is not operated for a long time in an environment that is less than 0ºC, there will be a large viscous resistance of the drive train immediately after starting which will cause the alarm.	- Perform a warm up operation or a low speed operation for several minutes.
	- After changing the motion program or the load condition, the CLALM alarm is displayed. - After changing the motion program or the load condition, the “Move error excess” alarm is displayed.	- It is likely that a robot collision occurred.	- If a robot collision has occurred, press the [RESET] key while pressing the [SHIFT] key. Then, jog the robot in the opposite direction while pressing the [SHIFT] key. - Check the motion program.
		[Overload] - It is likely that load exceeded the permissible value. - It is likely that the motion program is too severe for the robot. ・ Excessive motion due to a large “ACC (value)”. ・ Tight motion such as reverse motion using “CNT”. ・ Linear motion occurs near singularity point where axes revolve in high speed.	- Check the permissible value of the robot payload. If the load exceeds the permissible value, reduce the load or change the motion program. - Consider minimizing the cycle time by reducing the speed or acceleration, and changing the motion program. - Check that the load setting is performed correctly.
	- None of the symptoms stated above are the problem.	- It is likely the vibration occurred.	- Refer to the Symptoms: Vibration, Noise section of this troubleshooting for more information.
		- It is likely that rated voltage is not supplied due to the voltage drop.	- Check that the robot is supplied with the proper rated voltage.
BZAL alarm occurred	- 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.

Symptom	Description	Cause	Measure
Though a person does not touch the robot, a contact stop or payload error occurs and stops the robot	- Though a person does not touch the robot, robot stops due to contact stop. - Robot stops due to payload error	- Unintended contact occurred. - Incorrect robot installation is performed. - Robot installation plate is not fixed. - Robot installation plate is not properly attached. - The end effector or the workpiece does not match the load setting. - Vibration of the floor or the hand is applied to the robot. - Gaps are present between the installation surfaces	- Get rid of the matter which contact with the robot. - Install the robot according to Section 1.2. - Properly attach the installation plate. - Correct warped installation surface using spacer etc. - Match the end effector and the workpiece to the load setting. - Make sure that vibration of the floor or the hand is not applied to the robot. - Fill any open spaces or gaps at the installation surfaces, especially directly underneath the robot base, with shim (spacer), grout or similar method so no gaps are present after installation.
Cross check alarm displayed.	- Cross check alarm is displayed on the teach pendant screen.	- Refer to “Though a person does not touch the robot, a contact stop or payload error occurs and stops the robot” contents - It is likely that the force sensor is broken.	- Refer to “Though a person does not touch the robot, a contact stop or payload error occurs and stops the robot” contents - Replace the force sensor.

APPENDIX

A PERIODIC MAINTENANCE TABLE

FANUC Robot CR-4*i*A, CR-7*i*A, CR-7*i*A/L, CR-14*i*A/L Periodic Maintenance Table

Items			Check time	Grease amount	First check 320	3 months 960	6 months 1920	9 months 2880	1 years 3840	4800	5760	6720	2 years 7680	8640	9600	10560
Mechanical unit	1	Check for external damage or peeling paint	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	2	Check for water	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	3	Check the force sensor *1	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	4	Check the exposed connector.(loosening)	0.2H	—		○			○				○			
	5	Tighten the end effector bolt.	0.2H	—		○			○				○			
	6	Tighten the cover and main bolt.	2.0H	—		○			○				○			
	7	Check the mechanical stopper.	0.1H	—		○			○				○			
	8	Clean spatters, sawdust and dust	1.0H	—		○	○	○	○	○	○	○	○	○	○	○
	9	Check hand cable and external battery cable (option)	0.1H	—		○			○				○			
	10	Replacing batteries *4	0.1H	—					●				●			
	11	Greasing the reducers.	0.5H	14ml												
	12	Replacing cable of mechanical unit	4.0H	—												
	13	Replacing the force sensor	2.0H	—												
Controller	14	Check the robot cable, teach pendant cable and robot connecting cable	0.2H	—		○			○				○			
	15	Cleaning the controller ventilation system	0.2H	—	○	○	○	○	○	○	○	○	○	○	○	○
	16	Replacing battery *2 *4	0.1H	—												

*1 Check the force sensor every month or 320 hours, whichever comes first.

*2 Refer to the “REPLACING UNITS Chapter of “MAINTENANCE” in the following manuals.
CONTROLLER MAINTENANCE MANUAL (B-83525EN)

*3 ●: requires order of parts
○: does not require order of parts

*4 Regardless of the operating time, replace the mechanical unit batteries at 1 year, replace controller batteries at 4 years.

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
○				○				○				○				○					7
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		8
○				○				○				○				○					9
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○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		15
				●																	16

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.

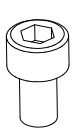
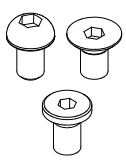
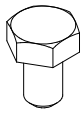
Use the following strength bolts. Comply with any bolt specification instructions.
Hexagon socket head bolt made of steel:

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.

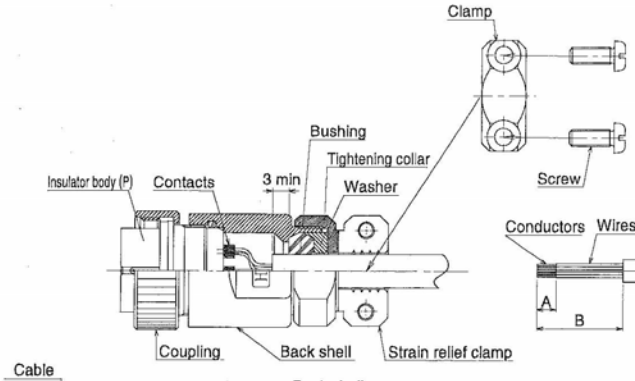
Recommended bolt tightening torques **Unit: Nm**

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	———	———	———	———	———	———
								

C OPTIONAL CONNECTOR WIRING PROCEDURE

Source of information: Hirose Electric Co., Ltd.

Plug – Disassembly / Assembly



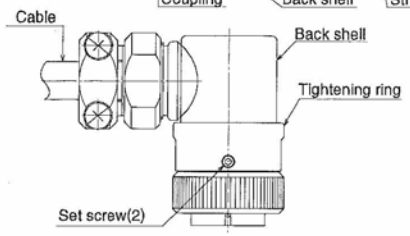


Table 1

Part Name	Number of Contacts	A	B	
RM15WTPZA-※※	3	6mm	21mm	
	2,4,8,10,12	3mm	21mm	
RM15WTPZ-※※	3	6mm	12mm	
	2,4,8,10,12	3mm	12mm	NOTE1
RM15WTLP-※※	10,12	3mm	25mm	NOTE2

1. Disassembly

① Fix the plug in the assembly fixture (RM15TP-T01 (CL150-0098-0)), then remove the insulator body (P) and the back shell. Right-angle plugs have set screws in the tightening ring at 2 locations. Loosen the set screws before removing the back shell.

② Remove the 2 screws of the strain relief clamp, and then remove the clamp from the tightening collar.

2. Wiring

① Assure that the cable outer diameter will fit the strain relief clamp, and is prepared as recommended in Table 1. It is recommended that the exposed conductors be pre-soldered, to assure easier insertion in the soldering cup.

② Pass the parts over the cable in the order of: tightening collar, washer, bushing, back shell, and coupling. Refer to the drawings (above) for assembly orientation of all components.

③ Solder the wires to the contacts of the insulator body (P). Use of heat-shrink tubing or another insulating media between the soldered contacts is suggested.

3. Connector Assembly

Straight Plugs

① Place the completely wired insulator body (P) in the assembly fixture secured in a vise. Insert in the coupling, then back shell. The back shell should be tightened to a torque of 3 N·m.

Right-angle Plugs

① Place the completely wired insulator body (P) in an assembly fixture secured by a vise. Insert in the coupling, then back shell (with tightening ring). When attaching the back shell, orient the cable in the desired direction and fasten the tightening ring to the insulator body (P) with a torque of 3 N·m. After this, tighten and fix the 2 sets crews with a torque of 0.2 to 0.3 N·m.

Additional assembly recommendations:

In applications where continuous extremely high vibrations may be encountered it is recommended that a thread locking compound be applied to male threads prior to assembly (Loctite 271 ¸ manufactured by Henkel Japan K.K. or equivalent)

4. Waterproof verification - plug assembly

Apply air pressure of 17.6 kPa for 30 seconds from the mating side of the plug assembly. There shall not be any air leakage from inside the connector when submerged in the water tank.

5. Precautions

① Follow the correct assembly sequence, cable preparation and tightening torques.

② Assure that the applicable cable outer surfaces are free of scratches, oil, grease or any other contamination.

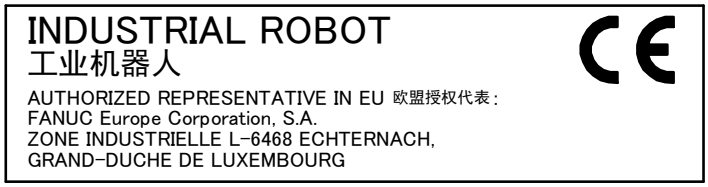
③ Do not use excessive forces or improper tools when assembling or mounting the connectors.

NOTE1) Corresponds to A05B-1137-J057.
NOTE2) Corresponds to A05B-1137-J058 and A05B-1139-J059.

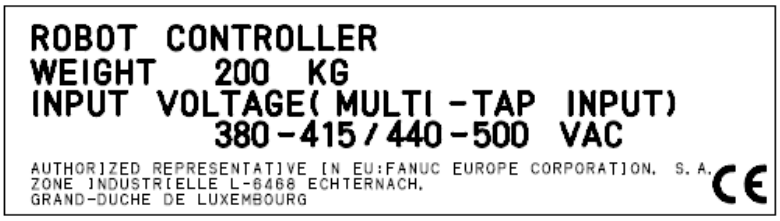
D EU DECLARATION OF CONFORMITY

For FANUC robot series (for CE marking : both of the following labels are attached), EU declarations of conformity with the following contents are applied.

Label for CE marking
(on the robot mechanical unit)



Label for CE marking
(on the robot controller)



*Note:
Value of "WEIGHT" and "INPUT VOLTAGE" depend on the robot controller specification.

Contents of
EU declarations of conformity
for Machinery Directive
(2006/42/EC)

Item	Contents	
	Machinery Directive (2006/42/EC)	**EMC Directive (2014/30/EU) Low Voltage Directive (2014/35/EU)**
Name of the manufacturer	FANUC CORPORATION	
Address of the manufacturer	3580 Komanba, Shibokusa Oshino-mura, Minamitsuru-gun Yamanashi Prefecture, 401-0597 Japan	
Model	Please refer to "operator's manual" for each robot models. At the beginning of "PREFACE", following information is listed. Model : "Model name" Designation : "Mechanical unit specification No."	
Designation		
Applied standards	EN ISO 10218-1:2011 EN 60204-1:2006+A1	EN 55011:2009+A1 (2014/30/EU) EN 61000-6-2:2005 (2014/30/EU) EN 60204-1:2006+A1 (2014/35/EU)
Importer/Distributor in EU	FANUC EUROPE CORPORATION 7, rue Benedikt Zender L-6468 Echternach	
Date	Date of manufacture (to be written in EC declaration of conformity attached for each robot system)	

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REVISION RECORD

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