FANUC Robot CR-35*i*A

MECHANICAL UNIT

OPERATOR'S MANUAL

B-83734EN/02

- **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.

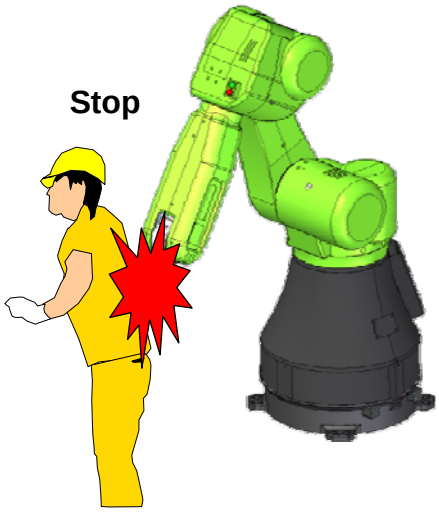
- Check this manual thoroughly, and keep it handy for the future reference.

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 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 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	○	○	○	○
Maintain for operator's panel			○	
Maintain 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

- 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 2.6 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 properly trained. Without appropriate training, any operation inside the safety fence may cause very severe injury or even death of personnel due to the multiple and various hazards caused by the robot arm.

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. 1.4.2 (c). Design with the Scaffolding and Safety-belt with circumspection.

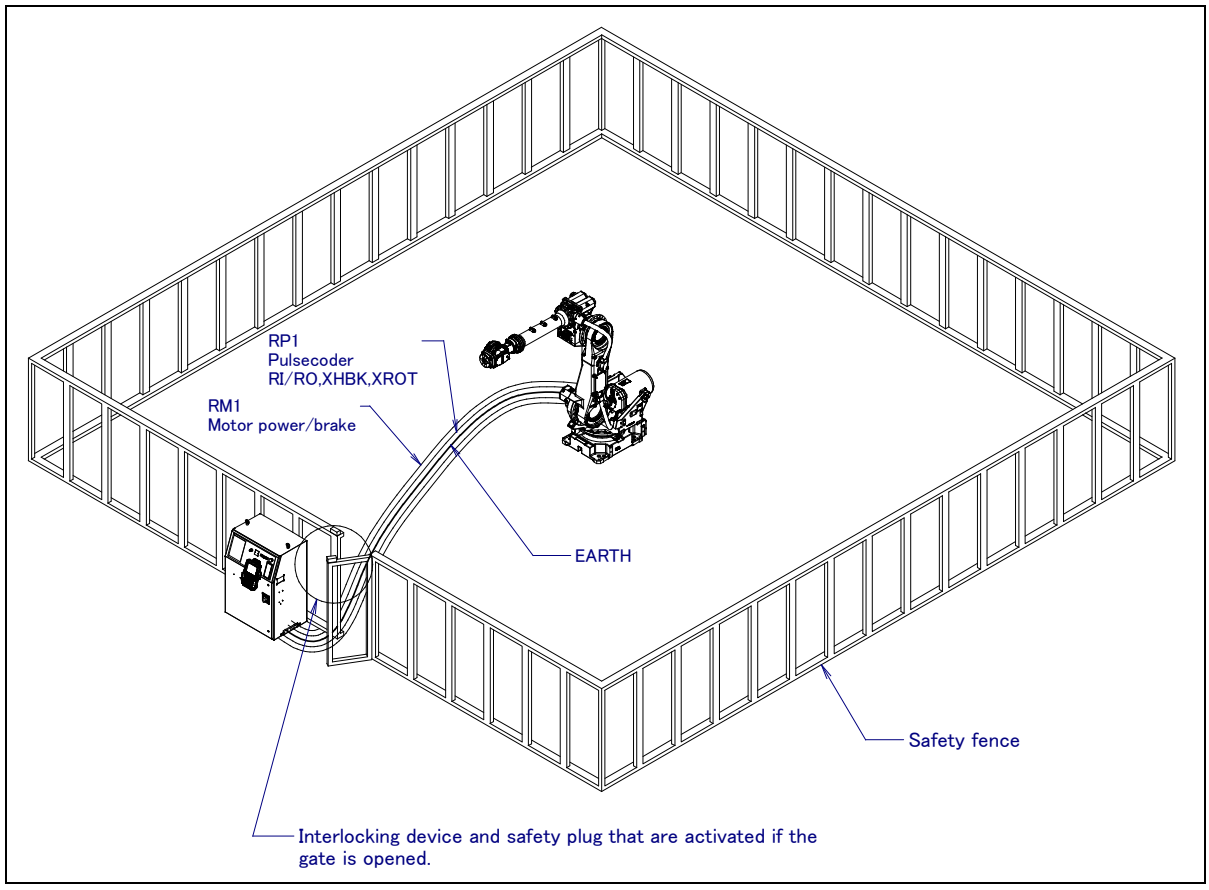


Fig. 2.4.2 (a) Safety fence and safety gate

> ⚠ **WARNING**
> When you close a fence, Make sure that no one is around the robot in closing the safety fence.

> ⚠ **WARNING**
> 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.).

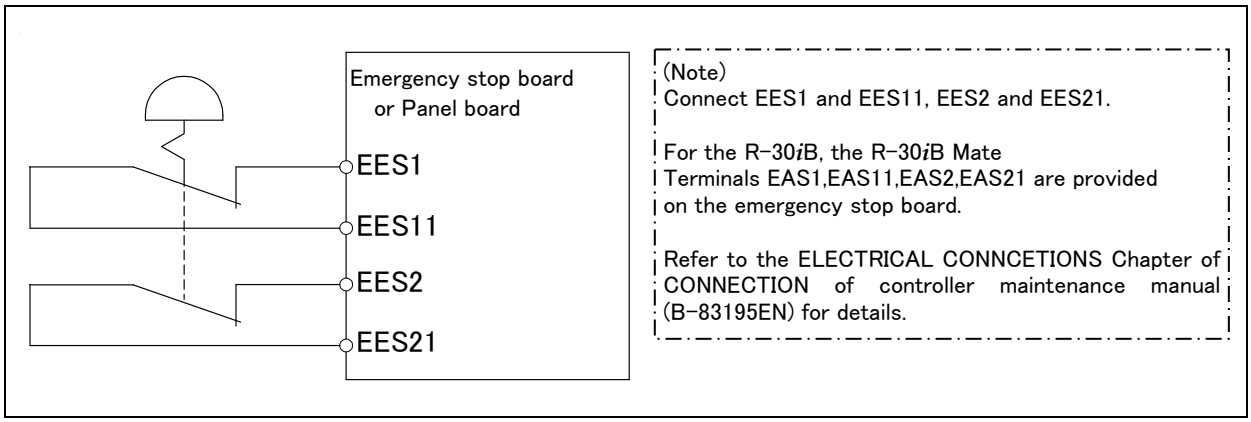


Fig. 2.4.2 (b) Connection diagram for the signal of the safety fence

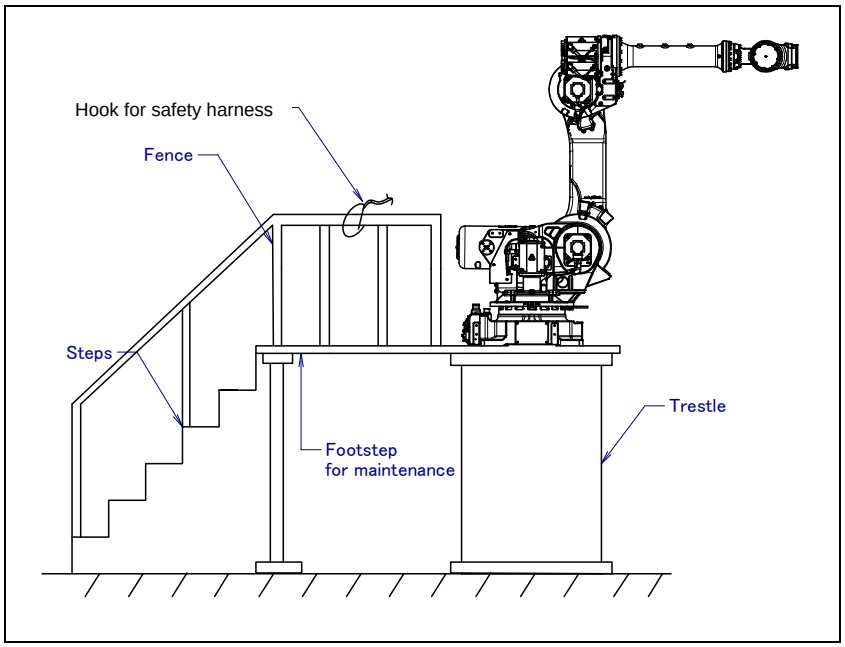


Fig. 2.4.2 (c) Footstep for maintenance

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.

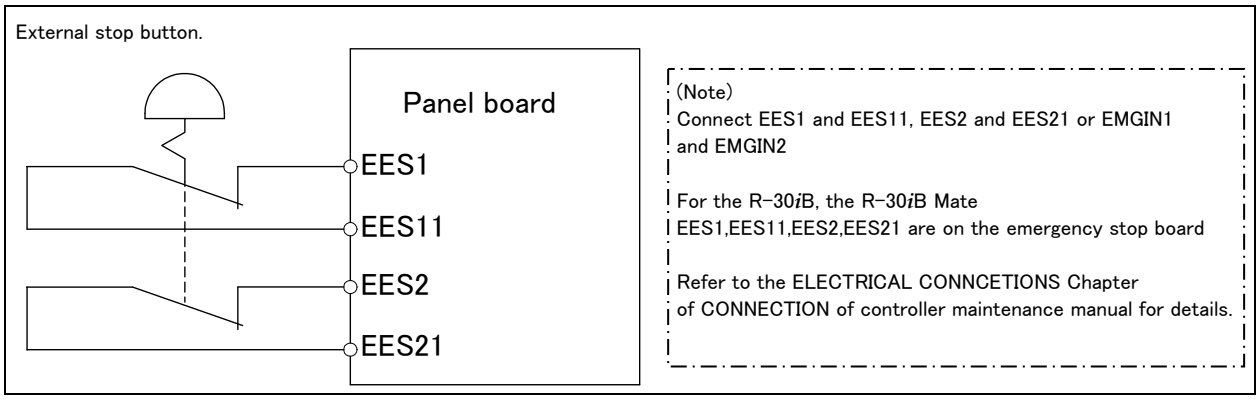


Fig. 2.4.4 Connection diagram for external emergency stop button

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 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 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) 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 DEADMAN switch or when the operator presses the switch strongly.

(b) Disable: The DEADMAN switch is disabled.

Note) The 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 DEADMAN switch, which allows the robot to operate when the 3-position DEADMAN switch is pressed to its intermediate point. When the operator releases the 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 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 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 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	Operator 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: 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.
(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, R-30*i*B Plus	[7DA5 or later] Cat.4 PL e SIL 3	[7DA5 or later] Cat.3 PL d SIL 2	[7DA5 or later] Cat.4 PL e SIL 3		EN ISO 13849-1:2008

Controller model	Collaborative robot function (Collaborative robot safety function)	Applied standard
R-30*i*B, R-30*i*B Plus	Cat.3 PL d	EN ISO 13849-1:2008

[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, TÜV SÜD 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.

Following ISO 10218-2 a risk assessment must be performed for all robot systems to ensure that selection and design of appropriate safeguarding measures are sufficient to reduce the risk of accident or injury to a person exposed to the hazards presented in the robot system.

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.

ISO10218-2 requires performing risk assessment for the whole robot system. 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 EN ISO 10218 (ANSI/RIA/ISO 10218) and Annex I of Machinery 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.

- Keep the robot operating space clean, and operate under an environment free of grease, water, and dust.

- 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 that can function with several different conditions (speed, etc.), the selection of the condition must be safely and securely done.

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 Collaborative Robot Function OPERATOR'S MANUAL (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.

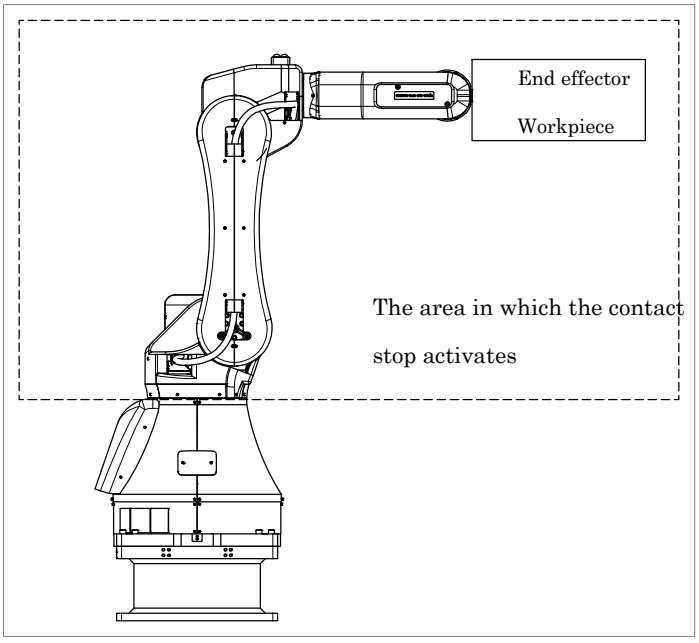


Fig. 3.6 (a) Contact stop parts of robot

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 150N, which is the maximum setting.
- 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. Please note that a default value of collaborative motion speed is 250mm/s, and the maximum setting value is 750mm/s (The maximum setting value is 250mm/s when software version is before 7DC3/42 or 7DF1/14.). For reference, acceptable motion speed for body regions are shown below.

Acceptable motion speed for body regions

Body region	Acceptable motion speed (mm/s)
Skull, Forehead, Face, Neck	Not applicable
Lower legs	250
Arms, Hands, Fingers	750
Body region excluding the above region	300

- 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.

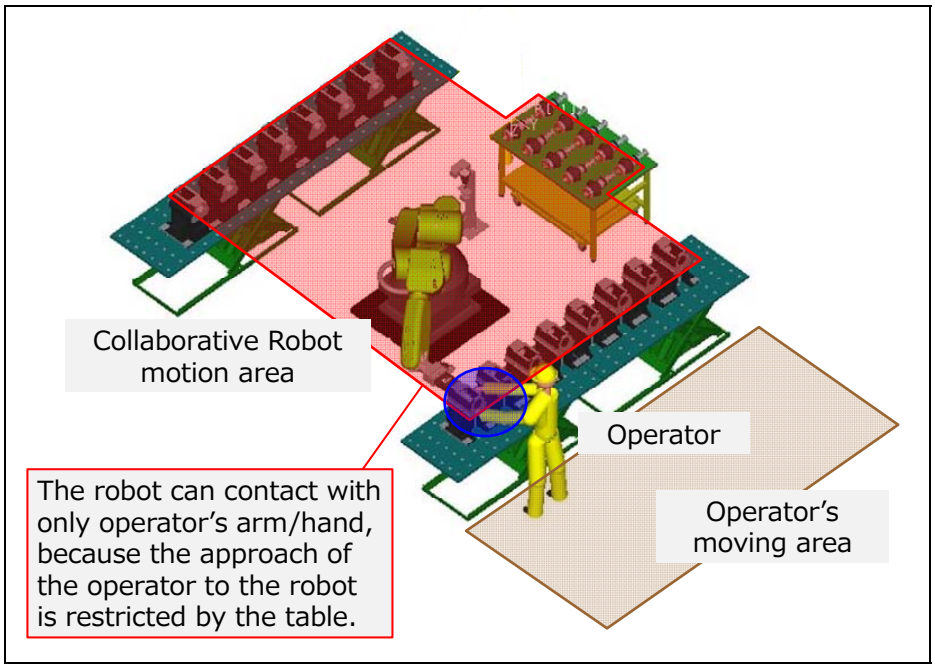


Fig. 3.6 (b) example of system

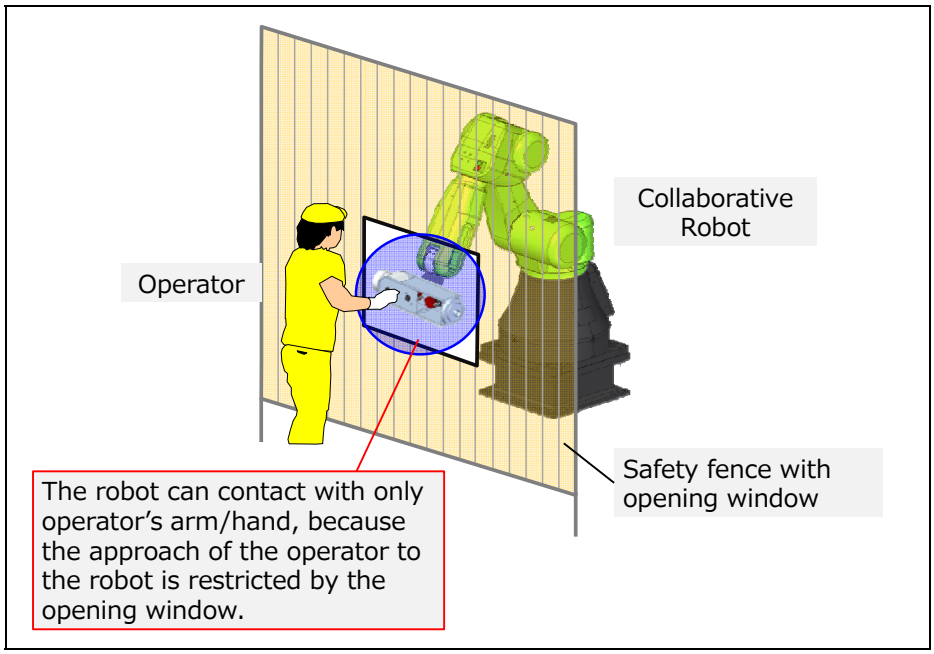


Fig. 3.6 (c) example of system

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.

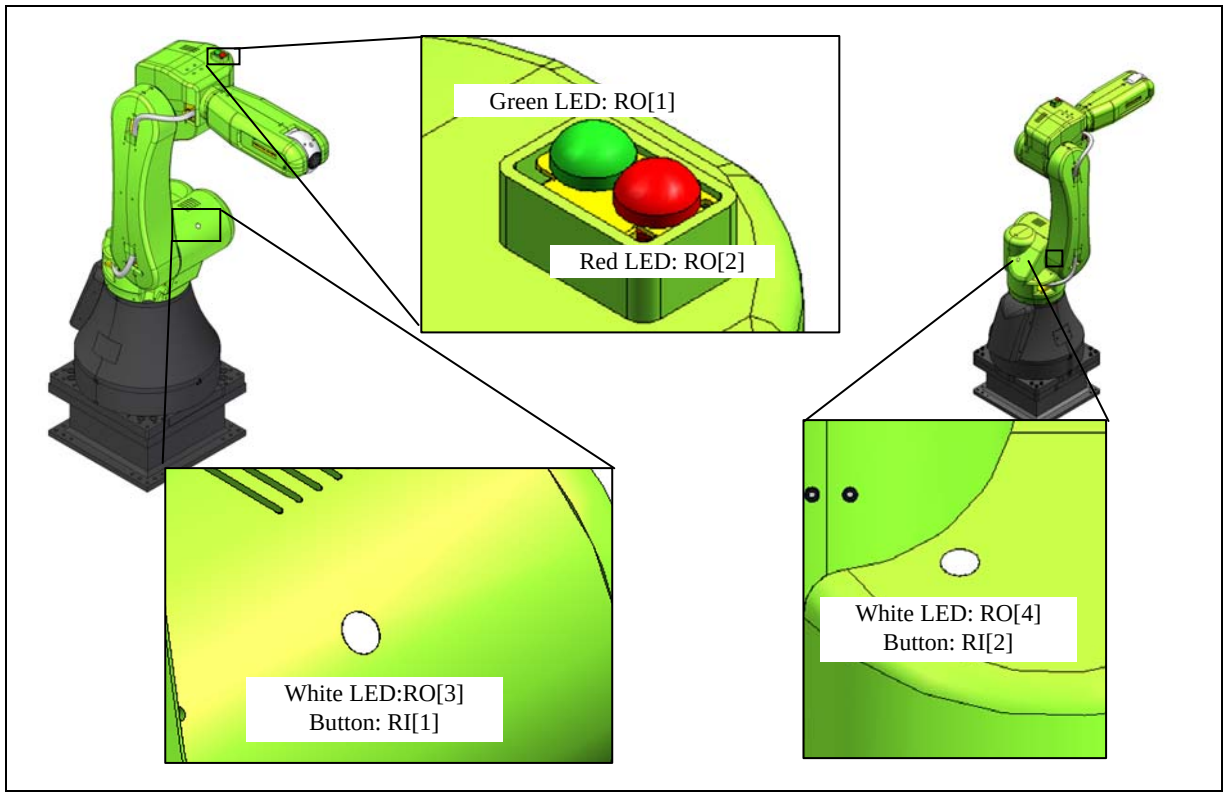
WORKING NOTE INSIDE THE COLLABORATIVE WORKSPACE

- Please don't put any objects on the robot. Foreign objects may cause an improper detection of the external contact seen by the CR-35iA.(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.

INDICATION OF COLLABORATION MODE

- The visual indication, for example lamp, indicating that the robot is in collaborative operation is necessary. Please prepare appropriate equipment. The LED installed on the robot is available for this purpose. Refer to Section 2.3(OUTPUT SIGNAL OF COLLABORATIVE STATUS), 7.3(LED AND BUTTON ON ROBOT ARM) of Collaborative Robot Function OPERATOR'S MANUAL (B-83744EN).
- Collaboration Mode LED (standard option) A05B-1701-K061 to K064 or the switch box A05B-1701-K071 are also available for this purpose.

⚠ CAUTION
When using a collaborative robot, be sure to install and turn collaborative mode LED.



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.

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 (maximum 750 mm/s), but in high speed mode (contact stop function disabled) the robot can move up to 750 mm/s. 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.

4 SAFETY DEVICES

4.1 STOP TYPE OF ROBOT

The following three robot stop types exist:

Power-Off Stop (Category 0 following IEC 60204-1/NFPA79)

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.
The following processing is performed at Power-Off stop.

- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. Execution of the program is paused.

Controlled stop (Category 1 following IEC 60204-1/NFPA79)

The robot is decelerated until it stops, and servo power is turned off.
The following processing is performed at Controlled stop.

- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

Hold (Category 2 following IEC 60204-1/NFPA79)

The robot is decelerated until it stops, and servo power remains on.
The following processing is performed at Hold.

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

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop is longer than the stopping distance and stopping time 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 is used.

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

There are the following 3 Stop patterns.

Stop pattern	Mode	E-Stop button	External E-Stop	FENCE open	SVOFF input	Servo disconnect
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	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

P-Stop: Power-Off stop
C-Stop: Controlled stop
-: Disable

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

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

(*) R-30*i*B does not have servo disconnect.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer "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 becomes 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 E-stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant E-stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*B controller)
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 stopping time of Controlled stop is longer than the stopping distance and stopping time of Power-Off stop, depending on the robot model and axis. Please refer the operator's manual of a particular robot model for the data of stopping distance and stopping time.

When this option is loaded, this function can not 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 stopping time of Controlled stop is longer than the stopping distance and stopping time 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.

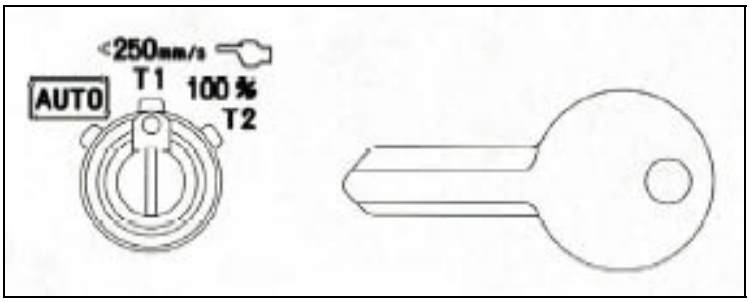


Fig. 4.3 Example of mode select switch

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 DEADMAN SWITCH

The DEADMAN SWITCH is used as an “enabling device”.
When the teach pendant is enabled, these switches allow robot motion only while at least one of deadman switches is gripped. If you release or hard grip switches, the robot stops immediately.

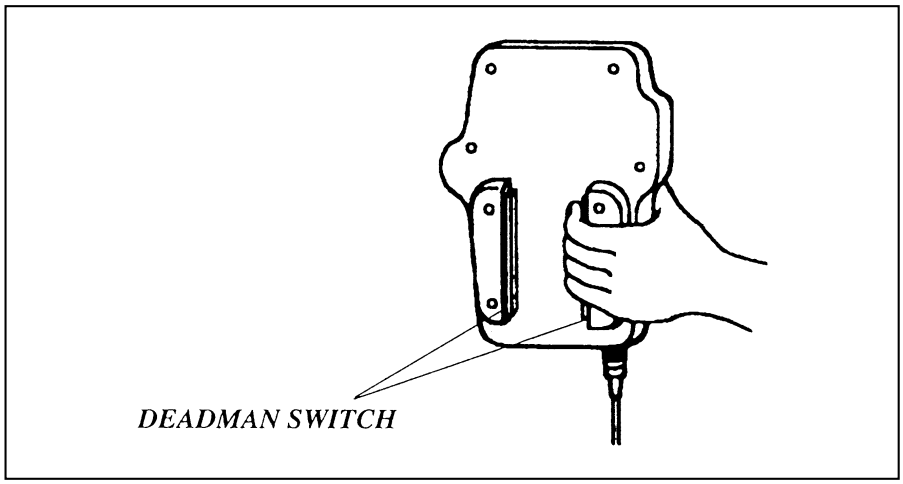


Fig.4.4 Deadman switch

Based on the risk assessment by FANUC, number of operation of DEADMAN SW 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 arises.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 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
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.

⚠ WARNING
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 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.

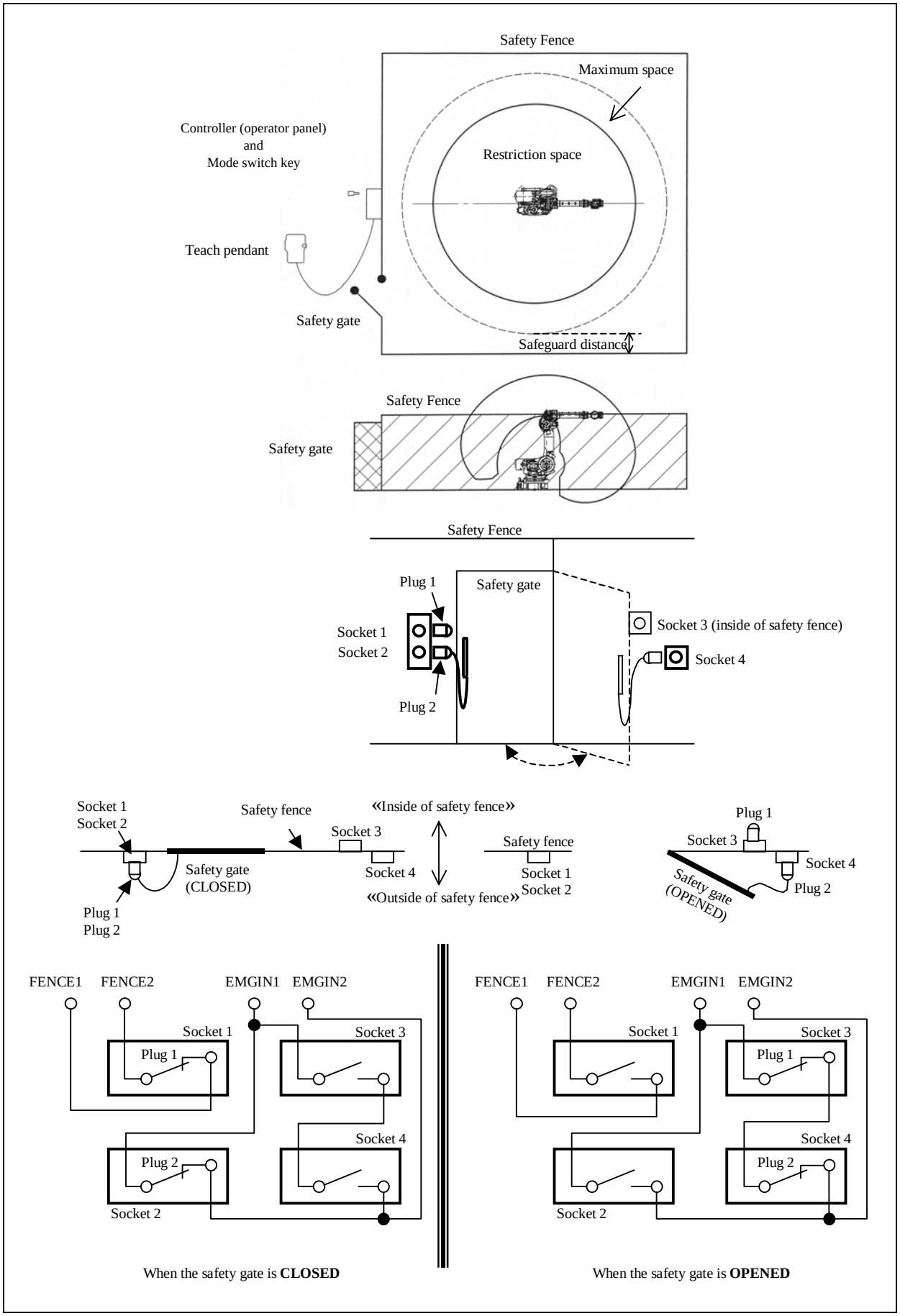


Fig. 4.7 SAFETY FENCE and SAFETY GATE example

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 (4.10)
- 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
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.

⚠WARNING
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

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,

⚠WARINIG
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), brake release unit can be used to move the robot axes without drive power.
Please order following unit and cable.

Name	Specification
Brake release unit	A05B-2450-J350 (Input voltage AC100-115V single phase) A05B-2450-J351 (Input voltage AC200-240V single phase)
Robot connection cable	A05B-2525-J047 (5m) A05B-2525-J048 (10m)

Name	Specification
Power cable	A05B-2525-J010 (5m) (AC100-115V Power plug) (*) A05B-2525-J011 (10m) (AC100-115V Power plug) (*) A05B-2450-J364 (5m) (AC100-115V or AC200-240V No power plug) A05B-2450-J365 (10m) (AC100-115V or AC200-240V No power plug)

(*) Not supporting CE Marking.

(2) Prepare and store adequate numbers of brake release units which are ready and readily accessible for robot system before installation.
(3) Regarding how to use brake release unit, please refer to "**Robot controller maintenance manual**".

⚠CAUTION
Robot systems installed without adequate number of brake release units or similar means are neither in compliance with EN ISO 10218-1 nor with the Machinery Directive and therefore cannot bear the CE marking.

⚠WARNING
Robot arm would fall down by releasing its brake because of the gravity. Therefore, it is strongly recommended to take adequate measures such as hanging Robot arm by a crane before releasing a brake.

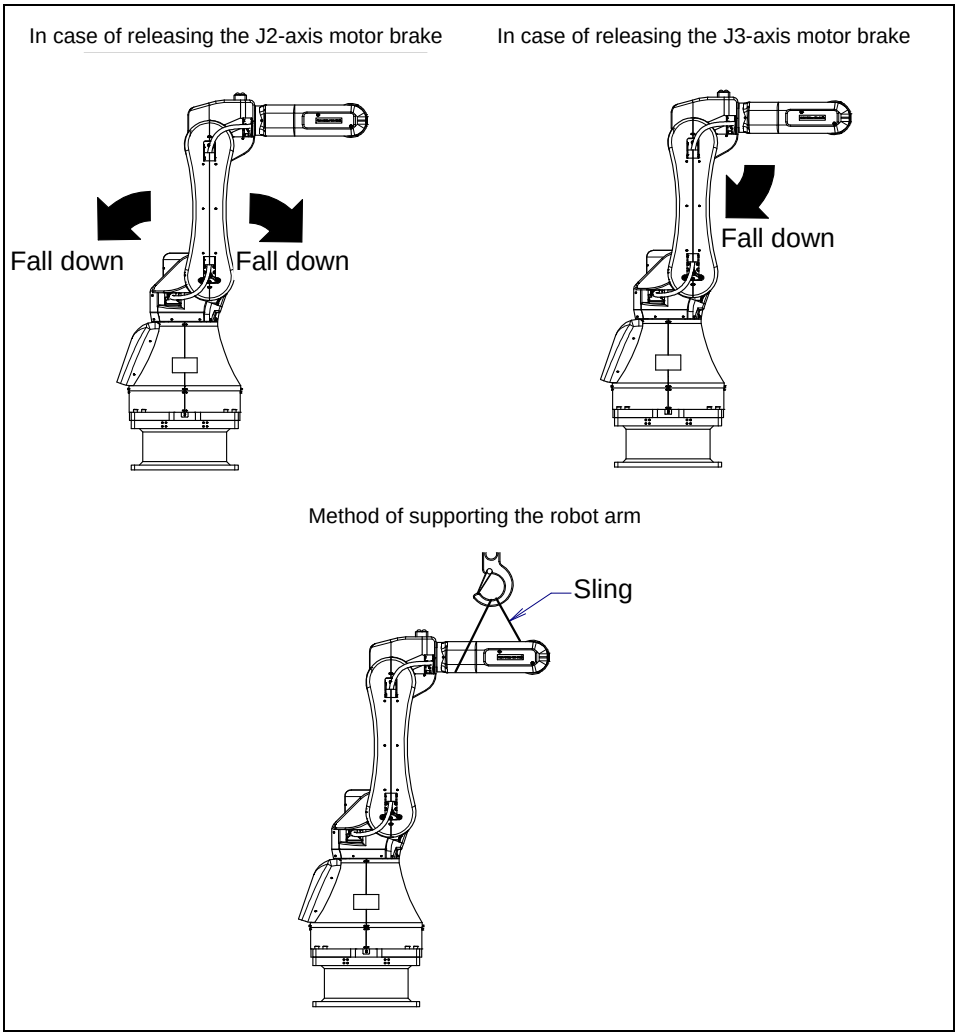


Fig. 5.10 Releasing J2 and J3 motor brake and measures

5.11 WARNING & CAUTION LABEL

(1) Greasing and degreasing label

Fig. 5.11 (a) Greasing and degreasing label

Description

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

(1) Open the grease outlet at greasing.
(2) Use a hand pump at greasing.
(3) Use designated grease at greasing.

> **⚠CAUTION**
> See Section 7.3 for explanations about specified greases, the amount of grease to be supplied, and the locations of grease and degrease outlets for individual models.

(2) Disassembly prohibitive label

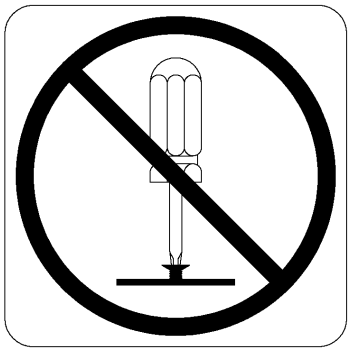


Fig. 5.11 (b) Disassembly prohibitive label

Description

Do not disassemble the base plate.

(3) Transportation label

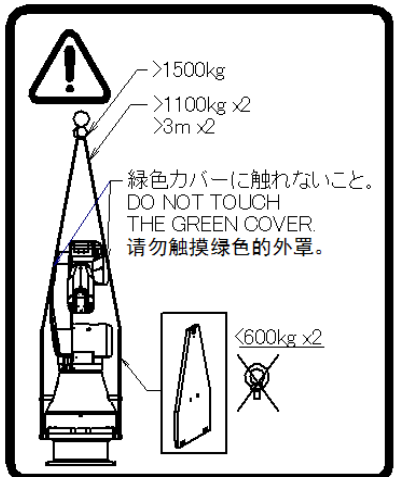


Fig. 5.11 (c) Transportation label

Description

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

- Use a crane with a load capacity of 1500kgf or greater.
- Use two slings with each load capacity of 1000kgf or greater which length is 3m or more.
- Do not touch the green cover.
- Do not install the eyebolts to transport the robot.

NOTE
See Section 1.1 TRANSPORTATION of operator's manual for explanations about the posture a specific model should take when it is transported.

(4) Transportation label

Fig. 5.11 (d) Transportation label

Description

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

1) Do not lift the robot by using the eyebolt attached on the transport member, or the eyebolts will be failed and The robot will be dropped down.
2) Do not hook the lashing belt to the transport member directly, or the internal sensor will be damaged.
3) Do not give a shock to the robot in installation, or the internal sensor will be damaged.

(5) Transporation label (Forklift bracket option when A05B-1701-H072 is specified)

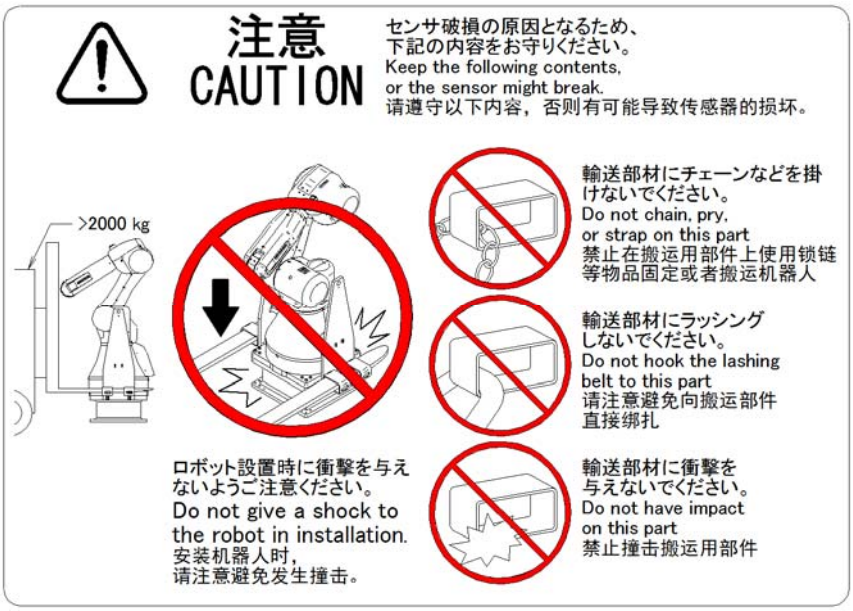


Fig. 5.11 (e) Transportation label

Description

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

1) Use a forklift having a load capacity of 2000 kgf or greater.
2) Do not give a shock to the robot in installation.
3) Do not chain, pry or strap on this part.
4) Do not have impact on this part.
5) Do not hook the lashing belt to this part.

(6) Connection caution label

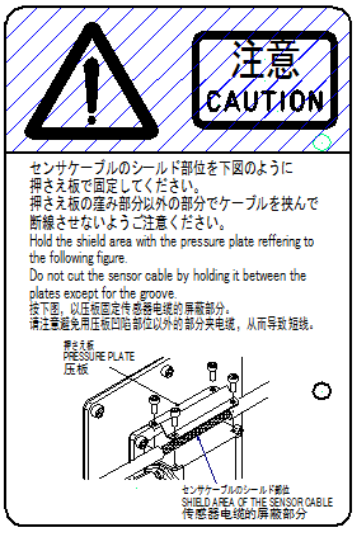


Fig. 5.11 (e) Connection caution label

Description

When connecting the force sensor cable to the robot, observe the instructions indicated on this label. Hold the shield area with the pressure plate. Do not cut the sensor cable by holding it between the plates excepts for the groove.

(7) Operating space and payload label

Below label is added when CE specification is specified.

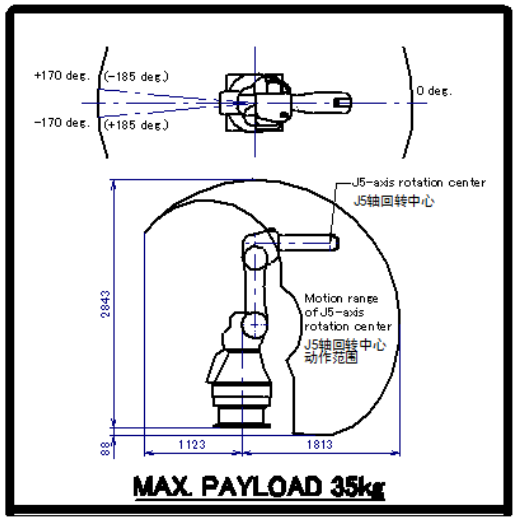


Fig. 5.11 (f) Operating space and payload label

6 DAILY MAINTENANCE

6.1 MECHANICAL UNIT

To keep the robot system safe, please perform periodic maintenance those are specified in mechanical unit operators 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
- Damage of green covers
- Periodic check of the force sensor precision (refer to Collaborative Robot Function OPERATOR'S MANUAL (B-83744EN)
- Emergency stop functions
- Effectiveness of 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.

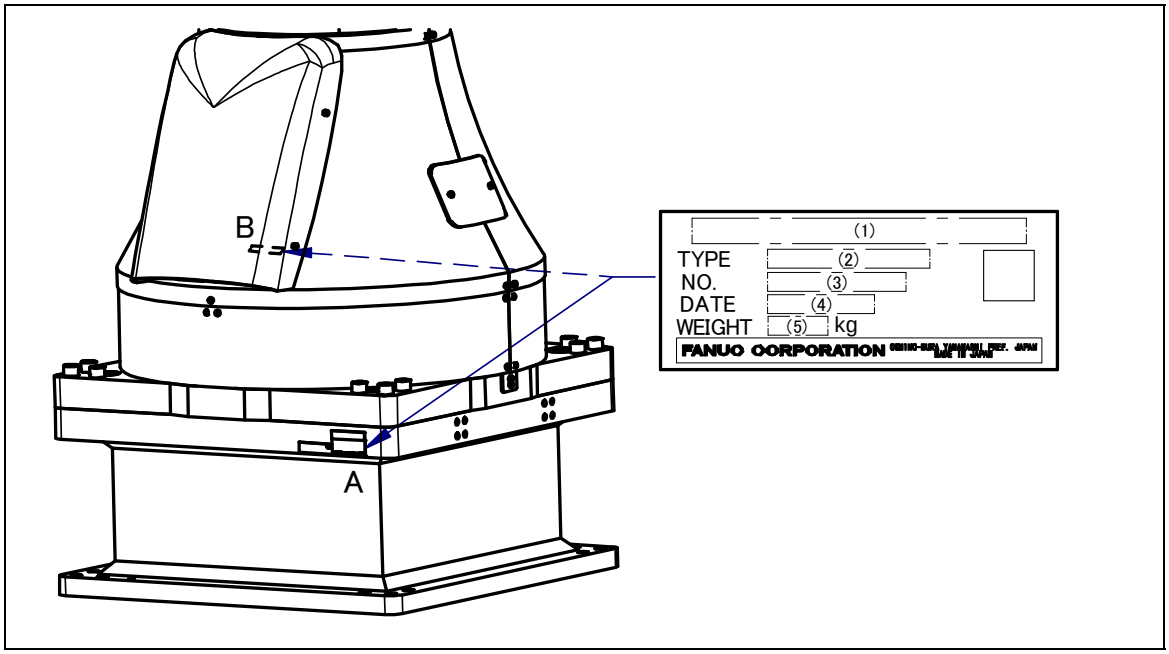
(b) After service operation
At the end of service operation, return the robot to the proper position, then turned off the controller. Clean each part, and check for any damage or cracks.
If the ventilation port and the fan motor of the controller are dusty, wipe off the dust.

PREFACE

This manual explains operation procedures for the following mechanical units:

Model name	Mechanical unit specification No.	Maximum load
FANUC Robot CR-35*i*A	A05B-1701-B201	35kg

The label stating the mechanical unit and force sensor specification number is affixed in the following position. 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

CONTENTS	(1) Model name	(2) TYPE	(3) No.	(4) DATE	(5) WEIGHT kg (Without controller)
LETTERS	FANUC Robot CR-35*i*A	A05B-1701-B201	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	990

TABLE 2) B: Force sensor

CONTENTS	(1) Name	(2) TYPE	(3) No.	(4) DATE	(5) WEIGHT kg
LETTERS	FANUC CR-35*i*A Force Sensor	A05B-1425-H101	SERIAL NO. IS PRINTED	PRODUCTION YEAR AND MONTH ARE PRINTED	710

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▽▽■○○○○○

■=1～9, X, Y, Z

Force Sensor Serial number (on TP)

▽▽□□○○○○○

□□=01～09, 10, 11, 12

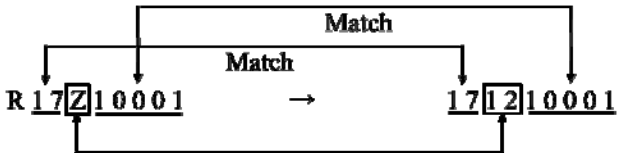
Correspondence table

■	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 **R-30*i*B Plus** **controller**	OPERATOR'S MANUAL (Basic Operation) **B-83284EN** OPERATOR'S MANUAL (Alarm Code List) **B-83284EN-1** OPERATOR'S MANUAL (Optional Function) **B-83284EN-2** ARC Welding Function OPERATOR'S MANUAL **B-83284EN-3** Spot Welding Function OPERATOR'S MANUAL **B-83284EN-4** Dispense Function OPERATOR'S MANUAL **B-83284EN-5** Collaborative Robot Function OPERATOR'S MANUAL **B-83744EN**	Intended readers : Operator, programmer, Teaching operator, Maintenance engineer, System designer Topics : Robot functions, Operations, Programming, Setup, Interfaces, Alarms Use : Robot operation, Teaching, System design
	MAINTENANCE MANUAL **B-83195EN**	Intended readers : Maintenance engineer, System designer Topics : Installation, Connection to the controller, 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 or a forklift 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 member at their points.

> ⚠ **CAUTION**
> When hoisting or lowering the robot with a crane or a forklift, move it slowly with great care. When placing the robot on the floor, exercise care to prevent the installation surface of the robot from striking the floor strongly.
> If these cautions are not followed, internal sensor might break.

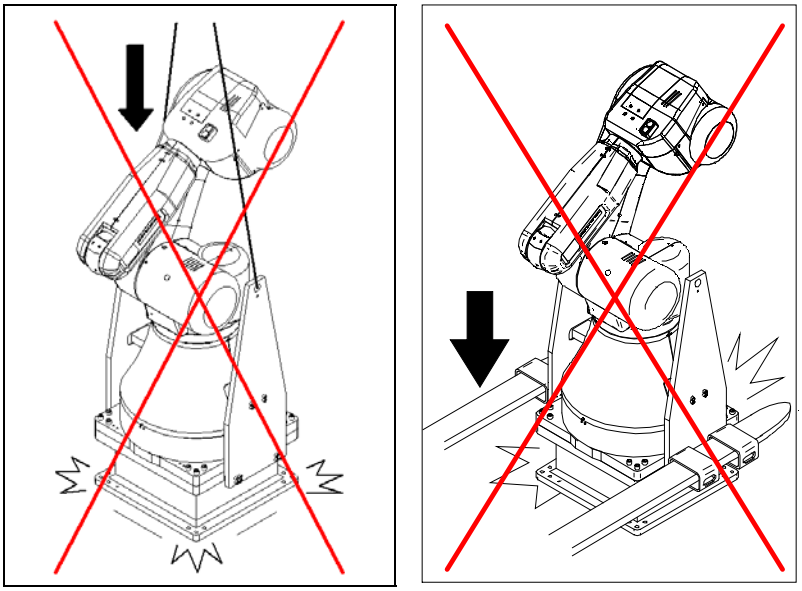


Fig. 1.1 (a) Caution for installation

> ⚠ **WARNING**
> 1 Robot becomes unstable when it is transported with the end effector or equipment is installed, and it is dangerous. Make sure to remove end effector when robot is transported. (Except light cargo)
> 2 Before transport the robot by using crane, check and tighten if there is any loose bolts on the forklift member left.

Transportation using a crane (Fig. 1.1 (b))
Fasten special transport member to two points of the robot base and lift the robot with two slings. In this case, arrange and hoist two Slings crossed referring to the figure below.

⚠ CAUTION

1 When transporting a robot, be careful not to damage a motor connector with a sling for lifting the robot.
Careful not to make a fierce shock in installing. These may cause the crash of sensor.
2 Do not attach eyebolt directly to the transport member. May cause the Eyebolt break and robot drop.

Transport member installing procedure (Fig. 1.1 (b))

1 Set the robot in transportation posture, and remove all bolts.
2 Clean the mounting both surface of robot side and transport member side. In this case, make sure that no foreign material will not tuck.
3 Hoist the robot with crane attaching Eyebolt to the transport member (60kg), and attach A,B,C,D parts temporarily tighten with bolts. In this case, tighten the bolt until just before the bolt fully buried.）(Avoid the bolt axis force acting on each parts)
4 According to a turn of C2 → D2 → C1 → D1,firm bolts with regulated 80 Nm diagonal line equally. At first, firm arbitrary 1 bolt of each part with regulated 80 Nm diagonal line equally. Then firm other bolts.
5 According to a turn of A2 → B2 → A1 → B1,firm bolts with regulated 80 Nm diagonal line equally. At first, firm arbitrary 1 bolt of each part with regulated 80 Nm diagonal line equally. Then firm other bolts.
6 Remove the Eyebolt attached to the transport member.

⚠ CAUTION

Avoid attaching the transport member without removing the robot mounting bolts. Internal sensor may be damaged. Placing the bolt in wrong order may damage the internal sensor.

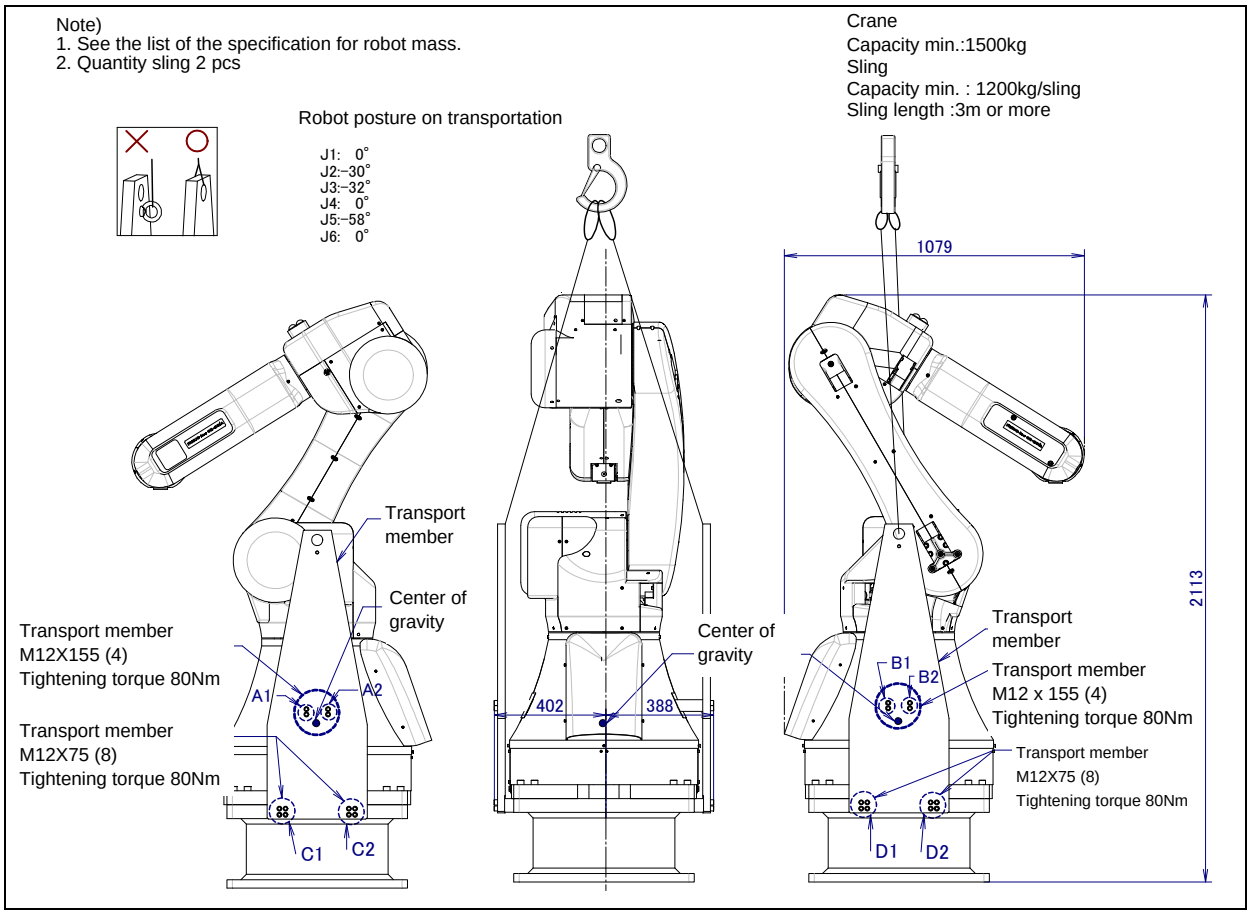


Fig. 1.1 (b) Transportation using a crane

Transporting the robot with a forklift (Fig. 1.1 (c))

When transporting a robot with a forklift, use special transport equipment. Transport equipment is prepared as the option.

> ⚠ **CAUTION**
> Be careful not to strike the transport equipment with the forklift forks.
> Internal sensor may be damaged.

Transport member installing procedure (Fig. 1.1 (c))

1 Set the robot in transportation posture, and remove all bolts.
2 Clean the mounting both surface of robot side and transport member side. In this case, make sure that no foreign material will not tuck.
3 Hoist the robot with crane attaching Eyebolt to the transport member (60kg), and attach A,B,C,D parts temporarily tighten with bolts. In this case, tighten the bolt until just before the bolt fully buried.）(Avoid the bolt axis force acting on each parts)
4 According to a turn of C2 → D2 → C1 → D1,firm bolts with regulated 80 Nm diagonal line equally. At first, firm arbitrary 1 bolt of each part with regulated 80 Nm diagonal line equally. Then firm other bolts.
5 According to a turn of A2 → B2 → A1 → B1,firm bolts with regulated 80 Nm diagonal line equally. At first, firm arbitrary 1 bolt of each part with regulated 80 Nm diagonal line equally. Then firm other bolts.
6 Attach the bracket on the transport equipment side with button bolts. Tighten those with torque of 94Nm.
7 Remove the Eyebolt attached to the transport member.

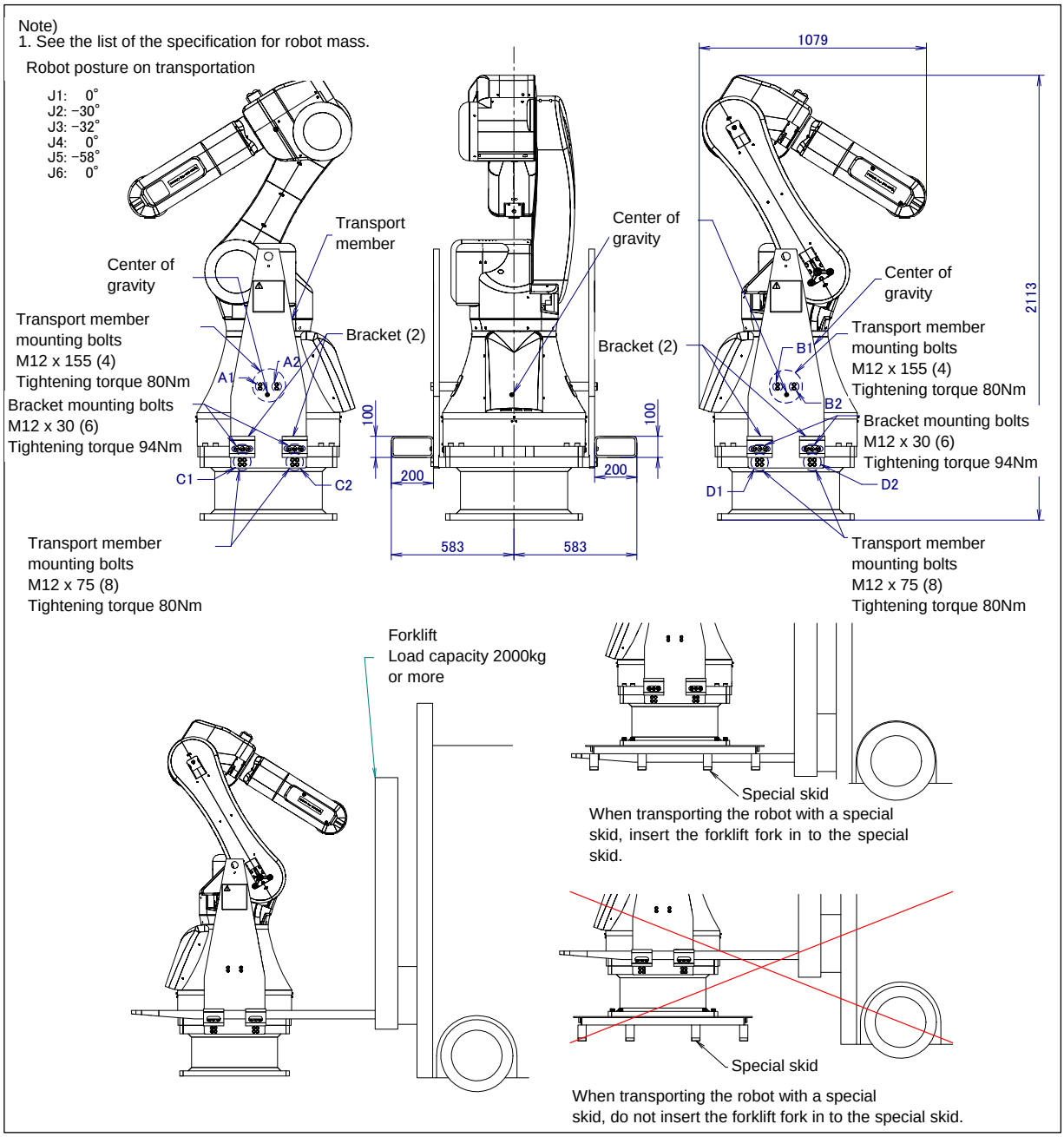


Fig. 1.1 (c) Transportation using a forklift

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.

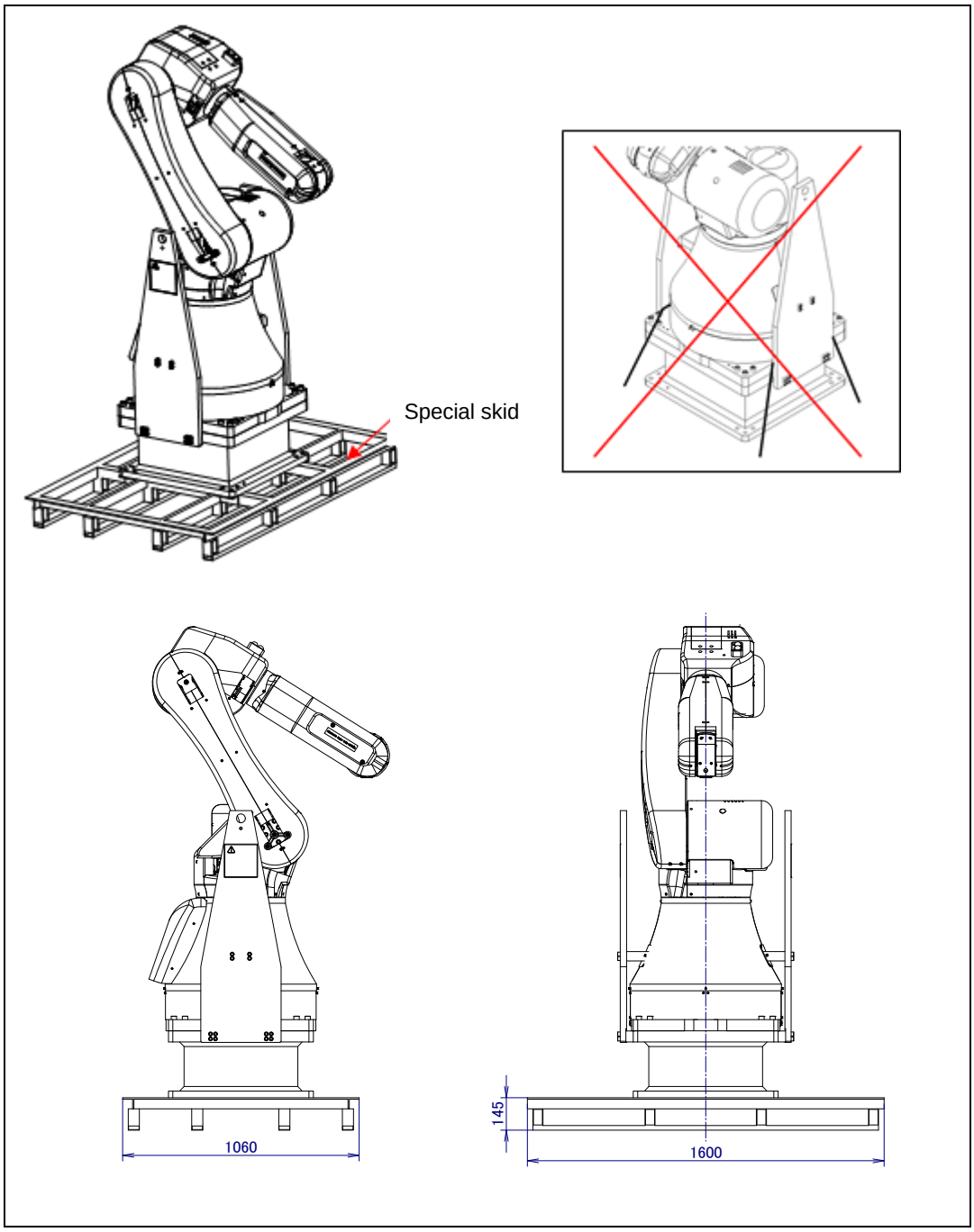


Fig. 1.1 (d) Robot shipment status

1.2 INSTALLATION

Fig. 1.2 (a) shows the robot base dimensions. Avoid placing any object in front of the robot on the mounting face to facilitate the installation of the mastering fixture.

The strength of the chemical anchor depends on that of concrete. Refer to the design guideline of the manufacturer for the execution of the chemical anchor and consider the safety ratio sufficiently before installation.

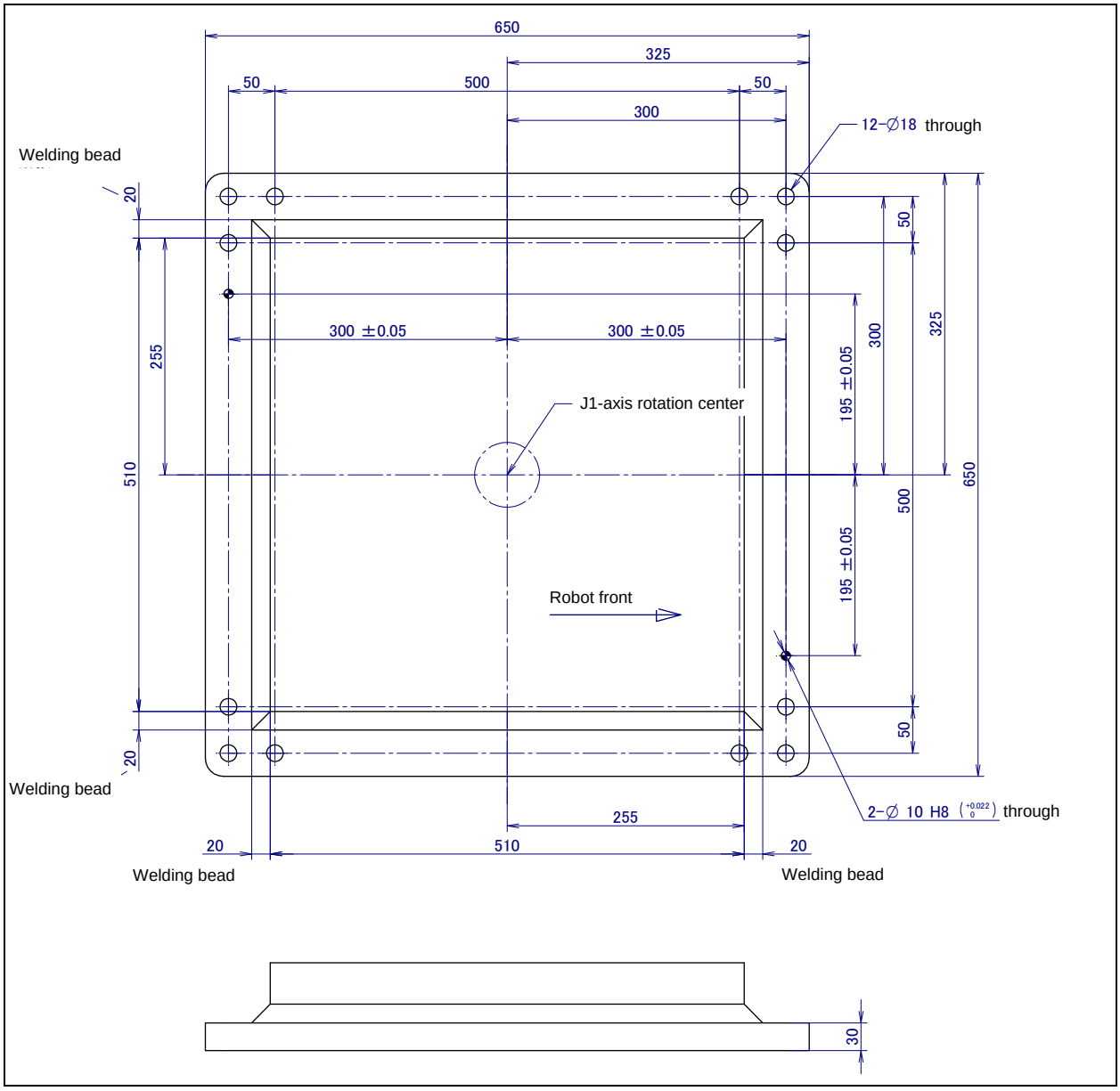


Fig. 1.2 (a) Dimensions of the robot base

Arrange the recommended Installation plate for delivering high performance referring to Fig. 1.2(b). Make sure that the area of □650mm＋αwhich considered to be installed the robot base must not be painted or fabricated for secure the leveling of mounting area.

> ⚠ **CAUTION**
> Flatness of robot installation surface must be less than or equal to 0.5mm.
> Inclination of robot installation surface must be less than or equal to 0.5º.
> 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.

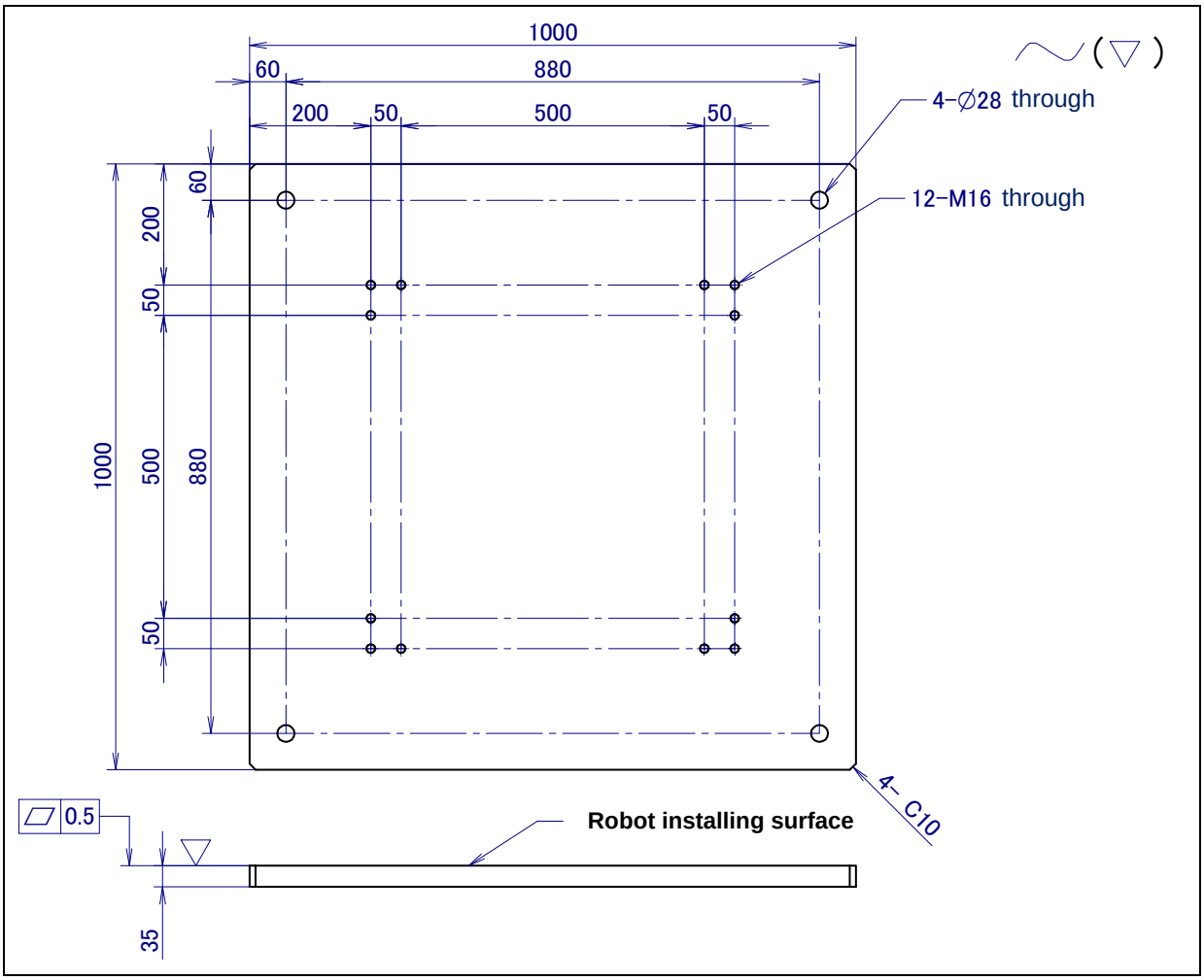


Fig. 1.2 (b) Recommended Installation Plate

Transport member removal and robot installation (Fig. 1.2 (c))

1 According to the cautions in Section 1.2, install the installation plate on the floor during securing flatness of robot installation part. Confirm that a setting plate does not have a distortion with levels.
2 Hang the robot with a crane according to caution of Section 1.1, and put it on the installation surface. During installation, clean the robot base lower side and installation surface upper side to prevent foreign materials from sandwiched. Hoist the Robot with crane and mount on the robot installation
3 Install the robot on the installation plate, and then insert the mounting bolts. At this chance, tighten the bolts until just before they contact the surface. (Avoid the bolt axis force acting on each parts)
4 Remove the bolt A and B of the transport member.
5 Attach the eyebolt on the transport member, hang the robot with a crane to prevent from falling during removing the transport member. Remove the bolts of C, then remove the transport member (60 kg).
6 Install the eyebolt on the opposite side transport member, hang it with a crane to prevent it from falling during removing the transport member. Remove the bolts of D, then remove the transport member (60 kg).
7 Tighten robot mounting all bolts with small torque according to the order of Fig. 1.2 (d), then tighten them with regulated torque 319Nm.

NOTE
Use twelve hexagon hole bolt M16 (Tensile strength 1200N/mm^2 or more), and tighten them with regulated 319Nm.

NOTE
If the transport member is removed after tightening the robot mounting bolts, the robot cannot deliver its rated performance if the transport member is removed. Remove the transport member according to the above procedure.

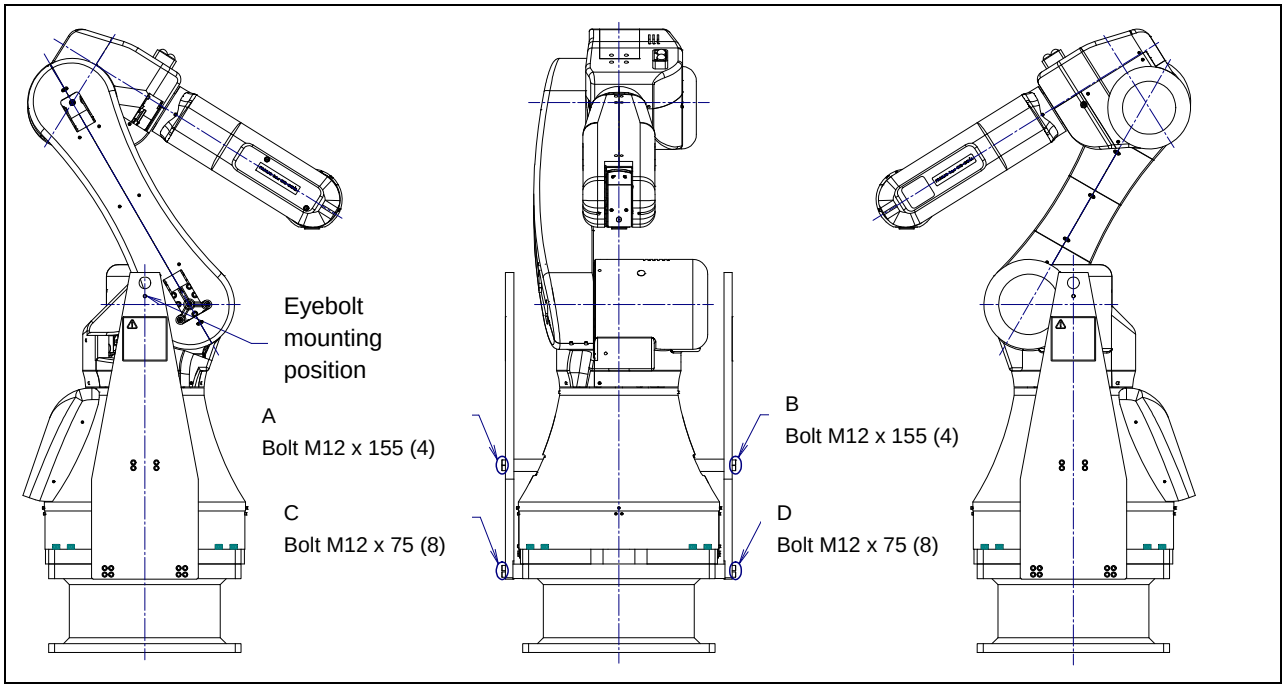


Fig. 1.2 (c) Removing the transport member

⚠ WARNING
If procedure is not followed, safety function may lost , and it may cause injury of the personnel.

Transport member removal and robot installation
(When Forklift bracket optionA05B-1701-H072 is specified Fig.1.2 (d))

1 According to the cautions in Section 1.2, install the installation plate on the floor during securing flatness of robot installation part. Confirm that a setting plate does not have a distortion with levels.
2 Hang the robot with a crane according to caution of Section 1.1, and put it on the installation surface. During installation, clean the robot base lower side and installation surface upper side to prevent foreign materials from sandwiched. Hoist the Robot with crane and mount on the robot installation
3 Install the robot on the installation plate, and then insert the mounting bolts. At this chance, tighten the bolts until just before they contact the surface. (Avoid the bolt axis force acting on each parts)
4 Remove the bracket on the transport member.
5 Remove the bolt A and B of the transport member.
6 Attach the eyebolt on the transport member, hang the robot with a crane to prevent from falling during removing the transport member. Remove the bolts of C, then remove the transport member (60 kg).
7 Install the eyebolt on the opposite side transport member, hang it with a crane to prevent it from falling during removing the transport member. Remove the bolts of D, then remove the transport member (60 kg).
8 Tighten robot mounting all bolts with small torque according to the order of Fig. 1.2 (d), then tighten them with regulated torque 319Nm.
9 Attach the cover on the transport member mounting position according to the following procedure.
   A) Loosen the appended cover bolts M5X12, and make a clearance between the pressure plate and the cover. (Fig. 1.2 (f))
   B) Tilt the cover according to Fig. 1.2(g), and then attach the cover on the transport member mounting portion. (Refer to Fig. 1.2 (g) for the cover direction.) In this case, hold the cone part with a pressure plate and the cover.
   C) Move the cover until the transport member mounting portion disappear, then tighten the bolts and fix it. (Fig. 1.2 (h))

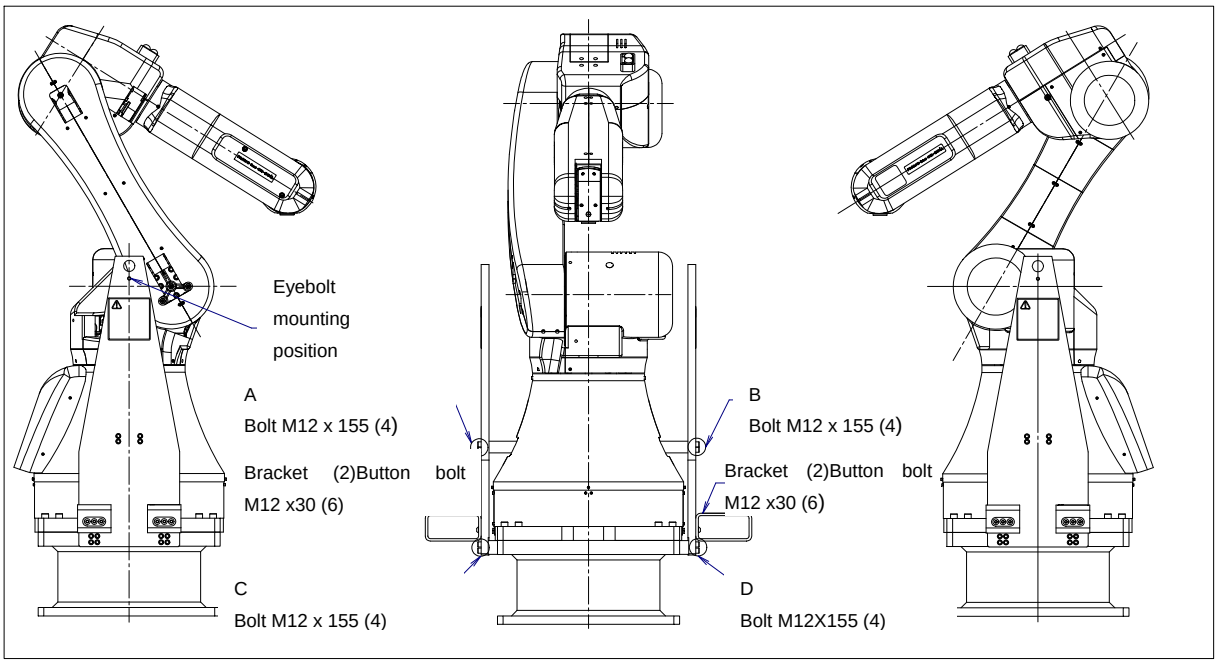


Fig. 1.2 (d) Removing the transport member

> ⚠ **WARNING**
> If procedure is not followed, safety function may lost , and it may cause injury of the personnel.

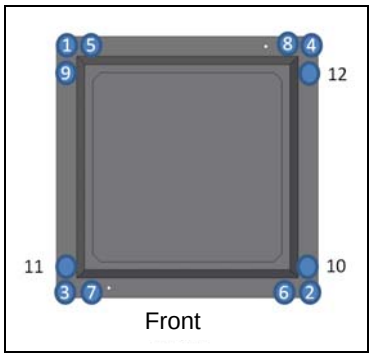


Fig. 1.2 (e) Tightening order of the robot mounting bolts

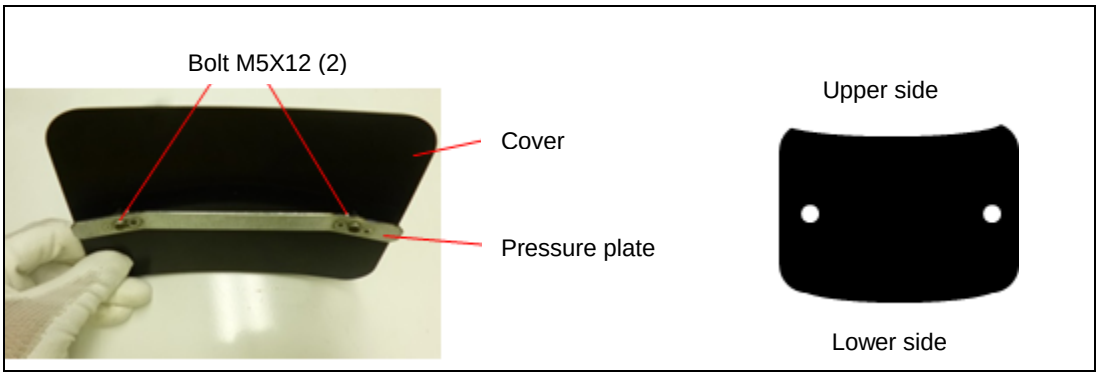


Fig. 1.2 (f) Cover

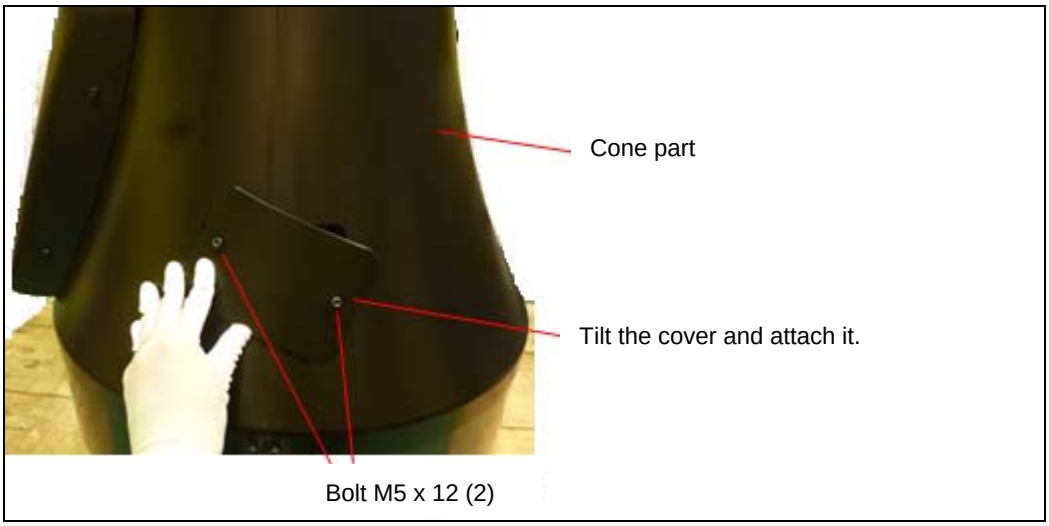


Fig. 1.2 (g) Cover attaching method

Fig. 1.2 (h) Cover attaching figure

Fig. 1.2 (i) shows an example of installing the robot. In this example, the recommended installation plate is fixed with four M20 chemical anchors (tensile strength 400N/mm^2 or more). Then the robot base is fastened to the recommended installation plate with twelve M16x55 bolts (tensile strength 1200N/mm^2 or more). If compatibility must be maintained in teaching the robot after the robot mechanical unit replacement, utilize the mounting face.

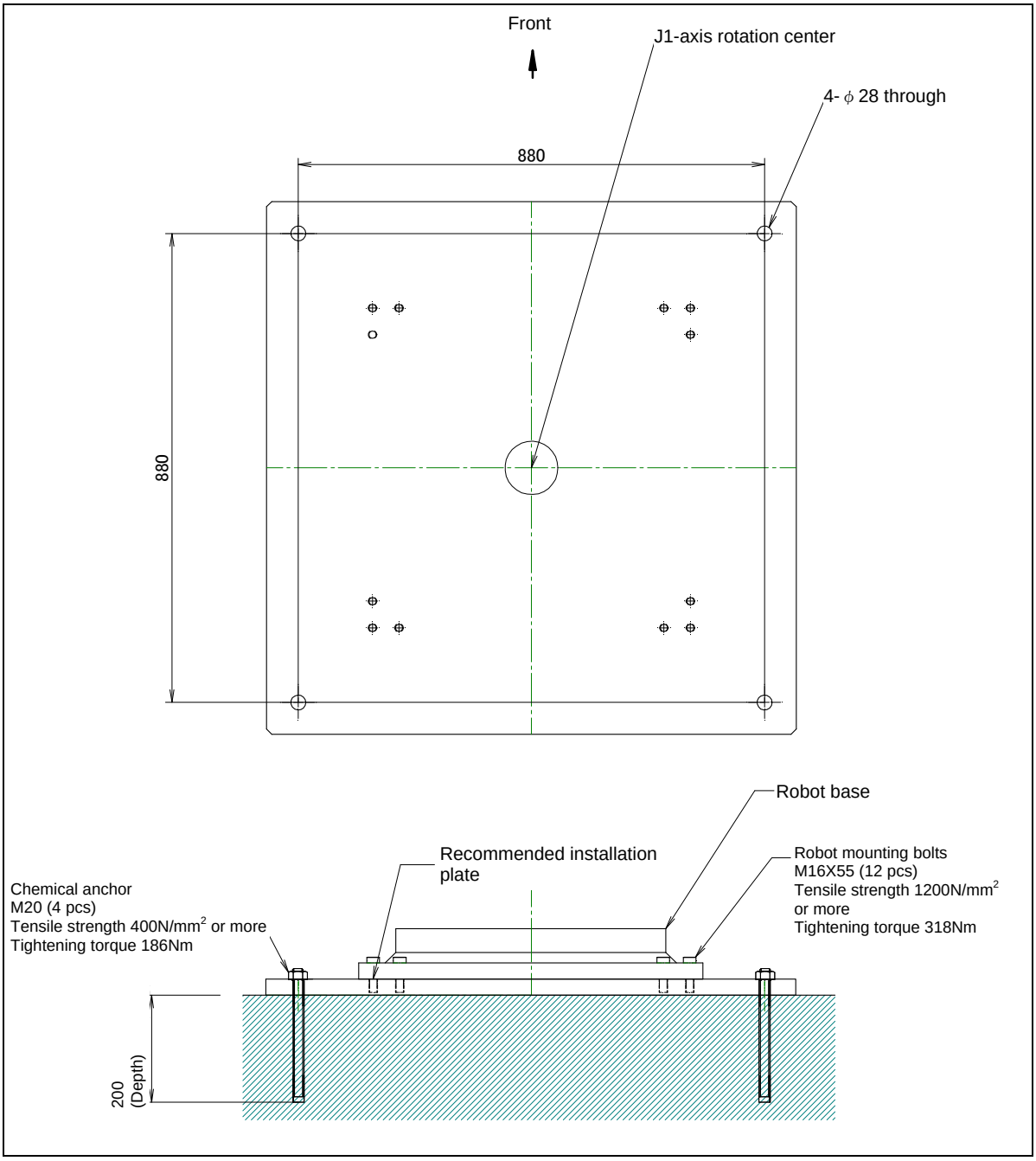


Fig. 1.2 (i) Example of installing the robot

NOTE

The customer must arrange for the positioning pin, anchor bolts, and floor plate. Don't perform leveling at the robot base directly using a push bolt or a wedge. For fixing the robot base, use four hexagon socket head bolt M16X55 (tensile strength 1200N/mm^2 or more) and tighten them with regulated tightening torque 318Nm.

Fig. 1.2 (j), Table 1.2 (a) - (c) indicate the force and moment applied to the robot base.
Table 1.2 (b)- (e) indicate the stopping distance and time of the J1 through J3 axes until the robot stopped by Power-Off stop or Controlled stop (contact stop) after input the stop signal.
Refer to the data below in considering the strength of the installation plane.

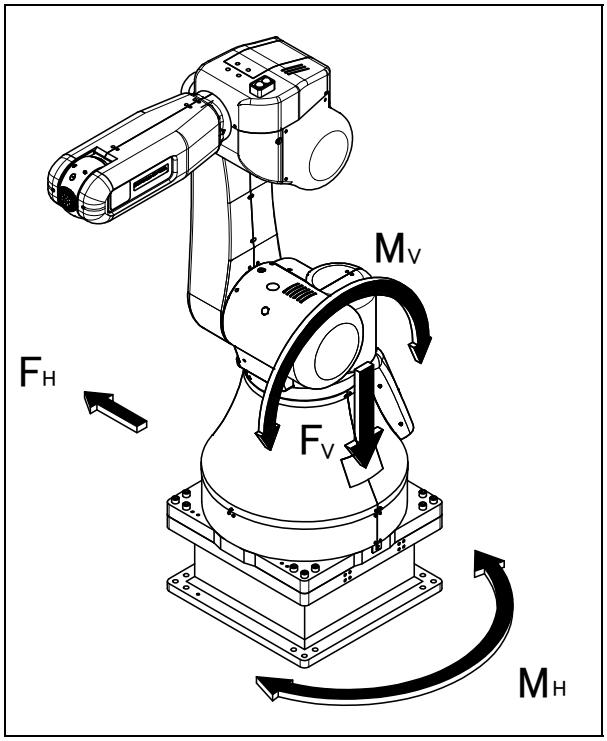


Fig. 1.2 (j) Force and moment that acts on the robot

base Table 1.2 (a) Force and moment that act on J1 base

	Vertical moment MV [Nm](kgfm	Force in vertical direction FV N (kgf)	Horizontal moment MH Nm (kgfm)	Force in horizontal direction FH N (kgf)
During stillness	2064 (211)	10050 (1026)	0 (0)	0 (0)
During acceleration or deceleration	4056 (414)	10851 (1107)	1505 (154)	1047 (107)
During Power-Off stop	13095 (1336)	13855 (1414)	4779 (488)	3305 (337)

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

Model		J1-axis	J2-axis	J3-axis
CR-35*i*A max speed 250mm/s	Stopping time [ms]	36	36	36
	Stopping angle [deg] (rad)	0.17(0.002)	0.19(0.002)	0.32(0.003)
CR-35*i*A max speed 750mm/s	Stopping time [ms]	108	100	60
	Stopping angle [deg] (rad)	1.27(0.011)	1.00(0.009)	1.33(0.012)

*Max payload

Table1.2 (c) Stopping time and distance until the robot stopping by Controlled stop (contact stop) after input of stop signal

Model		J1-axis	J2-axis	J3-axis
CR-35*i*A max speed 250mm/s	Stopping time [ms]	564	564	588
	Stopping angle [deg] (rad)	2.42(0.021)	2.62(0.023)	4.75(0.042)
CR-35*i*A max speed 750mm/s	Stopping time [ms]	580	580	596
	Stopping angle [deg] (rad)	7.23(0.063)	7.85(0.069)	14.2(0.124)

*Max payload

- Stopping time and distance until the robot stopping by contact stop after input of stop signal

  When contact stop is performed, robot stops in stopping time/ stopping distance which is shorter than the controlled stop. For the examination of the system, please use a value at the time of the controlled stop mentioned above.

1.3 MAINTENANCE AREA

Fig. 1.3 shows the maintenance area of the mechanical unit. Make sure to secure enough room for mastering. Refer to Chapter 8 for the mastering.

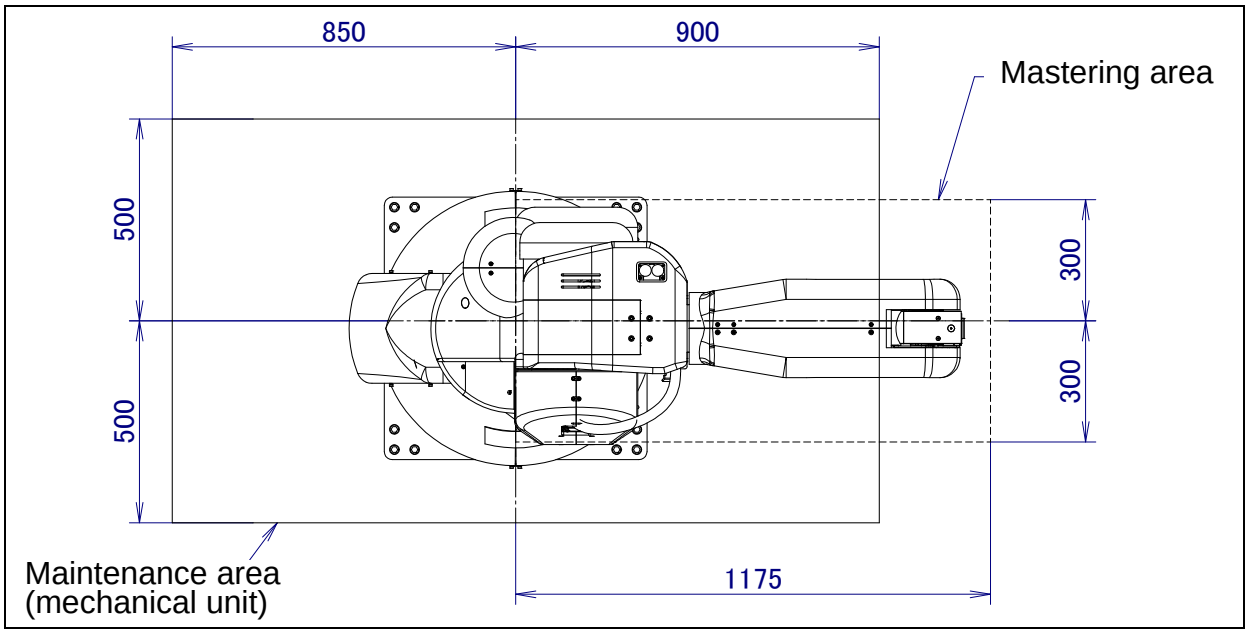


Fig. 1.3 Maintenance area

1.4 INSTALLATION CONDITIONS

Refer to specification of Section 3.1 about installation conditions.

2 CONNECTION WITH THE CONTROLLER

2.1 CONNECTION WITH THE CONTROLLER

The robot is connected with the controller (NC) via the power and signal cable and earth cable. Connect these cables to the connectors on the back of the base.
For details on air and option cables, see refer to Chapter 5.

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

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

1 Detach the cover.

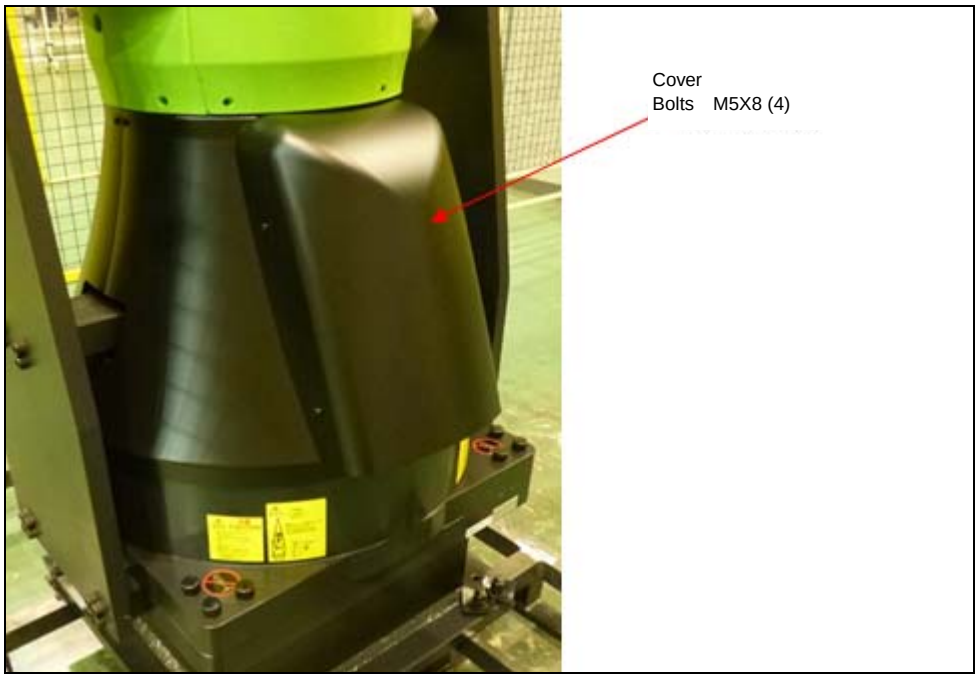


Fig. 2.1 (a) Cable connection (1/4)

2 Connect the Force sensor cable connector shown in Fig. 2.1 (b).
3 Fix the force sensor cable shield part with a pressure plate shown in Fig. 2.1 (b) and then drop it to the earth. In this case, avoid cable disconnection by tucking the cable into other than the deficient part of the pressure plate. Be careful not to drop the bolts inside of the cover during attaching the pressure plate.

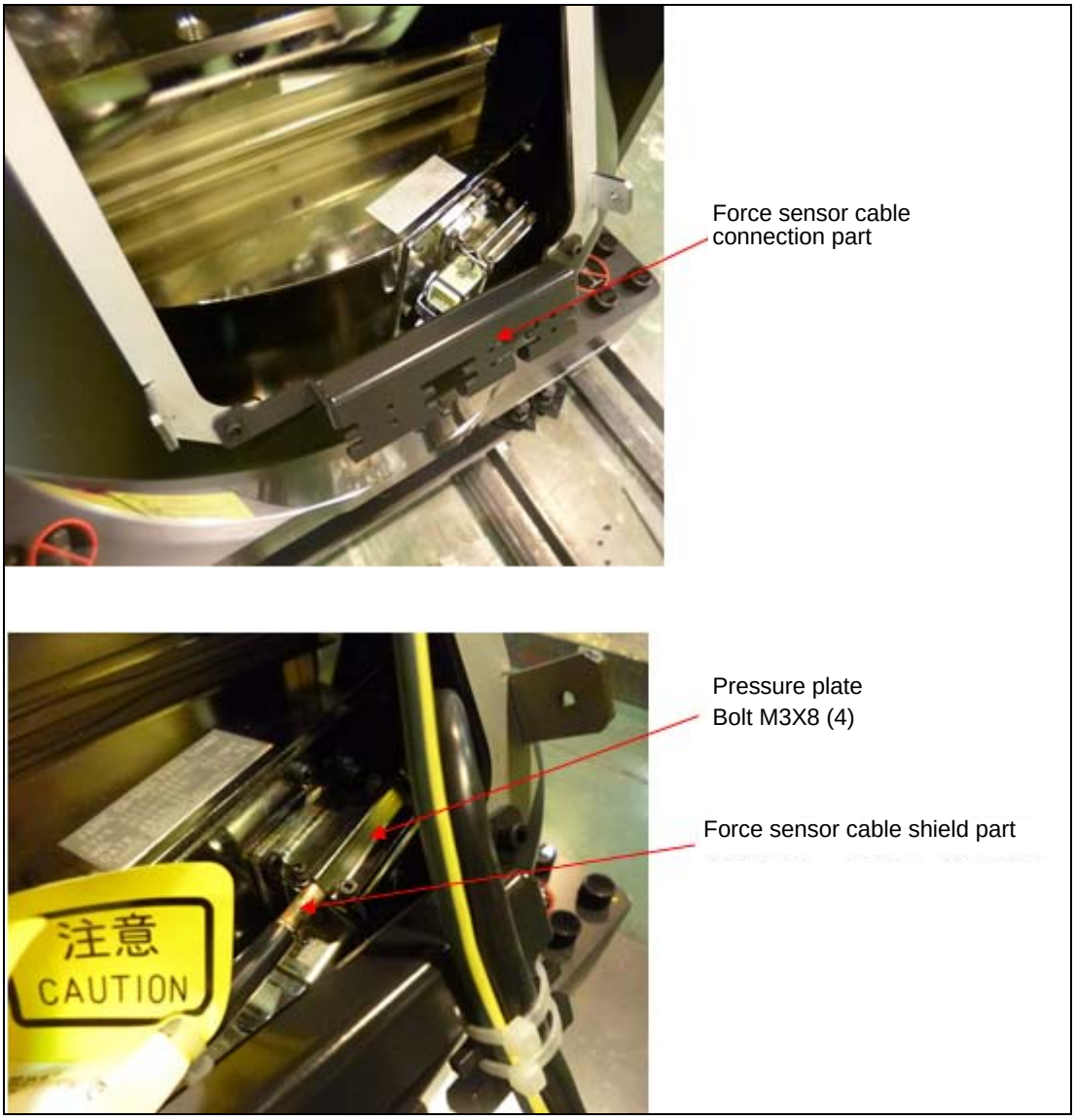


Fig. 2.1 (b) Cable connection (2/4)

4 Connect each cable to the connector part behind the robot base following Fig. 2.1 (c) and Fig. 2.1 (d). Be careful not to apply excessive force on the cables, and fix the cables on the lower side clamp with cable ties.
5 Assemble the cover back in place according to Fig. 2.1 (a).

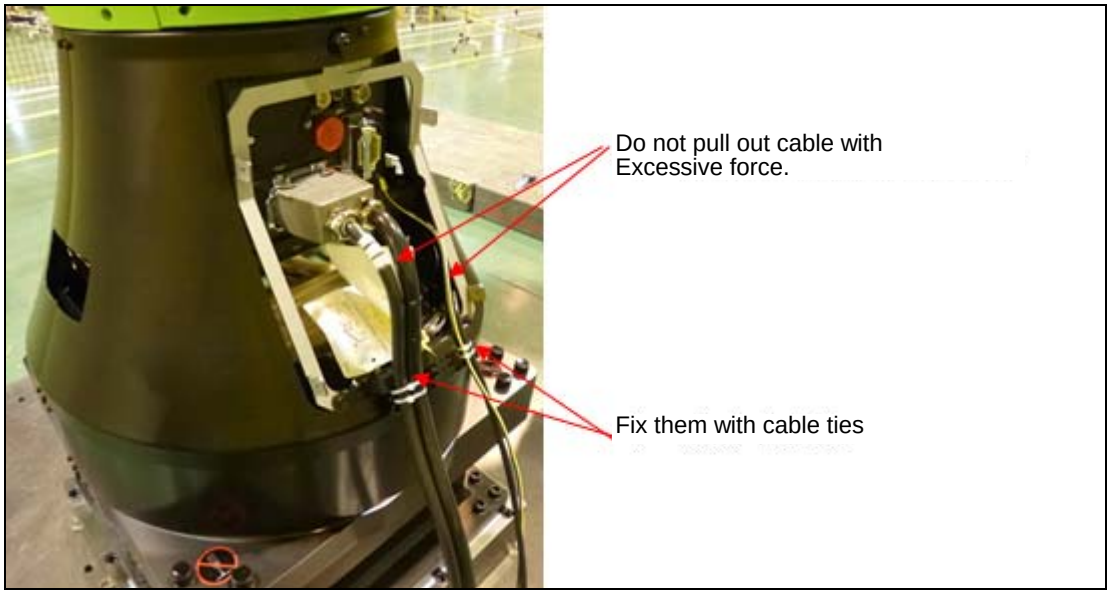


Fig. 2.1 (c) Cable connection (3/4)

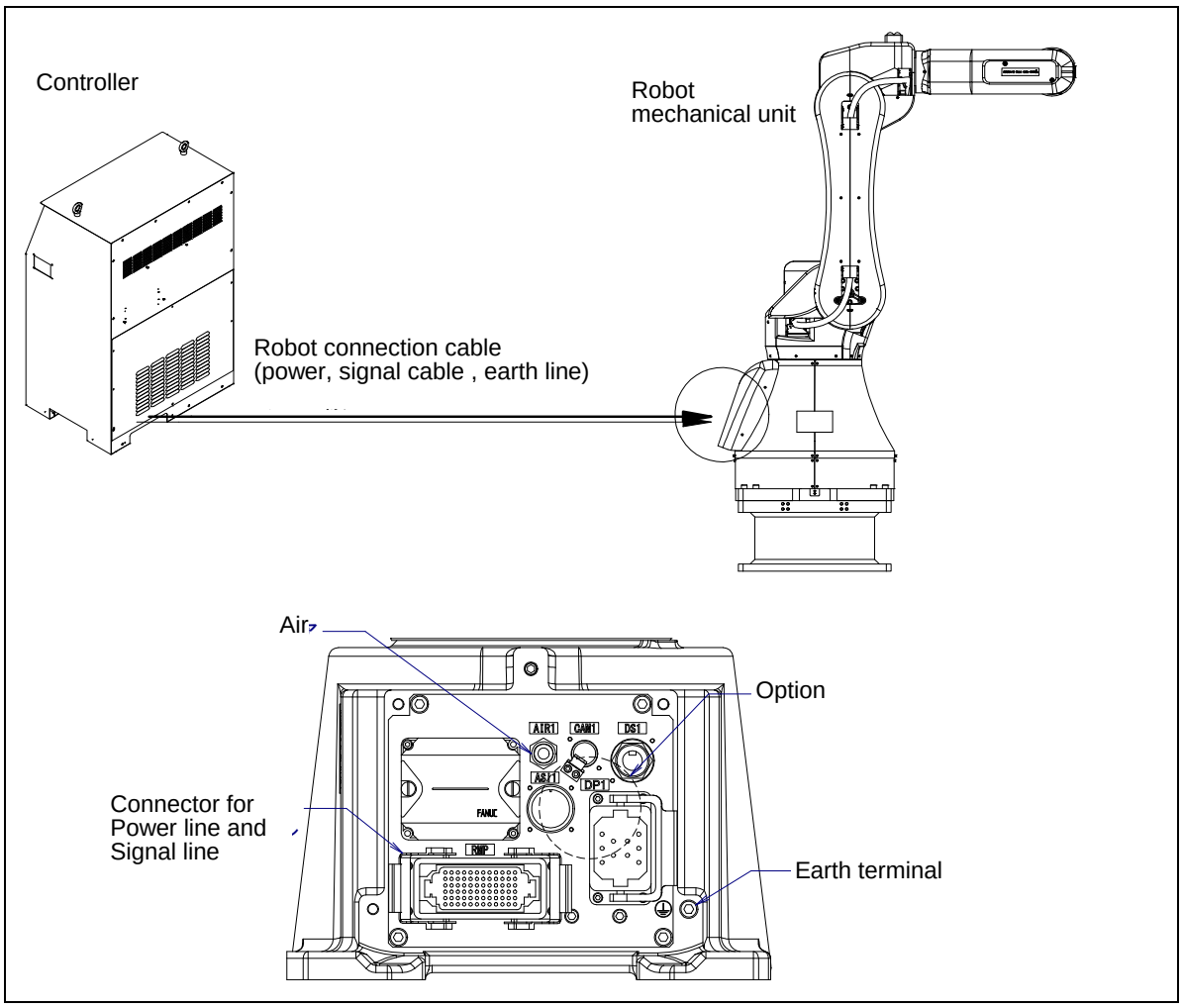


Fig. 2.1 (d) Cable connection (4/4)

3 BASIC SPECIFICATIONS

3.1 ROBOT CONFIGURATION

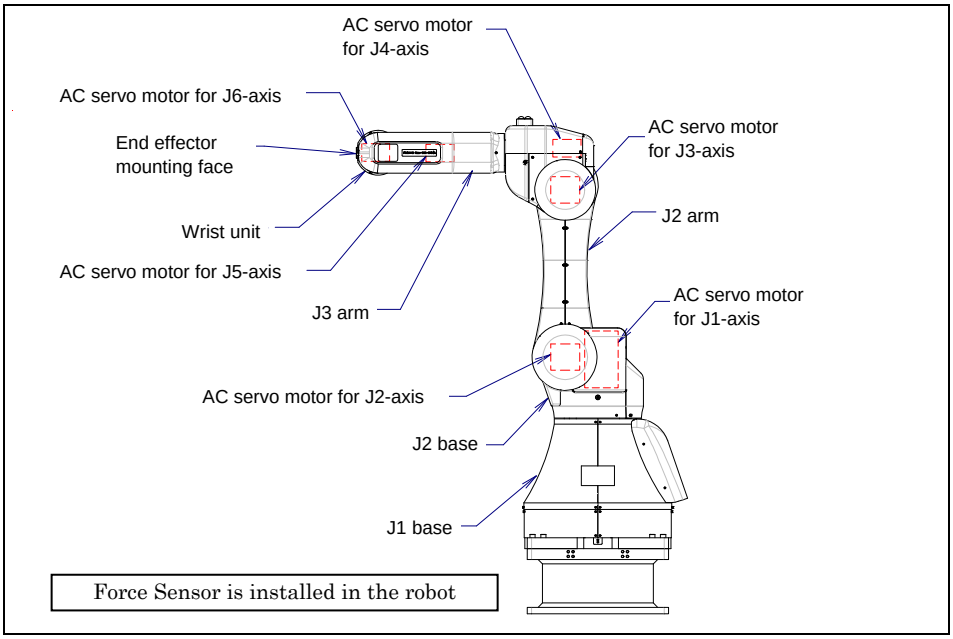


Fig. 3.1 (a) Mechanical unit configuration

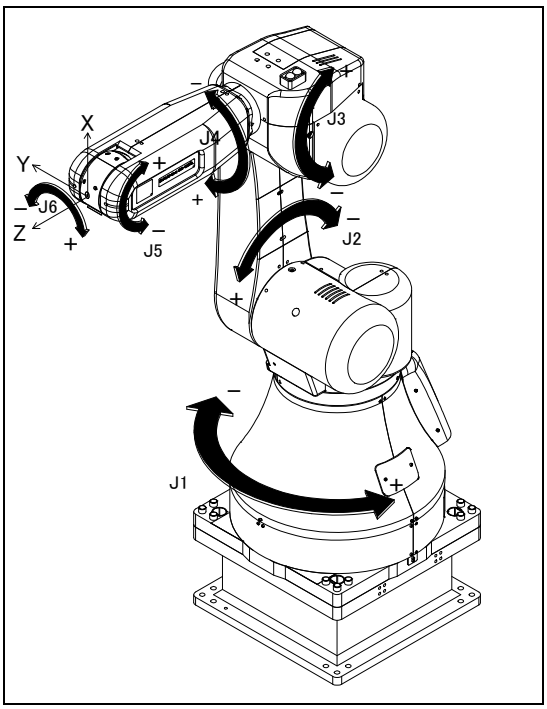


Fig. 3.1 (b) Each axes coordinates and mechanical interface coordinates

NOTE
Zero point of mechanical interface coordinates is the end effector mounting face center.

Table 3.1 (a) Specifications

Item		Specification
Model		CR-35*i*A
Type		Articulated type
Controlled axes		6-axis(J1, J2, J3, J4, J5, J6)
Installation		Floor
Motion range Upper limit /Lower limit	J1-axis	185° (3.23rad) / -185° (-3.23rad)
	J2-axis	120° (2.09rad) / -45° (-0.78rad)
	J3-axis	135° (2.36rad) / -122.9° (-2.15ad)
	J4-axis	200° (3.49rad) / -200° (-3.49rad)
	J5-axis	110° (1.92rad) / -110° (-1.92rad)
	J6-axis	450° (7.85rad) / -450° (-7.85rad)
Maximum speed (Note 1, Note 2)		750mm/s
Maximum load	At wrist	35kg
	On J3 casing (Note 3)	2kg
Allowable load moment at wrist	J4-axis	110.0Nm(kgf·m) (11.2kgf·m)
	J5-axis	110.0Nm(kgf·m) (11.2kgf·m)
	J6-axis	60.0Nm(kgf·m) (6.12kgf·m)
Allowable load inertia at wrist	J4-axis	4.00kg.m^2 (40.82 kgf·cm·s^2)
	J5-axis	4.00kg.m^2 (40.82 kgf·cm·s^2)
	J6-axis	1.50kg.m^2 (15.31 kgf·cm·s^2)
Repeatability (Note 4)		±0.03mm
Robot mass		990kg
Acoustic noise level		Less than 70dB (Note 5)
Installation environment		Ambient temperature: 0 to 45℃ (Note 6) Ambient humidity: Normally 75%RH or less (No dew or frost allowed) Short time (within one month) Max 95%RH Permissible altitude: Above the sea 1000m or less Free of corrosive gases (Note 7) Vibration acceleration : 4.9m/s^2 (0.5G) or less (Note 8) Environment without fire

NOTE

1 During short distance motions, the axis speed may not reach the maximum value stated.
2 It is necessary to set a motion speed according to risk assessment of system considering pinching with the surroundings.
3 Maximum load on J3 casing depends on load of wrist. See Section 4.2 for detail.
4 Compliant with ISO9283.
5 This value is equivalent continuous A-weighted sound pressure level, which applied with ISO11201 (EN31201). This value is measured with the following conditions.
-Maximum load and speed
-Operating mode is AUTO
6 When robot is used in low temperature environment that is near to 0ºC, or not operated for a long time in the environment that is less than 0ºC in a holiday or the night, collision detection alarm (SRVO-050) etc. may occur since the resistance of the drive mechanism could be high immediately after starting the operation.
7 Contact the service representative, if the robot is to be used in an environment or a place subjected to hot/cold temperatures, severe vibrations, heavy dust, cutting oil splash and or other foreign substances.
8 Depending on the vibration of the floor or the hand, robot may stop due to the vibration in less than this value.

The following table lists the IEC60529-based Severe dust/liquid protection characteristics of the CR-35*i*A.

Table 3.1 (b) The dustproof and waterproof characteristics

	Normal specification
Wrist + J3 arm	IP67
Other part	IP54

NOTE
Definition of IP code
Definition of IP 67
6 = Dust-tight
7 = Protection from water immersion
Definition of IP 54
5 = Dust-protected
4 = Protection from splashing water

Performance of resistant chemicals and resistant solvents

(1) The robot (including severe dust/liquid protection model) cannot be used with the following liquids. Potentially these liquids will cause irreversible damage to the rubber parts (such as: green cover, gaskets, oil seals, O-rings etc.). (As exception to this only liquids tested and approved by FANUC can be used with the robot.)
   (a) Organic solvents
   (b) Cutting fluid including chlorine / gasoline
   (c) Amine type detergent
   (d) Acid, alkali and liquid causing rust
   (e) Other liquids or solutions, that will harm NBR or CR rubber
(2) When the robots work in the environment, using water or liquid, complete draining of J1 base must be done. Incomplete draining of J1 base will make the robot break down.
(3) Don not use unconfirmed cutting fluid and cleaning fluid.
(4) Do not use the robot immersed in water, neither temporary nor permanent. Robot must not be wet permanently. *Example : in case motor surface is exposed to water for a long time, liquid may invade inside the motor and cause failure.

3.2 MECHANICAL UNIT EXTERNAL DIMENSIONS AND OPERATING SPACE

Fig. 3.2 shows the robot operating space. When installing peripheral devices, be careful not to interfere with the robot and its operating space.

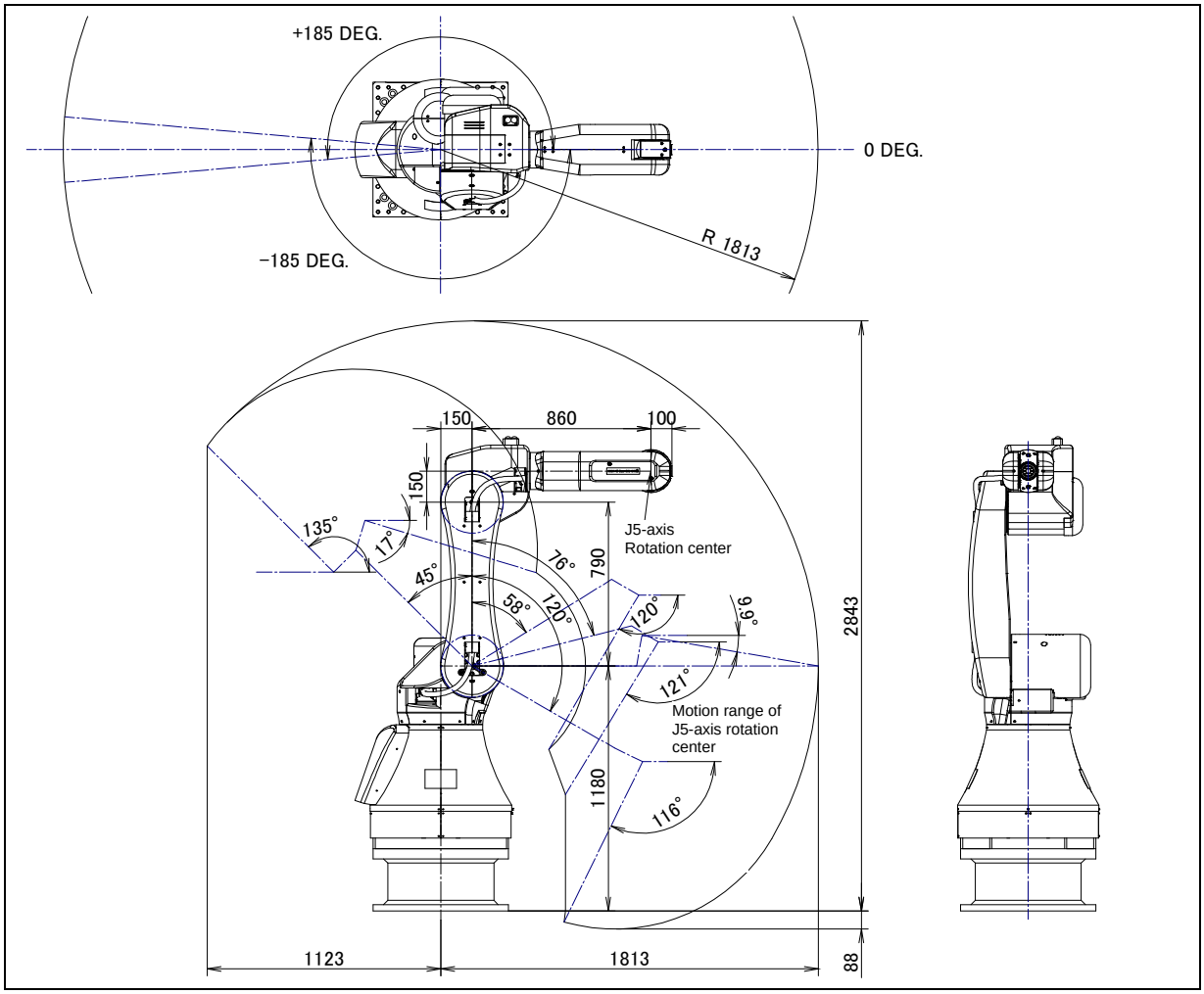


Fig. 3.2 Operating space

3.3 ZERO POINT POSITION AND MOTION LIMIT

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 zero point position due to abnormalities in servo system or system error. In addition, the motion range limit by a mechanical stopper is also prepared to improve safety.

In case of J1 to J3-axis, robot stops by transforming mechanical stopper. Be sure to exchange transformed stopper to new one referring to Fig. 3.3 (a). Don’t reconstruct the mechanical stopper. There is a possibility that the robot doesn't stop normally.

Fig.3.3 (b) to (h) show the zero point, and mechanical stopper position of each axis.

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

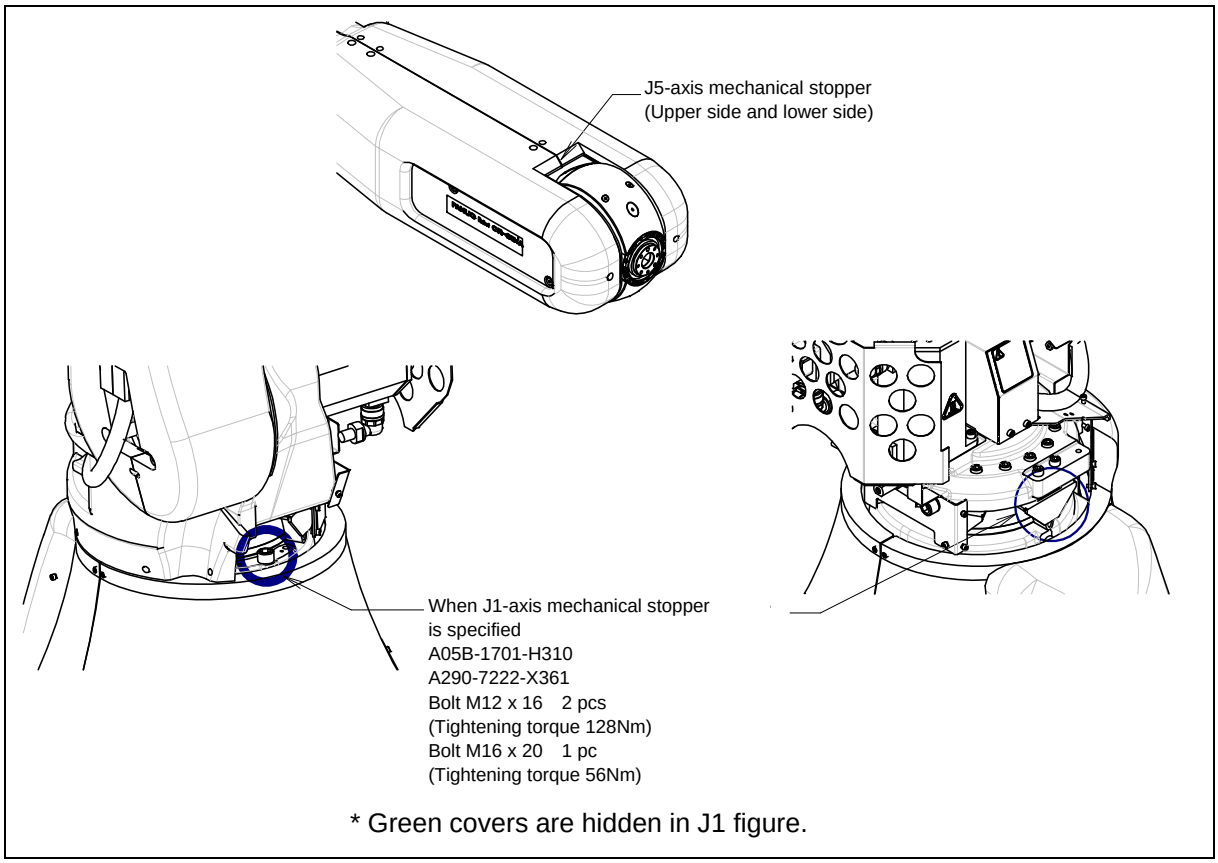


Fig. 3.3 (a) Position of mechanical stopper

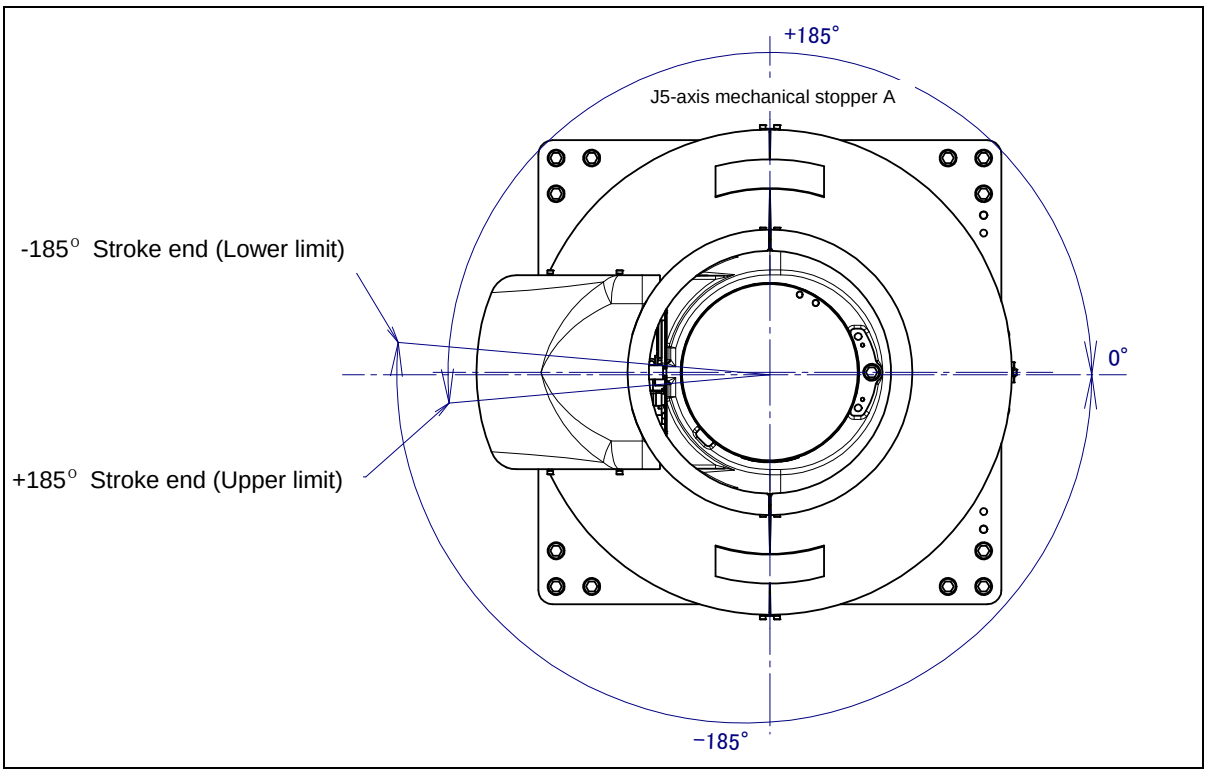


Fig. 3.3 (b) J1-axis motion limit (When mechanical stopper is not selected)

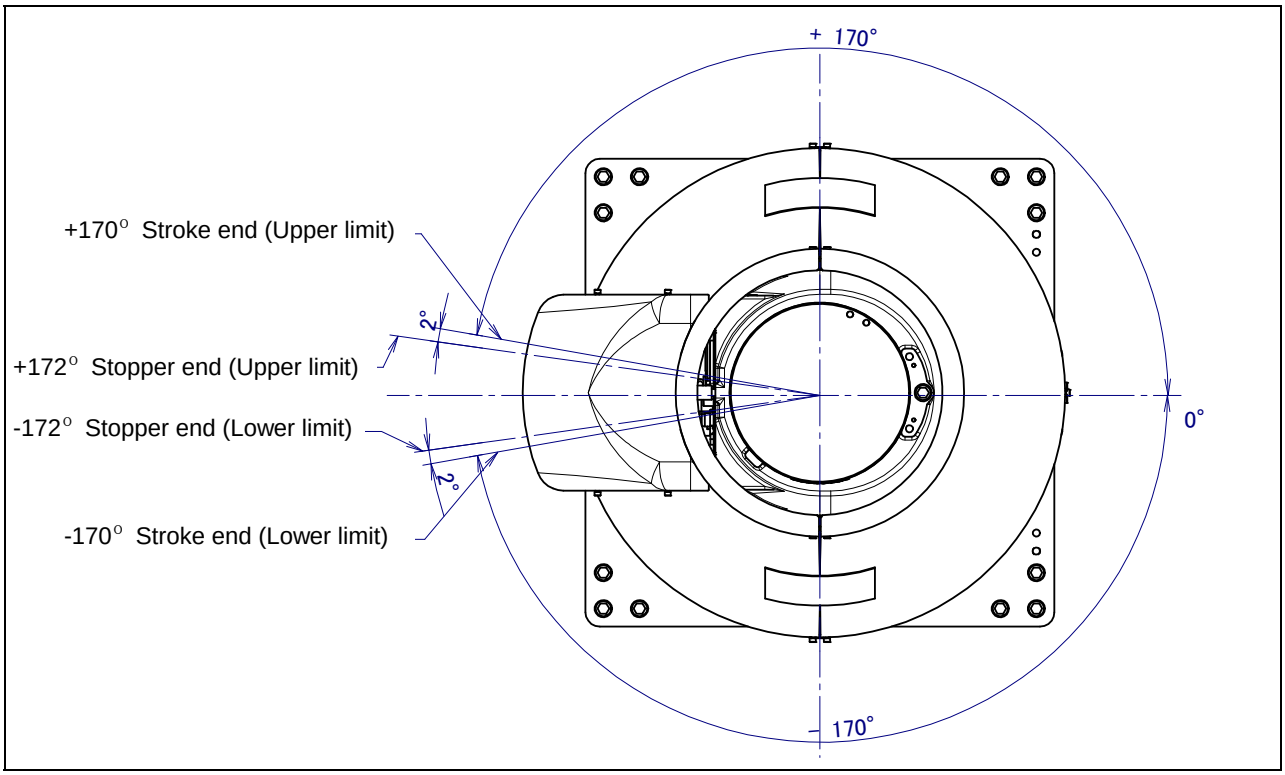


Fig. 3.3 (c) J1-axis motion limit (When mechanical stopper is selected)

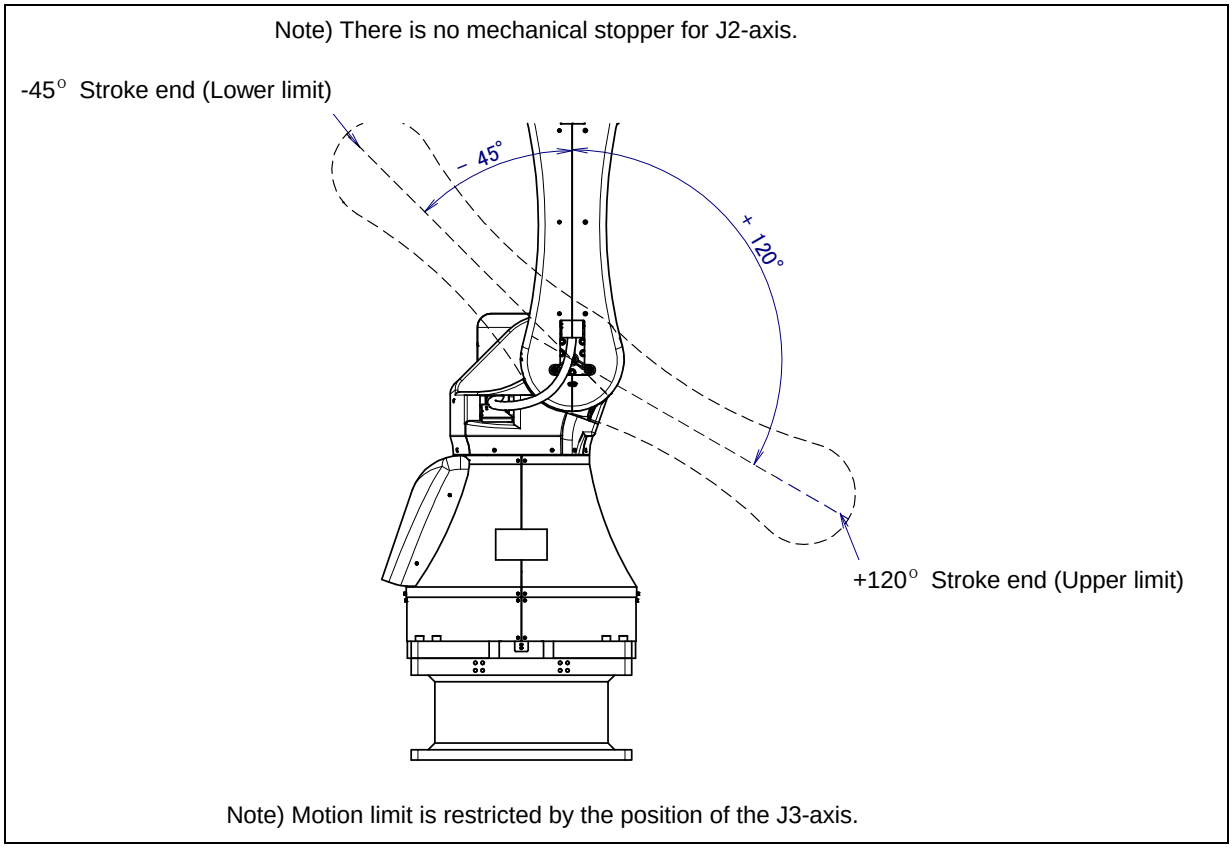


Fig. 3.3 (d) J2-axis motion limit

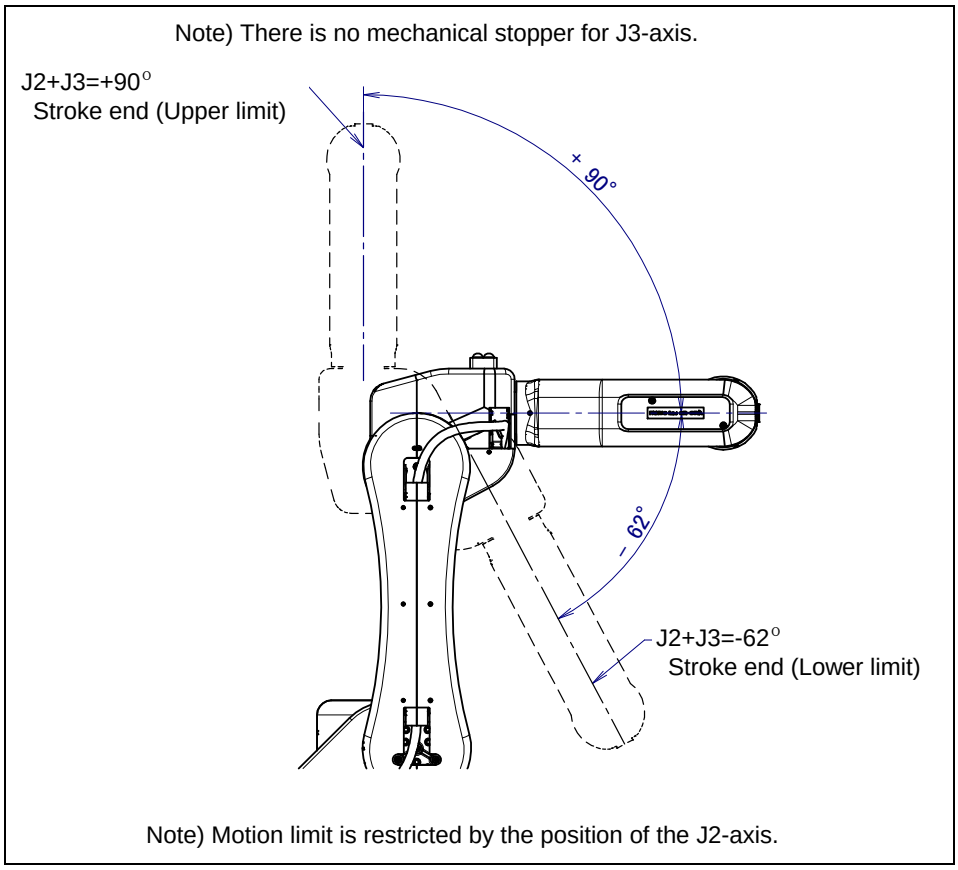


Fig. 3.3 (e) J3-axis motion limit

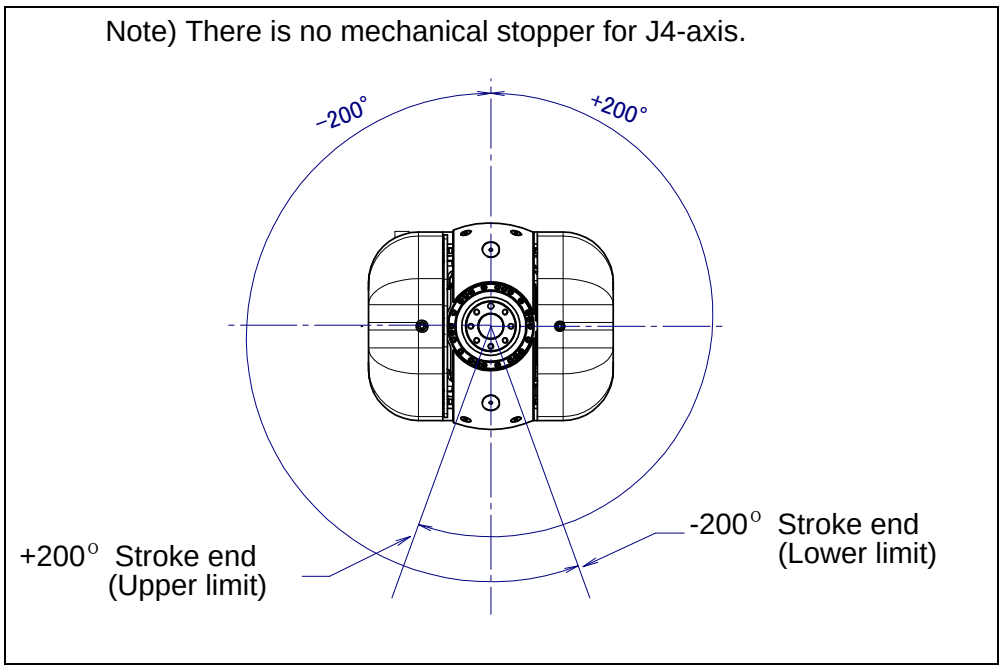


Fig. 3.3 (f) J4-axis motion limit

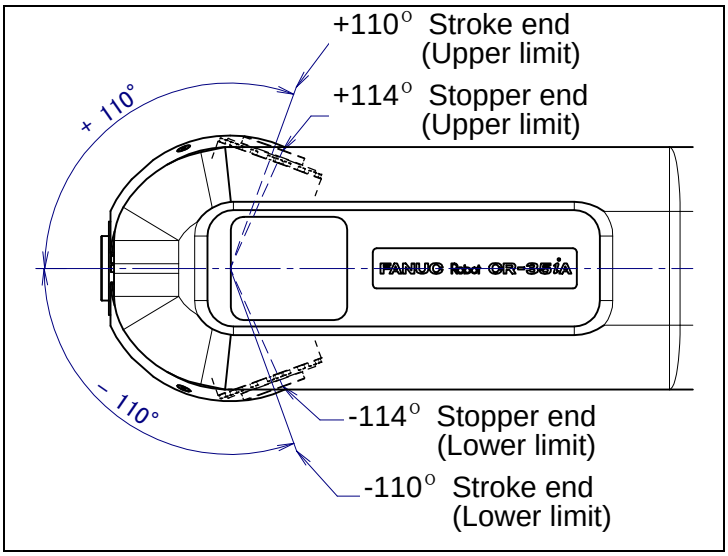


Fig. 3.3 (g) J5-axis motion limit

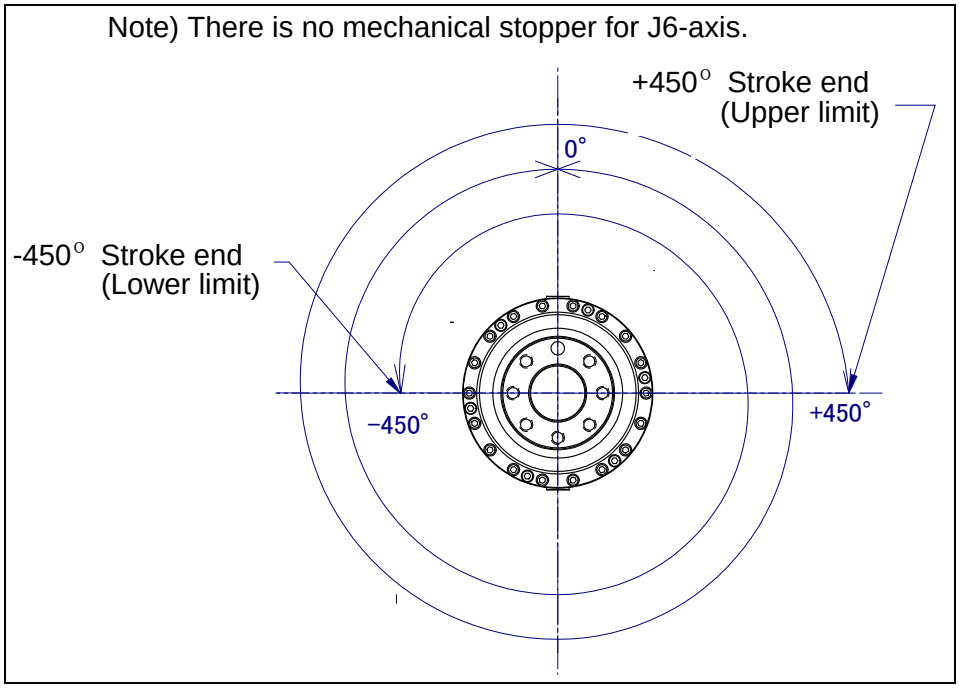


Fig. 3.3 (h) J6-axis motion limit

3.4 WRIST LOAD CONDITIONS

Fig. 3.4 is diagrams showing the allowable load that can be applied to the wrist section.

- Apply a load within the region indicated in the graph.
- Please use it to meet the requirement of the allowable load moment and inertia at wrist. See the 3.1 about allowable load moment and inertia at wrist.
- See Section 4.1 about mounting of end effector.

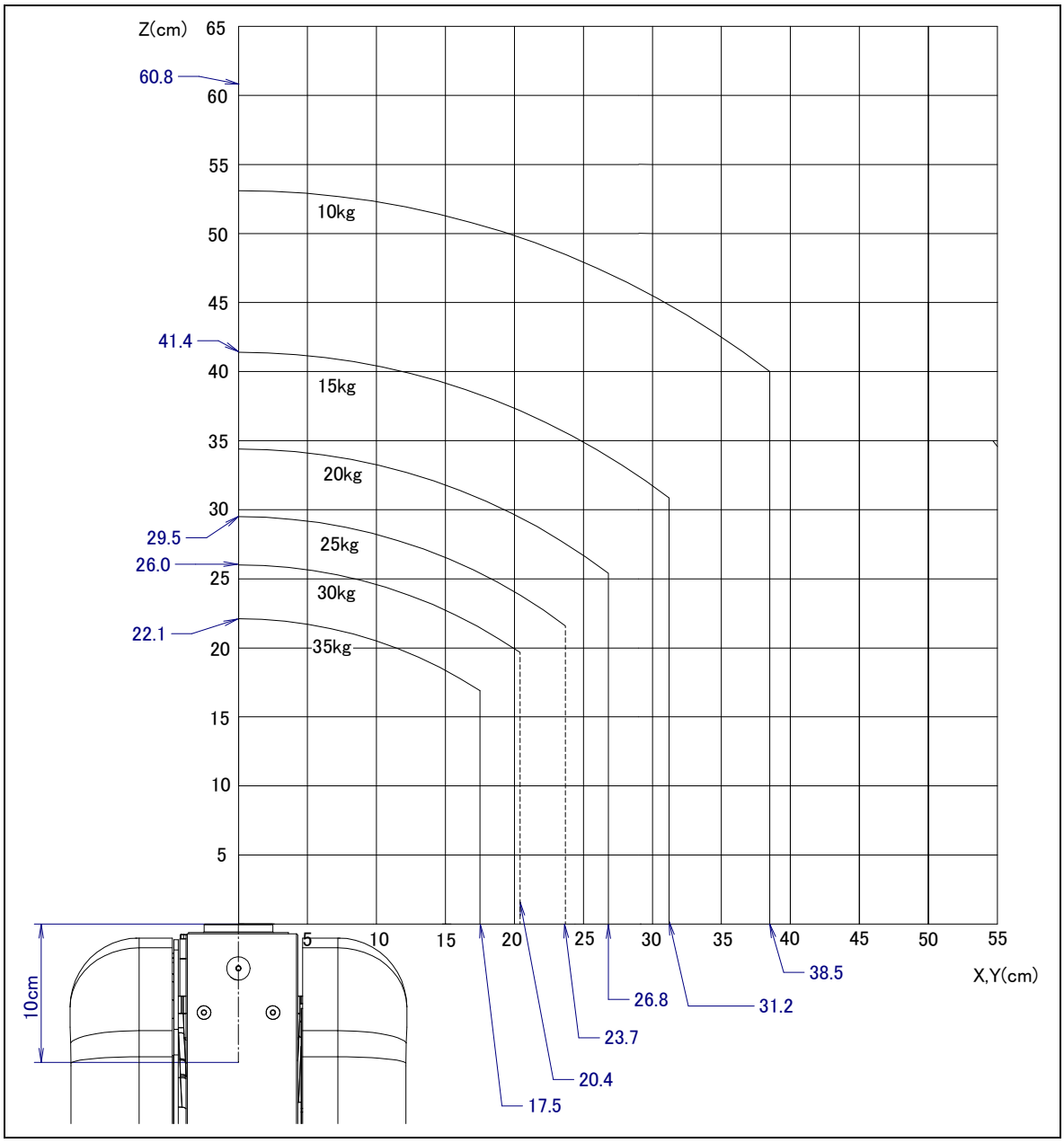


Fig. 3.4 Wrist load diagram

3.5 RESTRICTION FOR OPERATION

This robot cannot correspond to the Arc motion and Circle Arc motion.

4 EQUIPMENT INSTALLATION TO THE ROBOT

4.1 END EFFECTOR INSTALLATION TO WRIST

Fig. 4.1 shows the figures for installing end effectors on the wrist. Select screws and positioning pins of a length that matches the depth of the tapped holes and pin holes. See Appendix B “Bolt tightening torque” for tightening torque specifications.

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

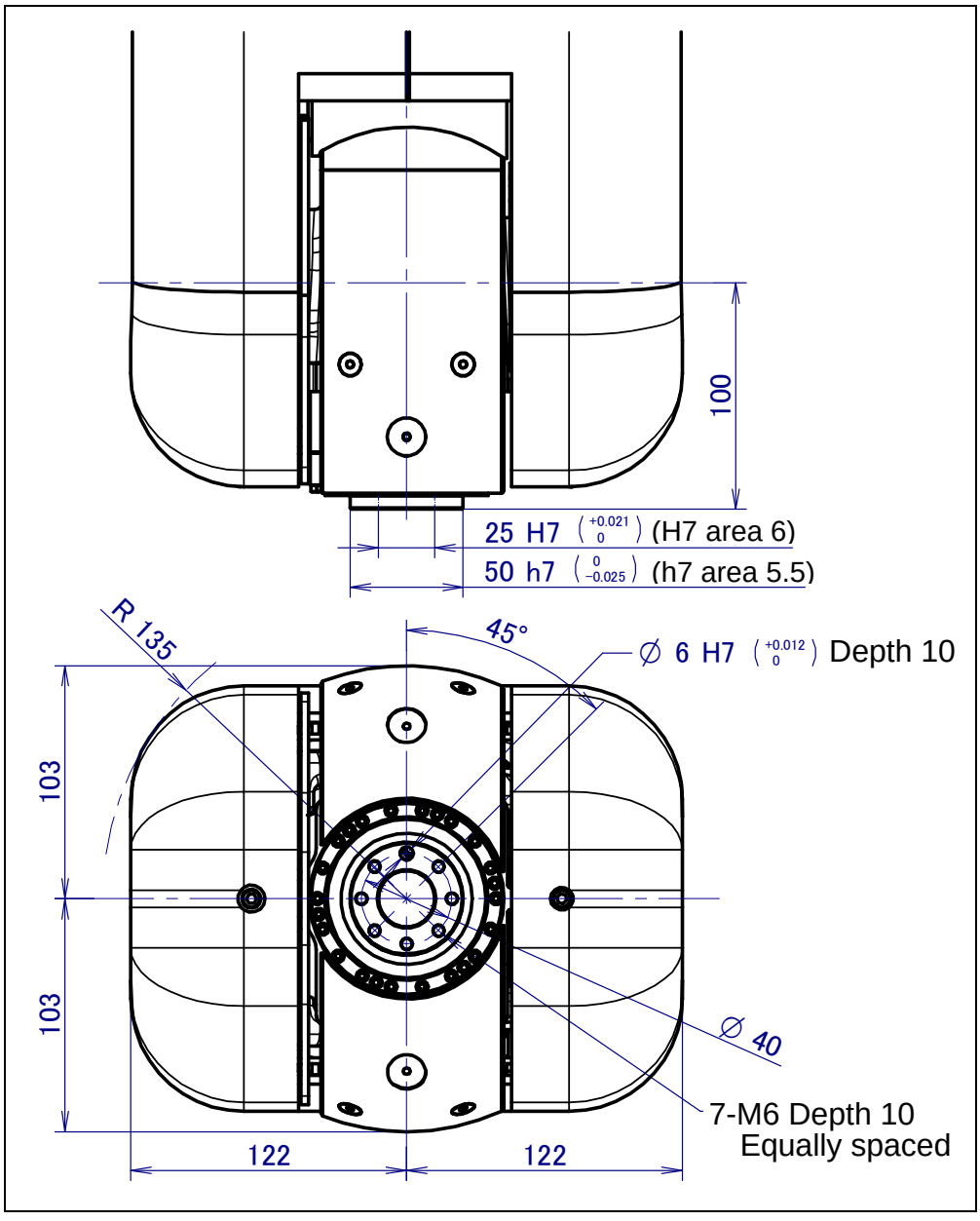


Fig. 4.1 End effector interface

4.2 EQUIPMENT MOUNTING FACE

Fig. 4.2 (a) shows position of tapped and load condition install equipment to the robot. According to Fig. 4.2 (b), remove the J3 casing part cover before using these taps.

⚠ 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.

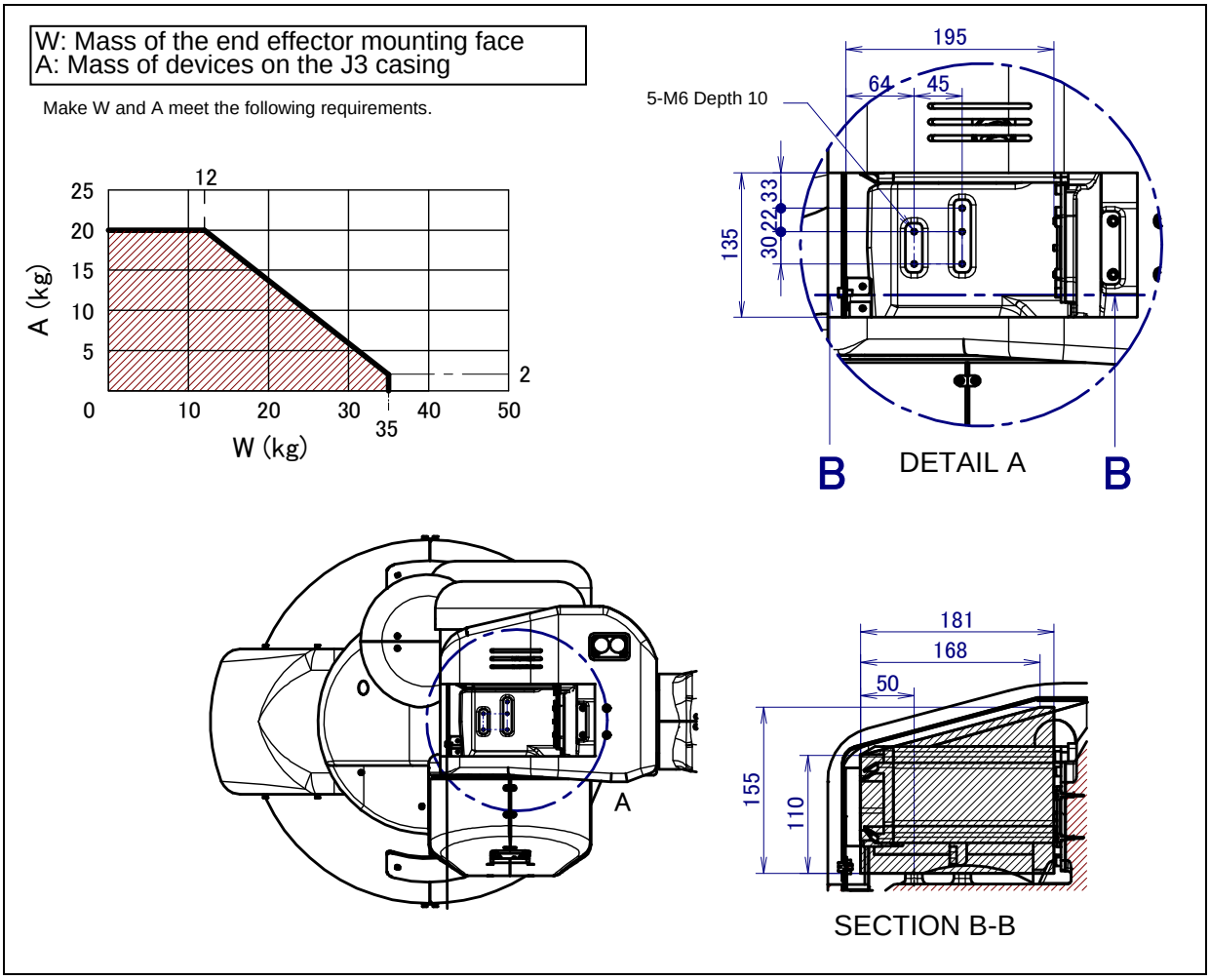


Fig. 4.2 (a) Equipment mounting faces and load limitation

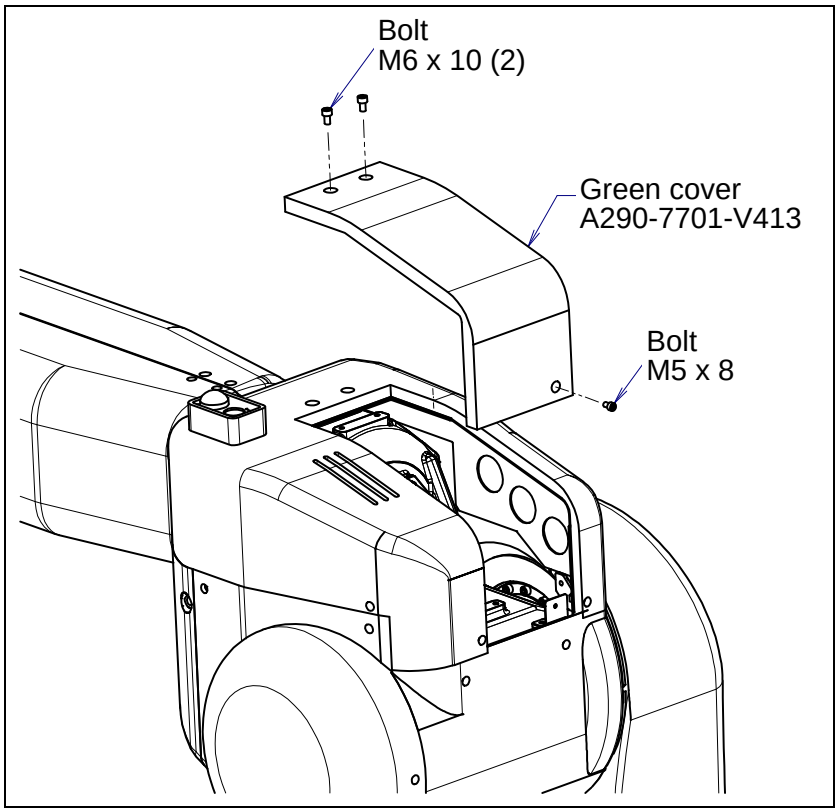


Fig. 4.2 (b) Removing the cover

Fig. 4.2 (c) shows taps for the cable clamp. To use these taps, detach the J3 arm cover referring to Fig. 4.2 (d). In addition, detach the side cover as shown in figure and draw out the cables to the outside.

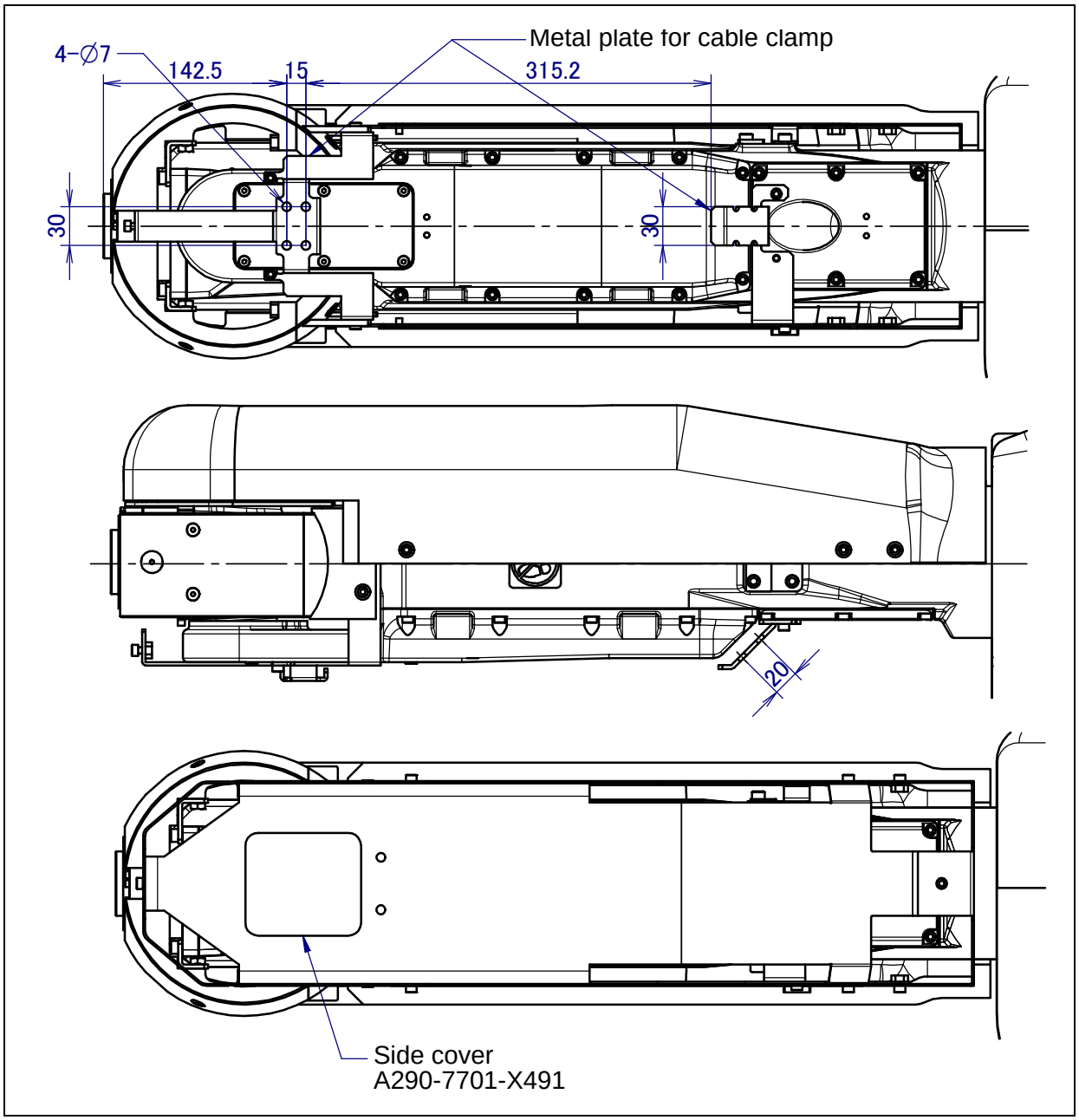


Fig. 4.2 (c) Equipment mounting faces (for the cable clamp)

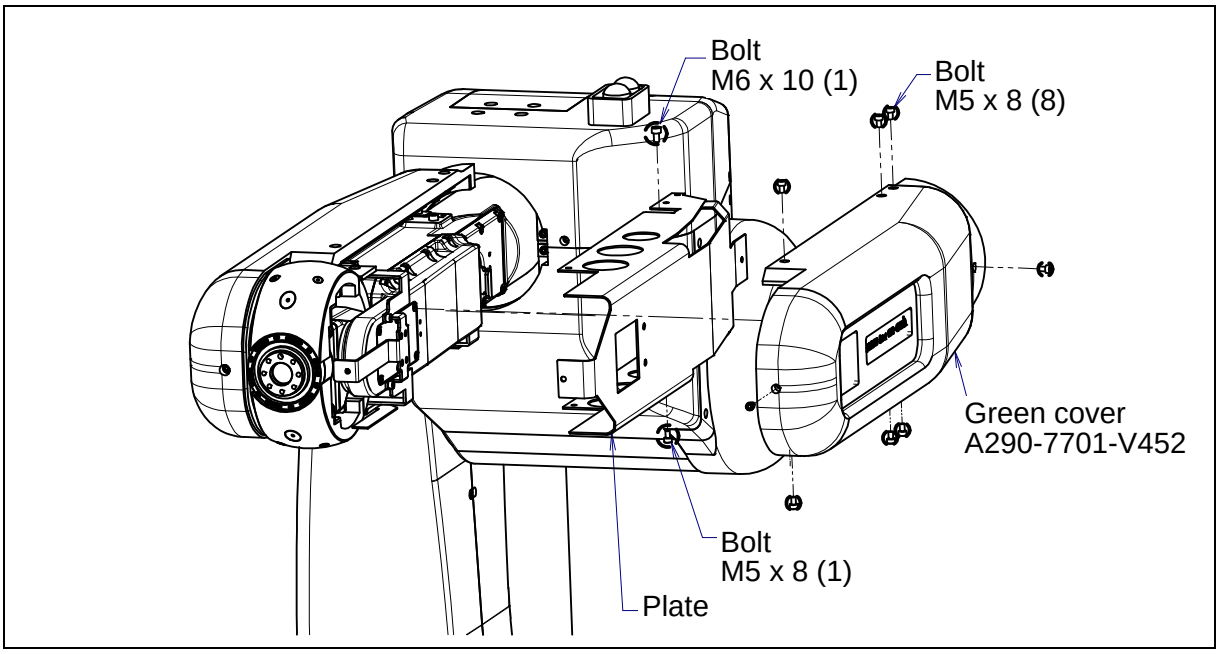


Fig. 4.2 (d) Removing the cover

> ⚠ **WARNING**
> Be sure to install green covers as before after attaching cables. Otherwise, safety function may lost and it may cause injury of the personnel

4.3 LOAD SETTING

> ⚠ **WARNING**
> If the load setting is wrong, safety function may lost, and it may cause injury of the personnel. If the load setting is changed, confirm the value and perform the test 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 and its swing. 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.

```
MOTION PERFORMANCE                    JOINT 10%
   Group1
No.   PAYLOAD[kg]          Comment
 1          35.00    [                    ]
 2           0.00    [                    ]
 3           0.00    [                    ]
 4           0.00    [                    ]
 5           0.00    [                    ]
 6           0.00    [                    ]
 7           0.00    [                    ]
 8           0.00    [                    ]
 9           0.00    [                    ]
10           0.00    [                    ]

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

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

```
MOTION PAYLOAD SET              JOINT   100%

  Group 1
  Schedule No[   1]:[Comment          ]
1 PAYLOAD             [kg]          35.00
2 PAYLOAD CENTER  X   [cm]          -7.99
3 PAYLOAD CENTER  Y   [cm]           0.00
4 PAYLOAD CENTER  Z   [cm]           6.44
5 PAYLOAD INERTIA X   [kgfcms^2]     0.13
6 PAYLOAD INERTIA Y   [kgfcms^2]     0.14
7 PAYLOAD INERTIA Z   [kgfcms^2]     0.07

 [TYPE]  GROUP  NUMBER  DEFAULT  HELP
```

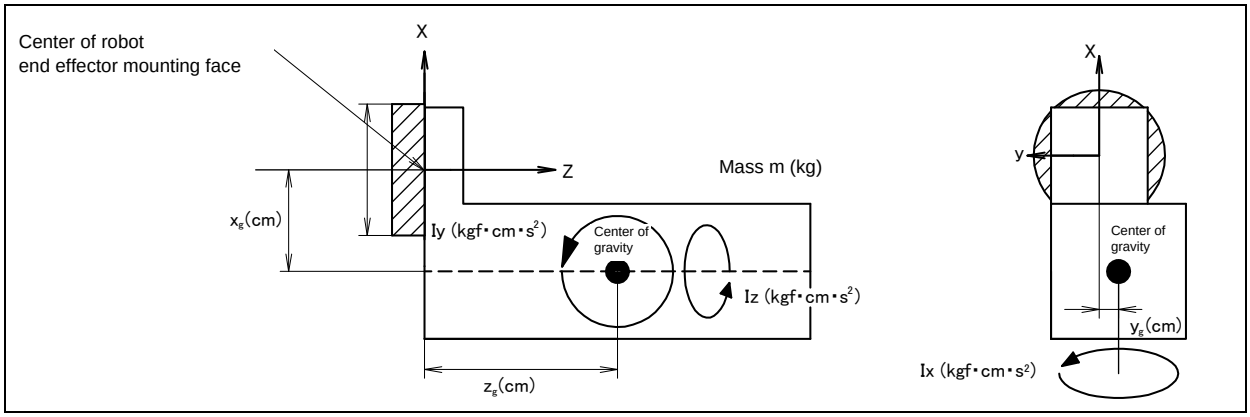


Fig. 4.3 Standard tool coordinate

6 Set the payload, gravity center position, and inertia around the gravity center on the MOTION PAYLOAD SET screen. The X, Y, and Z directions displayed on this screen correspond to the respective standard tool coordinates (with no tool coordinate system set up). When values are entered, the following message appears: “Path and Cycle time will change. Set it?” 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, pressing F2 ([GROUP]) will bring you to the MOTION PAYLOAD SET screen for another group

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

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]              2.00

[ TYPE ]    GROUP          DEFAULT   HELP
```

10 Specify the mass of the loads on the J2 base and J3 casing. When you enter following parameter,
ARMLOAD AXIS #1[kg]: Mass of the load on the J2 base
(Contact FANUC if you install equipment on J2 base.)
ARMLOAD AXIS #3[kg]: Mass of the load on the J3 casing
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 cable when cables are added to outside of mechanical unit.
- Please do not perform remodeling (adding a protective cover, or secure an additional outside cable) that obstructs the behavior of the outcrop of the cable.
- When external equipment is installed in the robot, make sure that it does not interfere with other parts of the robot.
- Cut and discard any unnecessary length of wire strand of the end effector (hand) cable. Insulate the cable with seal tape. (See Fig. 5)
- 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 end effector, robot faults, or damage to robot electrical hardware. In addition, electric shock could occur when touching the power cables.

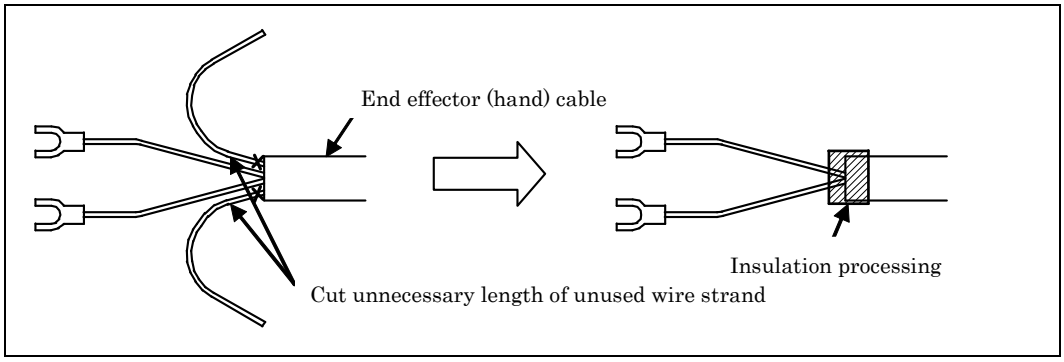


Fig. 5 Treatment method of end effector (hand) cable

5.1 AIR SUPPLY (OPTION)

Robot has air inlet and air outlet openings on the J1 base and the J3 casing used to supply air pressure to the end effector. As couplings are not supplied, it will be necessary to prepare couplings, which suit to the hose size.

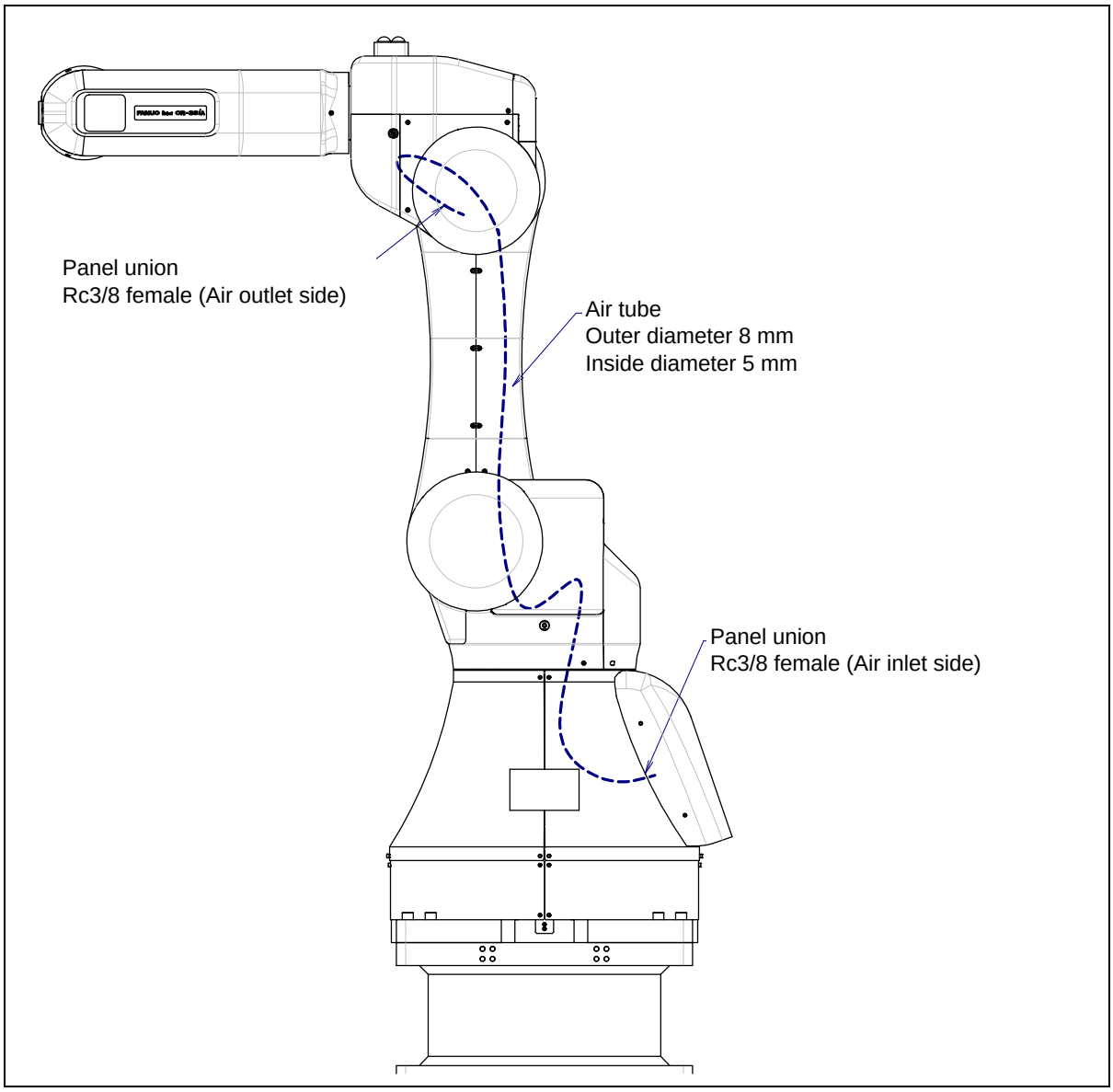


Fig. 5.1 Air supply (option)

5.2 AIR PIPING (OPTION)

Fig. 5.2 (a) shows how to connect air hose to the robot. If the air control set is specified as an option, the air hose between the mechanical unit and the air control set is provided. Mount the air control set using the information in Fig. 5.2 (b). This is outside FANUC delivery scope.

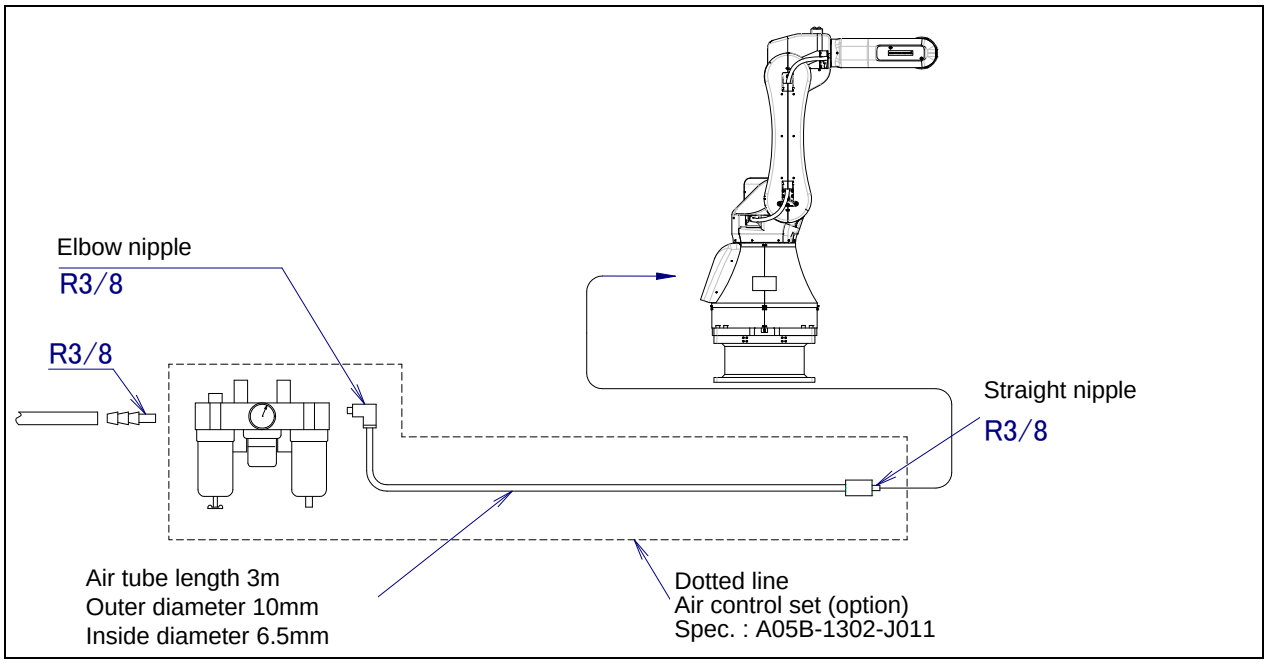


Fig. 5.2 (a) Air piping (Option)

Air control set

For the lubricator of air control set, fill in turbine oil #90 to #140 to the specified level. The machine tool builder is required to prepare mounting bolts.

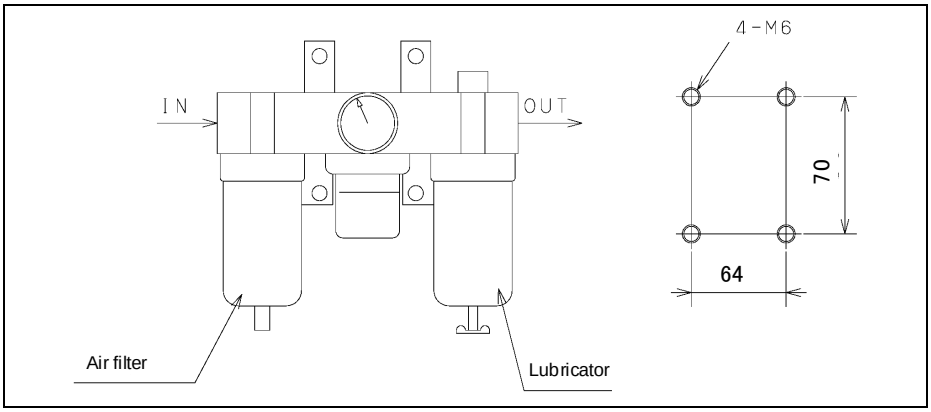


Fig. 5.2 (b) Air control set (Option)

NOTE
The capacity values of the air control set are determined as follows.
These values must not be exceeded.

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 150Nl/min (0.15Nm^3/min)

5.3 INTERFACE FOR OPTION CABLE (OPTION)

Fig. 5.3 (e) show the position of the option cable interface. EE interface (RI/RO), user cable (signal line, signal line usable to 3D Laser Vision Sensor and Force Sensor), user cable (power line), DeviceNet cable (signal line), DeviceNet cable (power line), camera cable are prepared as options.
Detaching J1 and J3 covers are required when connecting cables.

NOTE
Each option cable is written as shown below on the connector panel.
EE(RI/RO) interface : EE
User cable (signal) : AS
User cable usable to 3D Laser Vision Sensor and Force Sensor : ASi
DeviceNet cable (signal) : DS
DeviceNet cable (power) : DP
Camera cable : CAM

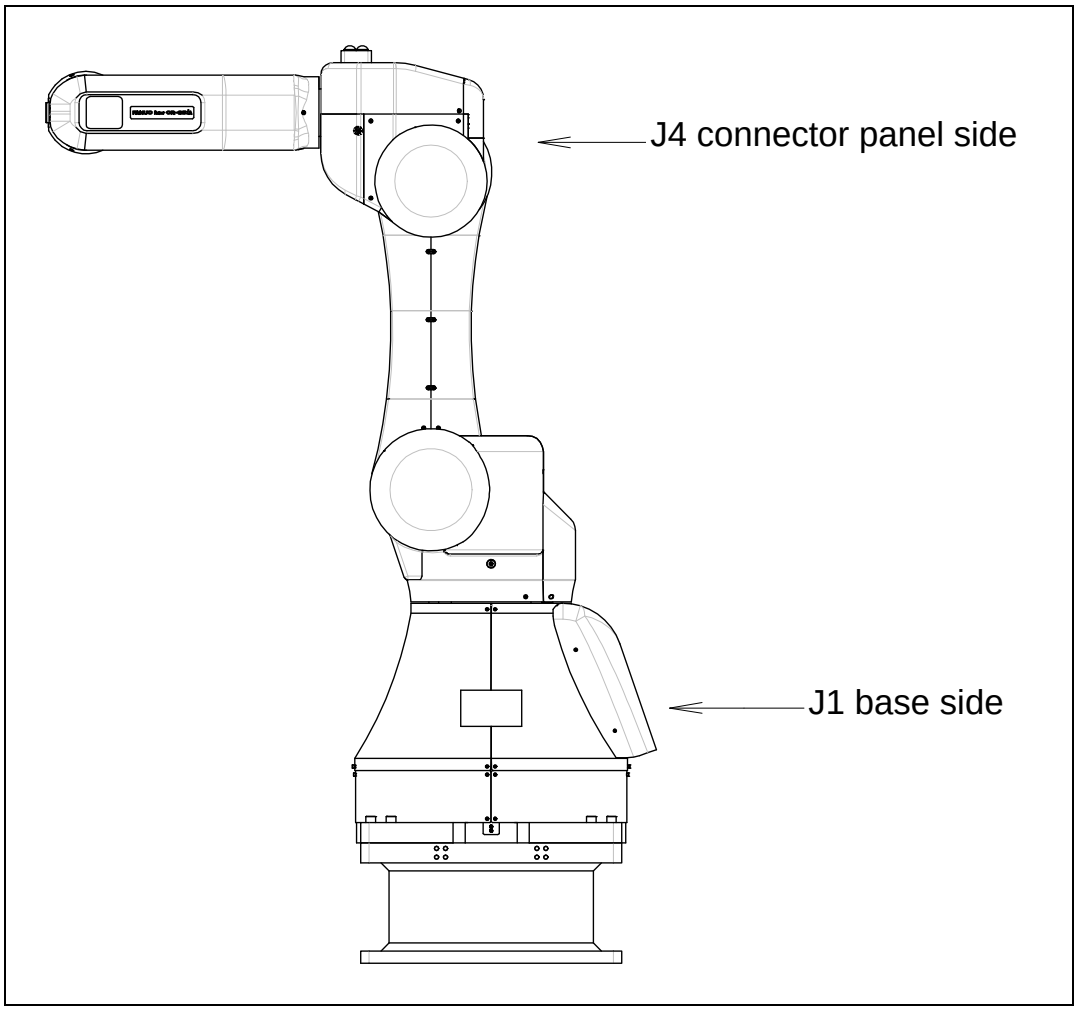


Fig. 5.3 (a) Interface for option cable (Option)

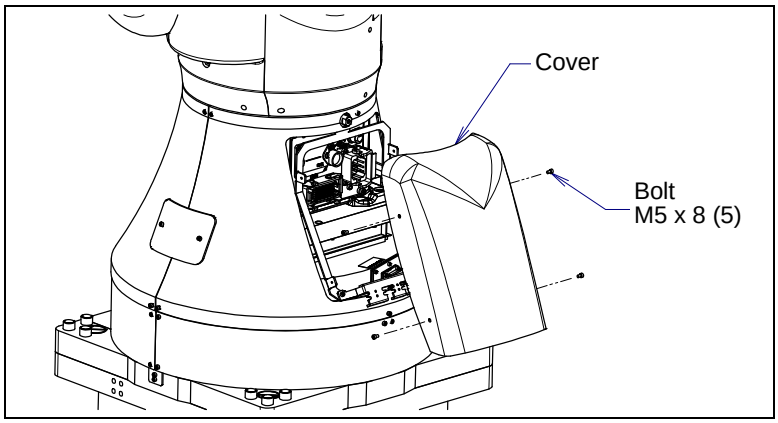


Fig. 5.3 (b) Removing the J1 cover

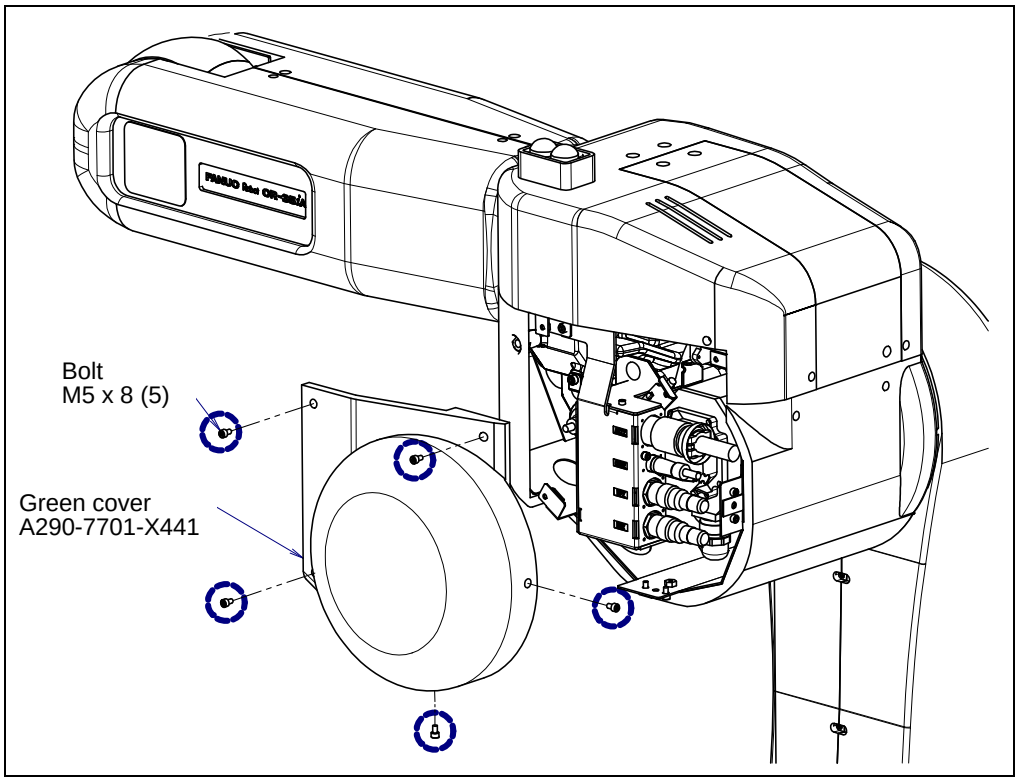


Fig. 5.3 (c) Removing the J3 cover (1/2)

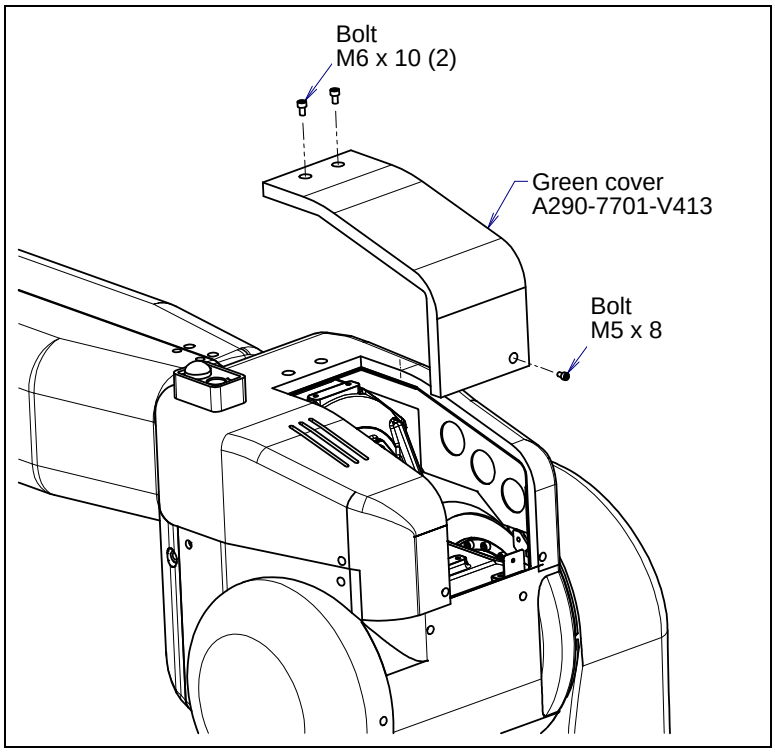


Fig. 5.3 (d) Removing the J3 cover (2/2)

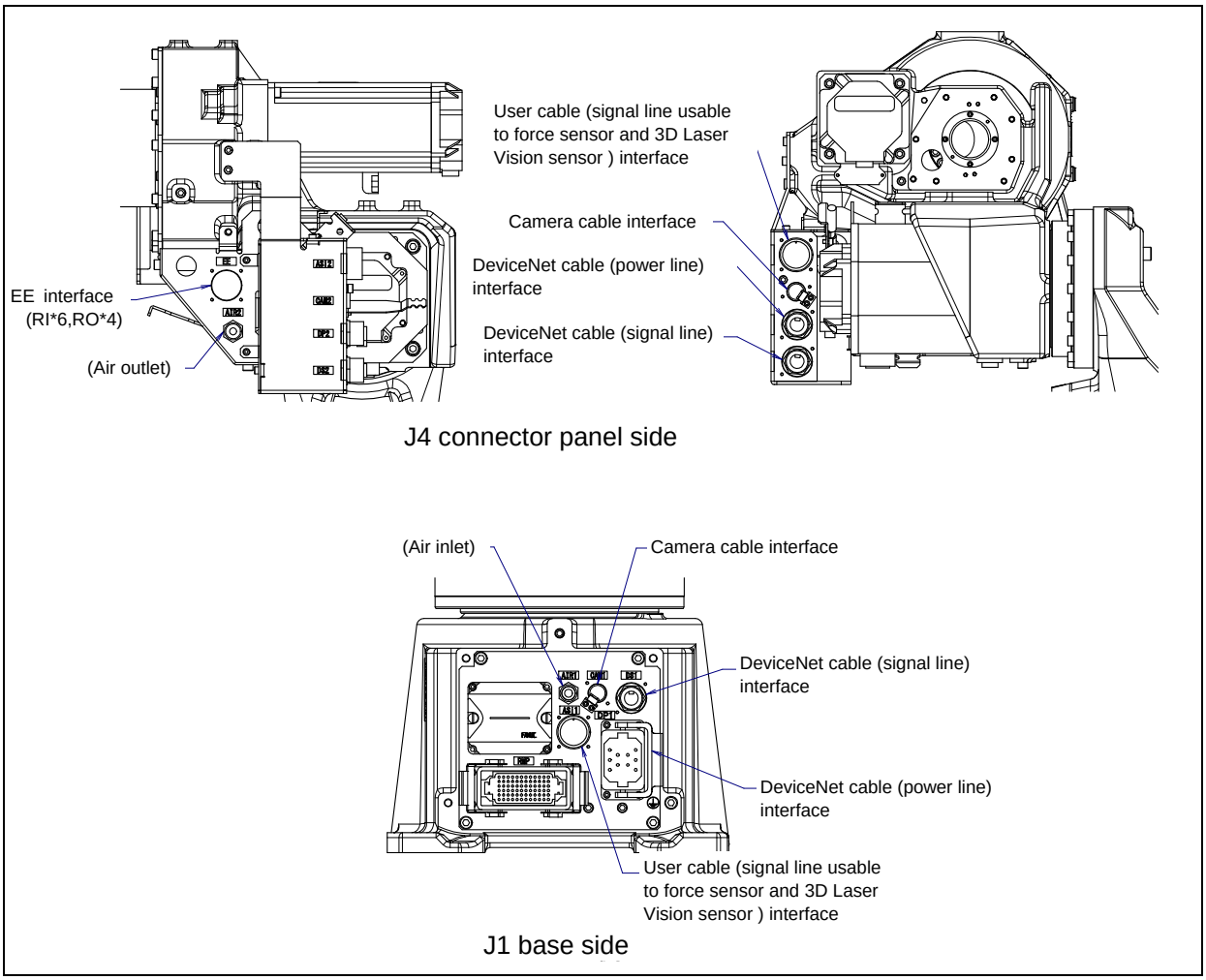


Fig. 5.3 (e) Interface for option cable (A05B-1701-H202 is specified)

⚠ WARNING
After attaching cables as before, otherwise safety function may lost and it may cause injury of the personnel.

1 EE interface (RI/RO) (Option)
Fig. 5.3 (f) shows the pin layout for the EE interface (RI/RO).

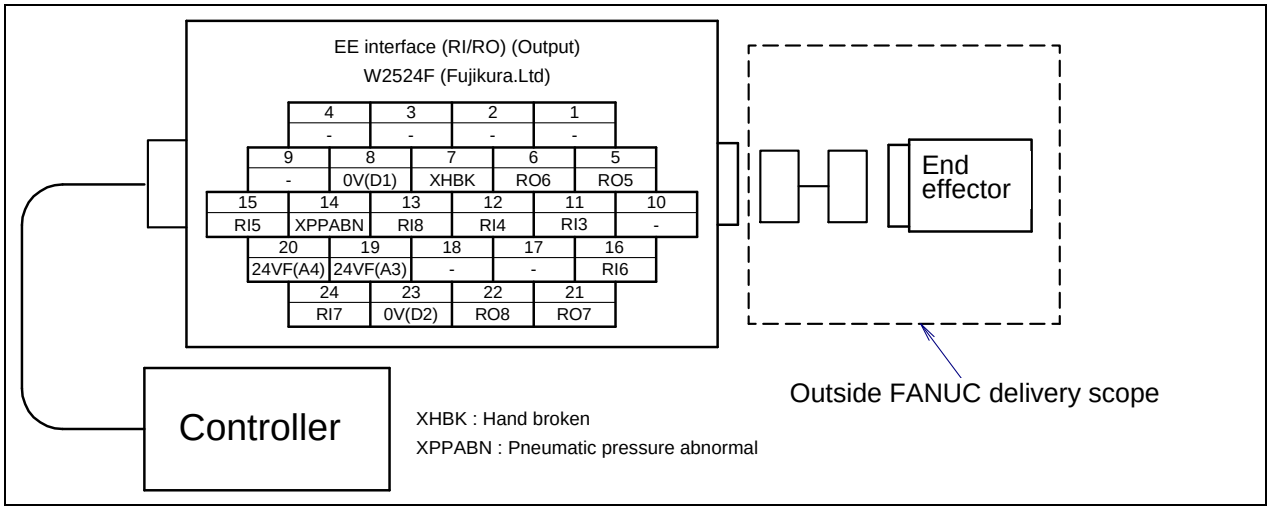


Fig. 5.3 (f) Pin layout for EE interface (RI/RO) (Option)

⚠ CAUTION
For wiring of the peripheral device to the end effector interface, refer to the CONTROLLER MAINTENANCE MANUAL.

2 User cable (signal line) (AS) Interface (Option)
Fig. 5.3 (g) shows the pin layout for the user cable (signal line) interface.

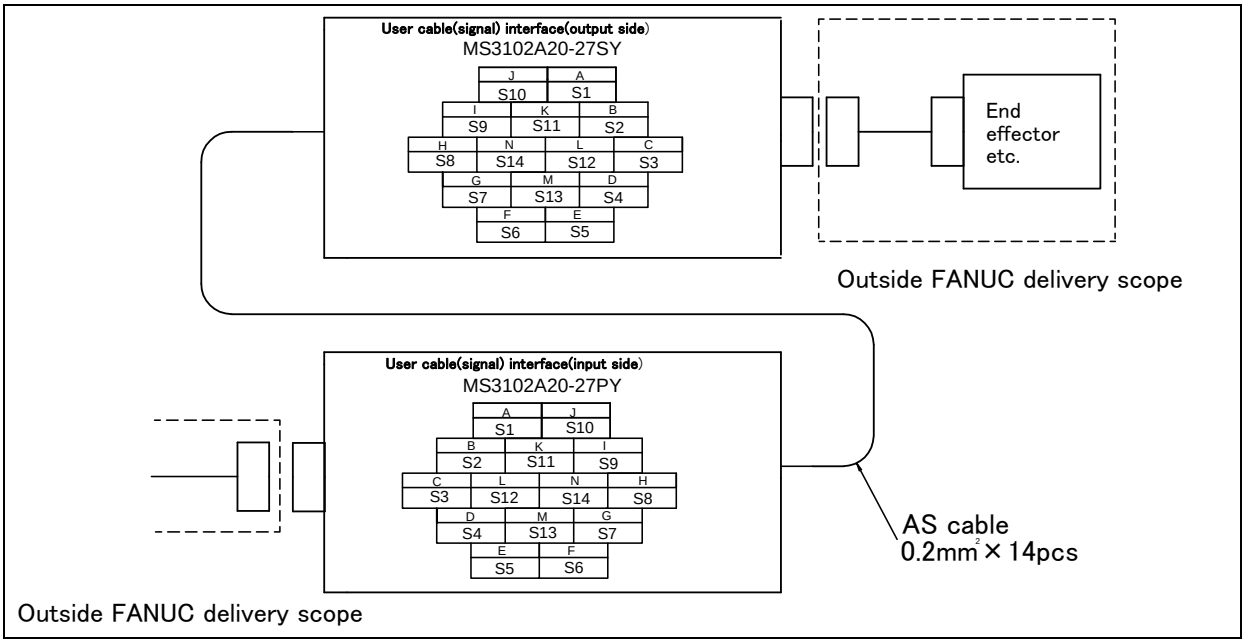


Fig. 5.3 (g) Pin layout for user cable (signal line) (AS) interface (Option)

3 DeviceNet cable (signal line) (DS) Interface (option)
Fig. 5.3 (h) shows the pin layout for the DeviceNet cable (signal line) interface.

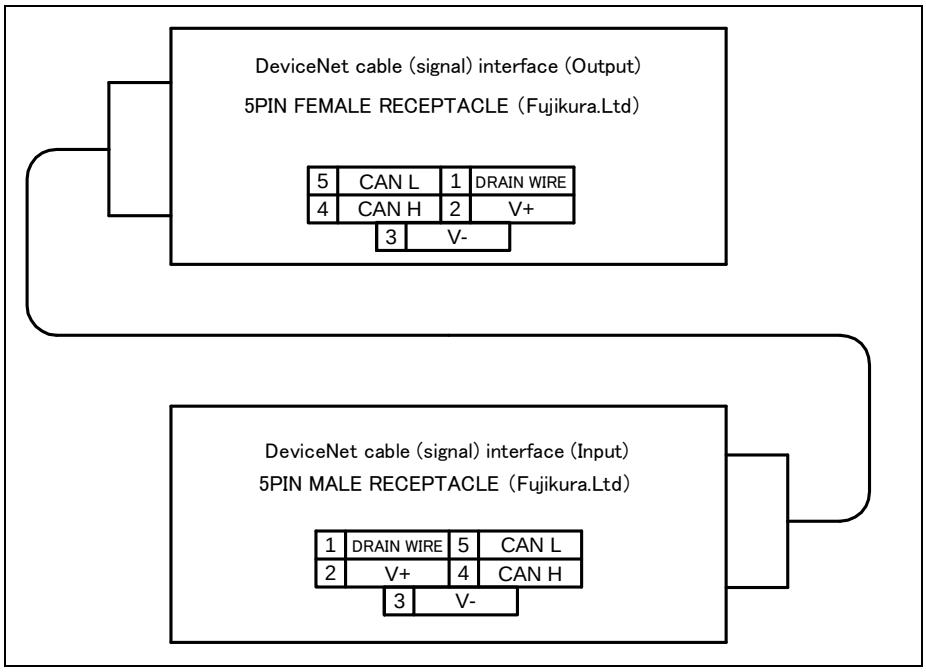


Fig. 5.3 (h) Pin layout for DeviceNet cable (signal line) (DS) interface (Option)

4 DeviceNet cable (power line) (DP) Interface (option)
Fig. 5.3 (i) shows the pin layout for the DeviceNet cable (power line) interface.

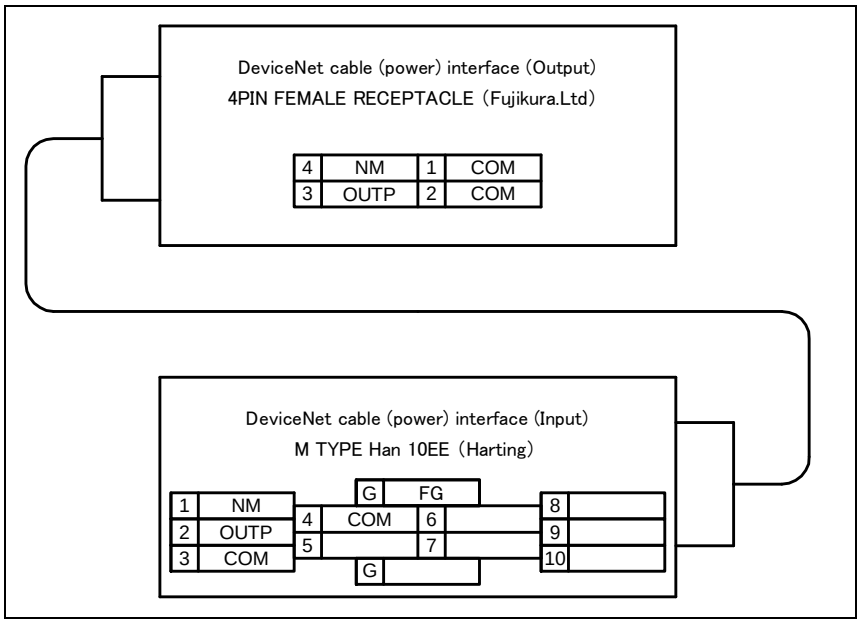


Fig. 5.3 (i) Pin layout for DeviceNet cable (power line) (DP) interface (Option)

Connector specifications

Table 5.3 (a) Connector specifications (User side) (1/2)

Cable name	Input side (J1 base)	Output side (J3 casing)	Maker/dealer
EE (RIx6,ROx4)	————	JMSP2524M Straight plug (Attached) (FANUC Spec: A63L-0001-0234#S2524M) JMLP2524M Angle plug	Fujikura.Ltd
AS ASi	Maker specification	Maker specification	Fujikura.Ltd Japan Aviation Electronics Industry, Ltd.
	Connector Straight plug: MS3106B20-27SY (*1) Elbow plug: MS3108B20-27SY Or a compatible mode Clamp MS3057-12A (*1)	Connector Straight plug: MS3106B20-27PY (*2) Elbow plug: MS3108B20-27PY Or a compatible mode Clamp MS3057-12A (*2)	
	FANUC specification	FANUC specification	
	A05B-1221-K843 (Straight plug (*1) and clamp (*1) are included)	A05B-1221-K841 (Straight plug (*2) and clamp (*2) are included)	

Table 5.3 (b) Connector specifications (User side) (2/2)

Cable	Input side (J1 base)		Maker /dealer	Output side (J3 casing)	Maker /dealer
DS	MINI connector for use on the device net 5-pin, FEMALE CM03-P5S		Fujikura Ltd.	MINI connector for use on the device net 5-pin, MALE CM03-J5P	Fujikura Ltd.
DP	Hood Select just one	09 30 006 1540 (Han 6E) Side entry 1541 0542 0543 1440 Top entry 1441 0442 0443	HARTING Electronic CO., LTD.	MINI connector for use on the device net 4-pin, MALE CM03-J4P	Fujikura Ltd.
	Insert	09 32 010 3101 (Han 10EE F)			
	Con tact	09 33 000 6220 AWG20 6214 AWG18 6205 AWG18 6204 AWG16 6202 AWG14 6207 AWG12			
	Clamp Select just one	09 00 000 5083 5086 5090 5094 Many other types are available.			

Table 5.3 (c) Connector specifications (Mechanical unit side・reference) (1/2)

Cable name	Input side (J1 base)	Output side (J3 casing)	Maker/dealer
EE (RIx6, ROx4)	————	JMWR2524F	Fujikura.Ltd
AS ASi	MS3102A20-27PY	MS3102A20-27SY	Fujikura.Ltd, Japan Aviation Electronics Industry, Ltd. etc

Table 5.3 (d) Connector specifications (DeviceNet cable, Mechanical unit side reference) (2/2)

Cable	Input side (J1 base)					Maker /dealer	Output side (J3 casing)	Maker /dealer
DS	CM03A-R5P-S-2					Fujikura Ltd.	CM03A-PR5S-S-2	Fujikura Ltd.
DP	Housing	09	30	006	0301 (Han 6E)	HARTING Electronic CO., LTD.	CM03A-PR4S-S-2	Fujikura Ltd.
	Insert	09	32	010	3001 (Han 10EE M)			
	Contact	09	33	000	6105			

NOTE

For details, such as the dimensions, of the parts listed above, refer to the related catalogs offered by the respective manufactures, or contact your local FANUC representative.

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 robot is effective under following circumstances:

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

The two methods used to prevent the robot from going beyond the necessary motion range.

- Axis limit by DCS (All axes)
- Axis limit adjustable mechanical stopper ((J1 axis) option)

⚠ WARNING

1 Changing the motion range of any axis affects the operating range of the robot. To avoid trouble, carefully consider the 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 when the robot tries to reach a previously taught position.
2 For J1-axis, use adjustable mechanical stoppers, for J2/J3-axis, use the DCS function so that damage to peripheral equipment and injuries to human bodies can be avoided.
3 Mechanical stoppers are physical obstacles. For J1-axis, it is possible to re-position the adjustable mechanical stoppers. But the robot cannot move beyond them. For J2, J3-axis, the mechanical stoppers are fixed. For the J4, J5 and J6-axis, only DCS-specified limits are available.
4 Adjustable mechanical stoppers (J1-axis) are damaged in any collision to stop the robot. Once a stopper is subjected to a collision, it can no longer assure its original strength and, therefore, might not stop the robot. When this happens, replace the mechanical stopper with a new one.

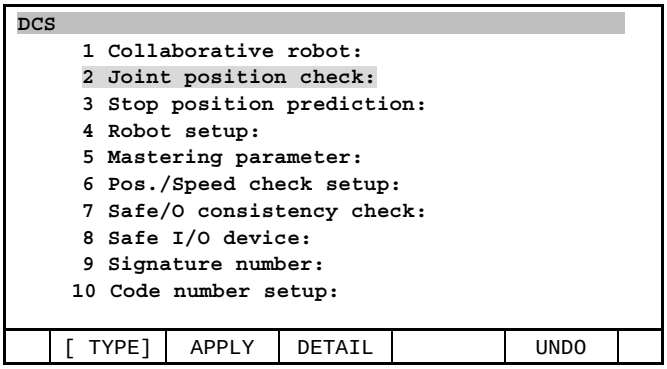
6.1 CHANGE AXIS LIMIT BY DCS

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. The stop position prediction is disabled by default.

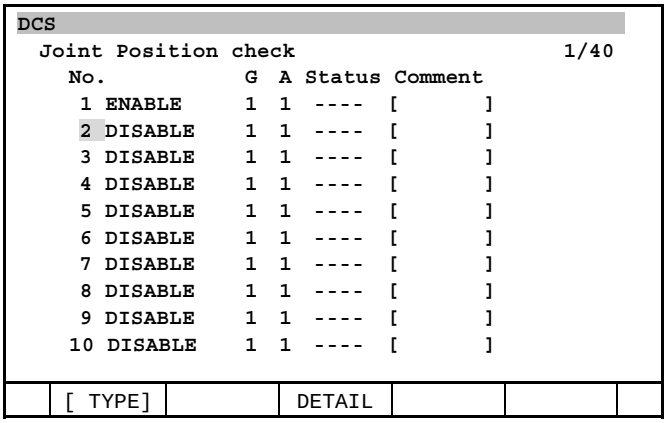
As an example, we shows the procedure to set $\pm 30^{o}$ for J2-axis in here. Refer to Controller Dual check safety function Operator's Manual (B-83184EN) for details of other setting, function and DCS stop position prediction.

Setting procedure

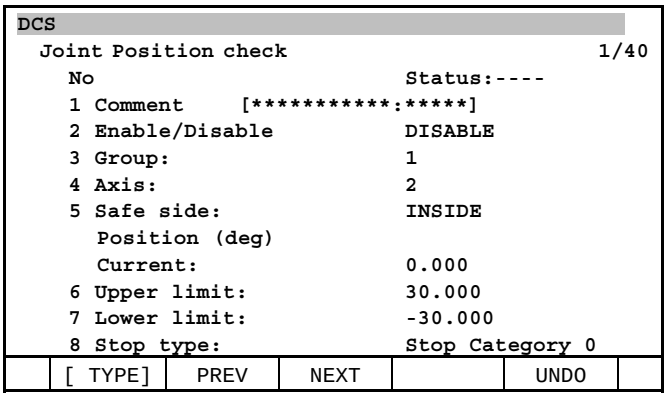
1 Press the [MENU] key to display the screen menu.
2 Press [0 NEXT] and press [6 SYSTEM].
3 Press the F1 ([TYPE]).
4 Select [DCS]. The following screen will be displayed.



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

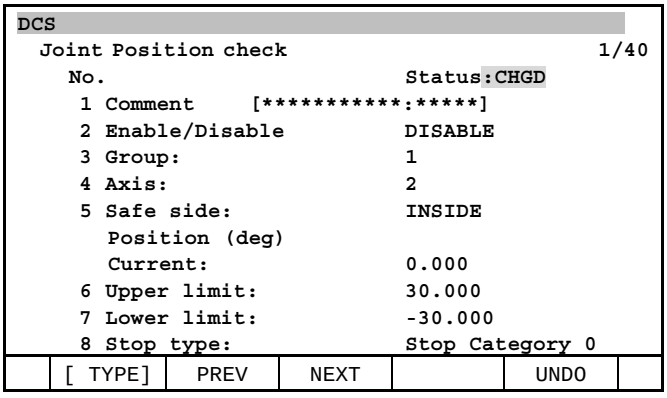


6 Move the cursor to [1], then press the [DETAIL].

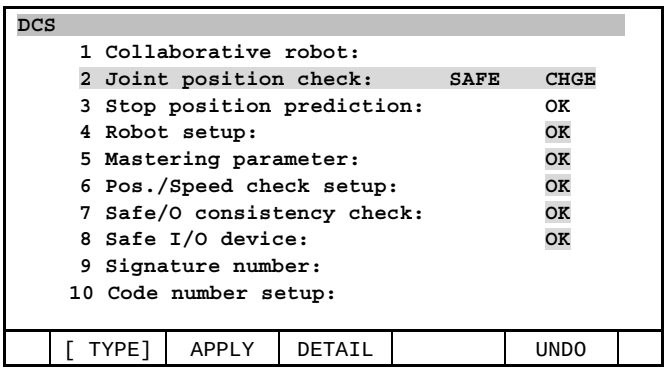


7 Move the cursor to [DISABLE], then press [CHOICE], set the status to [ENABLE].
8 Move the cursor to [Group], then input the robot group number, then press the [ENTER] key.
9 Move the cursor to [Axis], then input “2”, then press the [ENTER] key.
10 Move the cursor to [Upper limit] right side, then input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

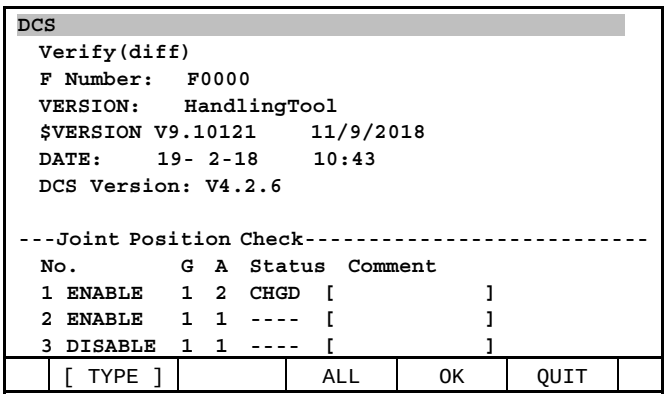
> ⚠ **WARNING**
> If only the operating space is set using Joint Position Check, the robot stops after it goes beyond the workspace. When the motor power is shut down, the robot's momentum causes it to move some distance before it completely stops. The actual "Robot Stop Position" will be beyond the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



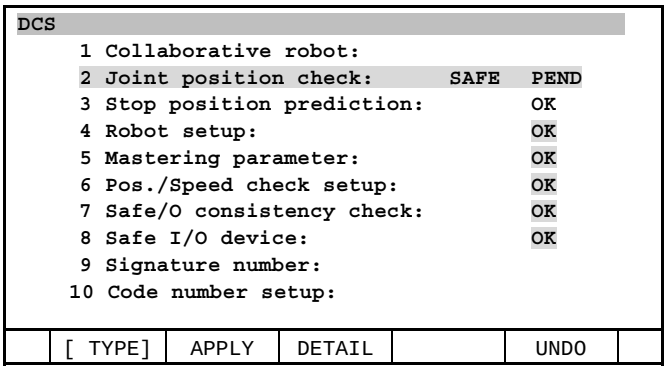
12 Press the [PREV] key two times, back to the first screen.



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 ADJUSTABLE MECHANICAL STOPPER SETTING (OPTION)

For the J1 axis, it is possible to re-position mechanical stoppers. There are following choices. Contact your local FANUC representative to change the motion range. In addition, Replacing the adjustable mechanical stopper is required when it is transformed due to collisions.

Table 6.2 Choices for J1 motion range

	Upper limit	Lower limit	
1	+185	-185	When A05B-1701-H311 is specified
2	+170	-170	When A05B-1701-H310 is specified
3	-10	-170	When A05B-1701-J031 is specified
4	+170	+10	When A05B-1701-J031 is specified

6.2.1 Changing the Parameter Setting

Setting procedure

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

System Axis Limits JOINT 100%
Group1 1/16

AXIS	GROUP	LOWER	UPPER	
1	1	-185.00	185.00	deg
2	1	-45.00	120.00	deg
3	1	-122.90	135.00	deg
4	1	-200.00	200.00	deg
5	1	-110.00	110.00	deg
6	1	-450.00	450.00	deg
7	1	0.00	0.00	mm
8	1	0.00	0.00	mm
9	1	0.00	0.00	mm

[TYPE]

NOTE
0.00 indicates the robot does not have these axes.

5 Move the cursor to J1-axis. Type the new value using the numeric keys on the teach pendant. In this time, set the axial upper limit and the lower limit at the position same as adjustable mechanical stoppers are attached.

System Axis Limits JOINT 100%
Group1 1/16

AXIS	GROUP	LOWER	UPPER	
2	1	-45.0	120.00	deg

[TYPE]

6 Turn off the controller and then turn it back on again in the cold start mode so the new information can be used.

⚠ WARNING
1 You must turn off the controller and then turn it back on to use the new information; otherwise, the old settings remain valid and could cause personnel injury or equipment damage.
2 After changing system variables, be sure to run the robot at a low speed and make sure that the robot stops at the ends of the stroke.
3 If a collision should occur, the J1-axis adjustable mechanical stopper becomes deformed to absorb energy, so that the robot can stop safely. If the stopper is deformed by mistake, replace it. The replacing method and ordering parts are common to J1-axis mechanical stopper. Refer to Section 3.3.
4 Do not depend on parameter settings to control the motion range of your robot.

7 CHECKS AND MAINTENANCE

Optimum performance of the robot can be maintained by performing the periodic maintenance procedures presented in this chapter.
(See the 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 operating time/year vs. the 3840 hours/year should be used to calculate the new (higher) frequencies. For example, when using the robot 7680 hours a year, the maintenance frequency should be doubled – i.e. the interval should be divided by 2.

7.1 PERIODIC MAINTENANCE

7.1.1 Daily Checks

Check the following items when necessary before daily system operation.

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	(When air control set 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)**
Green cover	Confirm whether green covers are not damaged or deteriorated (hardening).
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 devices for proper operation	Check whether the peripheral devices operate properly according to commands from the robot and the peripheral devices.
Brakes for each axis	Check that the droppage of the end effector is within 5 mm when the servo power 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: **⇒"R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL (Alarm Code List)(B-83284EN-1)"**

⚠ WARNING
Be sure to replace damaged or deteriorated green cover. Otherwise, robot lost safety function and may cause injury of the personnel.

7.1.2 Periodic Check and Maintenance

Check the following items at the intervals recommended below based on the total operating time or the accumulated operating time, which ever comes first.

Check and maintenance intervals (Operating time, Accumulated operating time)							Check and maintenance item	Check points, management and maintenance method	Periodic maintenance table No.
1 month 320h	3 months 960h	1 year 3840h	2 years 7680h	3 years 11520h	4 years 15360h	8 years 30720h			
○ Only 1st check	○						Cleaning the controller ventilation system	Confirm the controller ventilation system is not dusty. If dust has accumulated, remove it.	20
○							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.	4
	○						Check for external damage	Check whether the robot has external damage 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 cannot be used, replace the damaged parts. (Perform diary checks for green covers.)	1
	○						Check damages of the cable protection sheaths	Check whether the cable protective sleeves of the mechanical unit cable have holes or tears. If damage is are found, replace the cable protective sleeve. If the cable protective sleeve is damaged due to the interference with peripheral devices, eliminate the cause. **⇒"7.2.3 Check the mechanical unit cable"**	2
	○						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.	3
	○ 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.	19
	○ Only 1st check	○					Check for damage to the mechanical unit cable (movable part)	Observe the movable part of the mechanical unit cable and check for damage. Also, check whether the cables are excessively bent or unevenly twisted. **⇒"7.2.3 Check the mechanical unit cable"**	5
	○ Only 1st Check	○					Check for damage to the end effector (hand) connection cable	Check whether the end effector connection cables are unevenly twisted or damaged. If damage is found, replace the damaged cables.	6

Check and maintenance intervals (Operating time, Accumulated operating time)							Check and maintenance item	Check points, management and maintenance method	Periodic maintenance table No.
1 month 320h	3 months 960h	1 year 3840h	2 years 7680h	3 years 11520h	4 years 15360h	8 years 30720h			
	○ Only 1st check	○					Check the exposed connectors	Check the connection of exposed connectors. ⇒"7.2.3 Check the mechanical unit cable"	7
	○ 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"**	8
	○ Only 1st check	○					Retightening the external main bolts	Retighten the robot installation bolts (according to procedure in Section 1.2), bolts to be 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. However, do not retighten bolts shown in Fig. 7.1.2.	9
	○ 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, and the cable protective sleeve).	10
		○					Replacing the mechanical unit batteries	Replace the mechanical unit batteries **⇒"7.3.1 Replacing the batteries"**	11
		○					Apply grease	Grease the J6-axis reducer **⇒"7.3.2 Greasing**	12
				○			Replacing the grease of J1 to J3- axis reducer and J4 to J5-axis gearbox	Replace the grease of each axis reducer and gearbox **⇒"7.3.2 Replacing the Grease of the Drive Mechanism"**	13 – 17
		○ Only 1st check	○				Check the green covers	Check the green covers. Replace the green covers necessarily if damage or deterioration (curing) are found. Contact your local FANUC representative for information regarding replacing the green covers.	18
					○		Replacing the mechanical unit cable	Replace the mechanical unit cable Contact your local FANUC representative for information regarding replacing the cable.	19
						○	Replacing the force sensor	Replace the force sensor Contact your local FANUC representative for information regarding replacing the force sensor.	20

Check and maintenance intervals (Operating time, Accumulated operating time)							Check and maintenance item	Check points, management and maintenance method	Periodic maintenance table No.
1 month 320h	3 months 960h	1 year 3840h	2 years 7680h	3 years 11520h	4 years 15360h	8 years 30720h			
					○		Replacing the controller batteries	Replace the controller batteries **⇒Chapter 7 Replacing batteries of R-30*i*B CONTROLLER MAINTENANCE MANUAL (B-83195EN) or R-30*i*B Mate CONTROLLER MAINTENANCE MANUAL (B-83525EN)"**	23

⚠ WARNING
Never loosen the bolts shown in Fig. 7.1.2. Otherwise, robot lost safety function and may cause injury of the personnel.

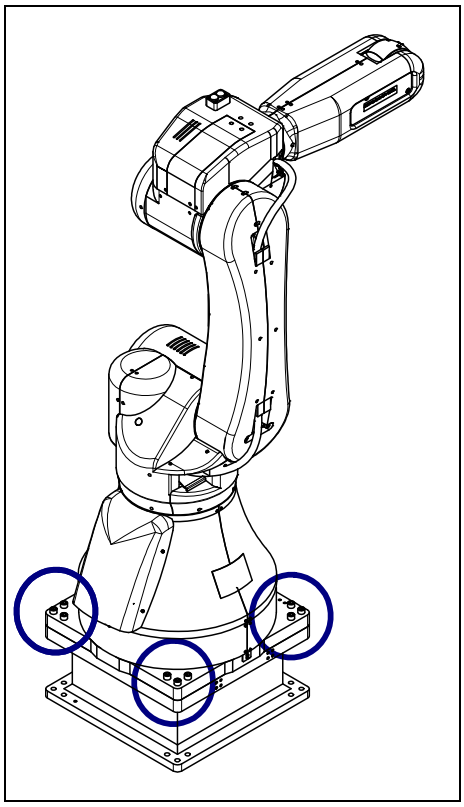


Fig. 7.1.2 Check points

7.2 CHECK POINTS

7.2.1 Confirmation of Oil Seepage

Check items

Check there is oil on sealed part of each joint parts. If there is oil seepage, clean them.

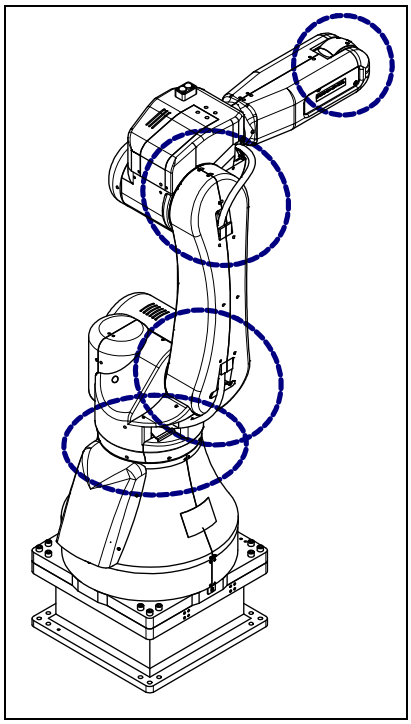


Fig. 7.2.1 Check parts of oil seepage

Management

- In case of oil seepage, please consider replacing the grease. This replacement potentially can help improving the seepage situation.
- 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 pressure can be restored by venting the grease outlet. (When opening the grease outlet, refer to Subsection 7.3.3 and ensure that grease is not expelled onto the machine or tooling.)

> **⚠WARNING**
> Hot grease may come out suddenly when opening the grease outlet. Attach bags for collecting grease and use appropriate protective equipment such as a gloves or protective glasses.

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)

Item	Check items	Check points
1	Air pressure	Check the air pressure using the pressure gauge on the air control set as shown in Fig. 7.2.2. If it does not meet the specified pressure of 0.49 to 0.69 MPa (5-7 kgf/cm^2), adjust it using the regulator pressure-setting handle.
2	Lubricator oil mist quantity	Check the number of oil drops during operation. If it does not meet the specified value (1 drop/10-20 sec), adjust it using the handle for lubricator adjustment. The lubricator becomes empty in about 10 to 20 days under normal operation.
3	Lubricator oil level	Check to see that the air control set oil level is within the specified level.
4	Leakage from hose	Check the joints, tubes, etc. for leaks. Retighten the joints or replace parts, as required.
5	Drain	Check the drain and release it. When quantity of the drain is remarkable, examine the setting of the air dryer to the air supply side.

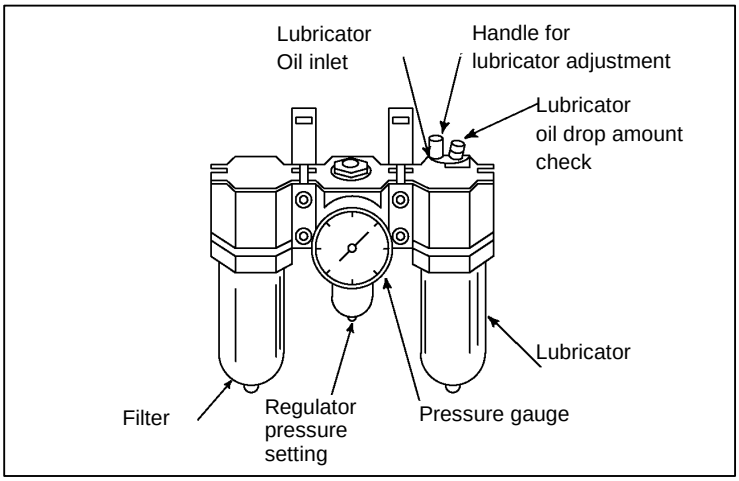


Fig. 7.2.2 Air control set (option)

7.2.3 Check the Mechanical Unit Cables

Inspection points of the mechanical unit cables

Check the cable for damage that has been exposed. Take special care for movable parts.
Clean it when the spatter adheres.

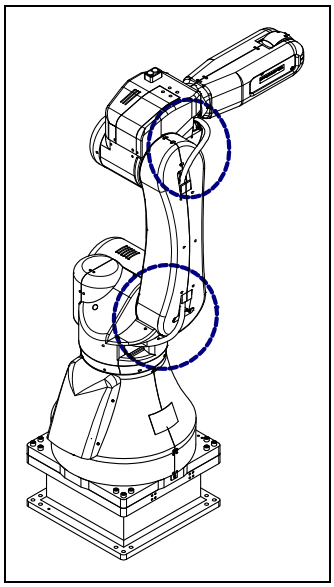


Fig. 7.2.3 (a) Inspection points of the mechanical unit cables

Check points

＜Cable protective sleeve＞

- Check that no holes or tears exist on the cable protective sleeves.
- If there is damage as shown in Fig.7.2.3 (b), replace the cable protective sleeves.

Fig. 7.2.3 (b) Damages on the cable protective sleeve

＜Cables＞

- Check that there is no wear or damage on the coating.
- If the inside wire strands are exposed due to wear or damage, replace the cables.

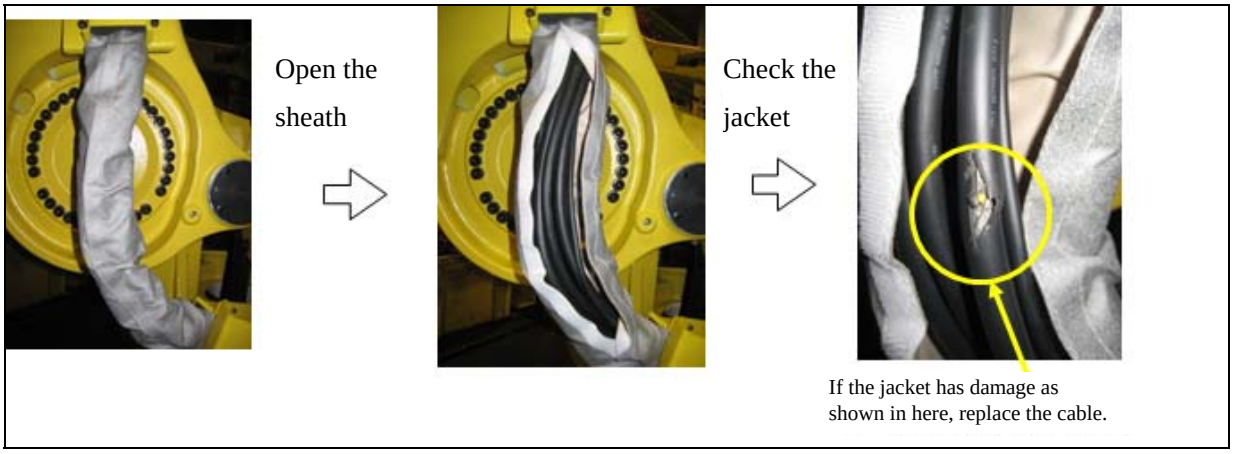


Fig. 7.2.3 (c) Cable check method

7.3 MAINTENANCE

7.3.1 Replacing the Batteries (1-year checks)

The position data of each axis is preserved by the backup batteries. The batteries need to be replaced every 1 year. Also, use the following procedure to replace when the backup battery voltage drop alarm occurs.

Procedure of replacing the battery

1 Keep the power on. Press the EMERGENCY STOP button to prohibit the robot motion.

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

2 Remove the bolts and the cover.
3 Remove the battery case cap. (Fig. 7.3.1) If it cannot be removed, tap it to side direction with a plastic hammer.
4 Take out the old batteries from the battery case. In this time, battery can be taken out by pulling the stick of the center of the battery box.
5 Insert new batteries into the battery case. Pay attention to the direction of batteries.
6 Close the battery case cap.
7 Assemble the cover back in place.

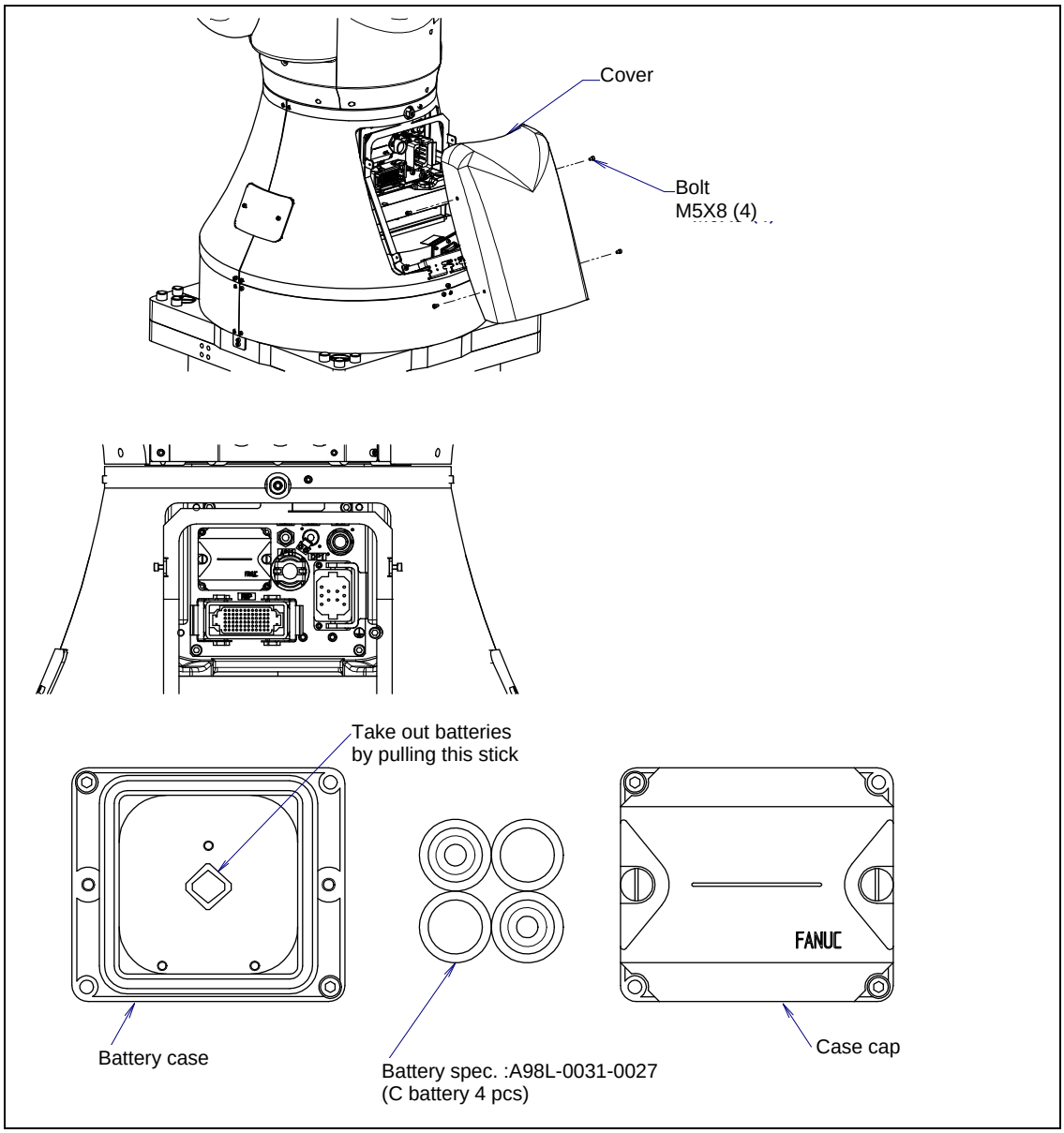


Fig. 7.3.1 Replacing the battery

7.3.2 Greasing

Following is the greasing procedure for J6-axis reducer.
When greasing the robot, keep its power turned off.

i) Replenish the J6-axis reducer with grease about every 12 months or after 3840 hours of operation.
ii) See Fig.7.3.2 and Table 7.3.2 (a) for greasing points and the method.
iii) After applying grease, release the remaining pressure within the grease bath as described in the procedure in Subsection 7.3.3.4.

Table 7.3.2 (a) Greasing points

Greasing point	Specified grease	Amount of grease	Gun tip pressure	Greasing method
J6-axis reducer	Harmonic grease 4BNo.2 Specification : A98L-0040-0230	44ml (39g)	0.1 MPa or less (NOTE)	Remove the plug, the extra low bolt and seal washers of the grease inlet/outlet. Attach the appended adapter (A290-7701-X711) to the grease inlet. Be careful not tighten the adapter too much. (The width across flat of adapter is 8mm) Attach the supplied grease nipple of the J6-axis to the adapter and greasing.

NOTE
When using a hand pump, apply grease approximately once per two seconds.

⚠ CAUTION
If you grease incorrectly, the pressure in the grease bath may increase steeply, leading to a broken seal, which will eventually cause grease leakage or malfunction. When greasing, be sure to follow the cautions stated in Subsection 7.3.3.1.

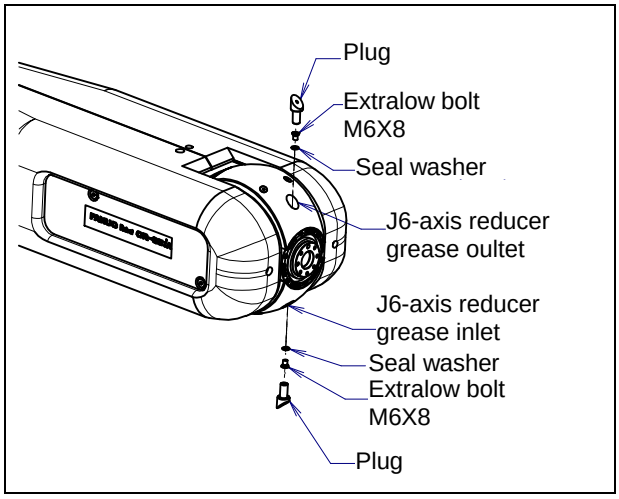


Fig. 7.3.2 Greasing point of J6-axis reducer

Table 7.3.2 (b) Spec. of the seal washer

Parts name	Specification
Seal washer (M6)	A30L-0001-0048#6M

7.3.3 Replacing the Grease of the Drive Mechanism (3-year (11520 hours) checks)

According to below, replace the grease of the reducers of J1, J2, and J3 axes and J4/J5 -axis gearbox at the intervals based on every 3 years or 11520 hours, which ever comes first.

7.3.3.1 Grease replacement procedure for J1 to J3-axis reducer

⚠ CAUTION

Failure to follow proper greasing 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 Before starting to grease, remove the seal bolt or the taper plug grease out.
2 Supply grease slowly, using a manual pump. (once per two seconds)
3 Whenever possible, avoid using an air pump, which is powered by the factory air supply. If the use of an air pump is unavoidable, supply grease with the pump at a pressure lower than or equal to the gun tip pressure (see Table 7.3.3.1 (a)).
4 Use grease only of the specified type. Grease of a type other than that specified may damage the reducer or lead to other problems.
5 After greasing, release remaining pressure from the grease bath using the procedure given in Subsection 7.3.3.3, and then close the grease outlet.
6 To prevent the accident like fall, fire, remove all the excess grease from the floor and robot.
7 Do not loosen grease inlet & outlet parts when attaching and removing the seal bolt, the taper plug and the grease nipple.

Table 7.3.3.1 (a) Grease name and amount (J1, J2, J3-axis reducer)

Grease supplying position	Amount of grease to be applied	Gun tip pressure	Specified grease
J1-axis reducer	1000g (1110ml)	0.1MPa or less (NOTE)	Kyodo Yushi VIGOGREASE RE0 (Specification: A98L-0040-0174)
J2-axis reducer	850g(940ml)		
J3-axis reducer	340g(380ml)		

NOTE

When using a hand pump, apply grease approximately once per two seconds.

⚠WARNING

Hot grease may come out suddenly when opening the grease outlet. Attach bags for collecting grease and use appropriate protective equipment such as a gloves or protective glasses.

Do the grease replacement with following posture.

Table 7.3.3.1 (b) Postures for greasing (J1, J2, J3-axis reducer)

Grease supplying position	Posture					
	J1	J2	J3	J4	J5	J6
J1-axis reducer grease supplying posture	Arbitrary	Arbitrary	Arbitrary	Arbitrary	Arbitrary	Arbitrary
J2-axis reducer grease supplying posture		0°	Arbitrary			
J3-axis reducer grease supplying posture		0°	0°			

1 Move the robot to the greasing posture described in Table 7.3.3.1 (b).
2 Turn off the controller power.
3 In greasing J1-axis, detach the cover referring to Fig. 7.3.3.1 .
4 Remove the seal bolt or taper plug from grease outlet. Hold the width across flat by a wrench etc. and do not loosen grease outlet parts when removing the seal bolt, the taper plug. (Fig.7.3.3.1)
J1-axis : 1 location (Taper plug R1/8)
J2-axis : 3 locations (Taper plug R1/8)
J3-axis : 1 locations (Taper plug R1/8)
5 Remove the taper plug from grease inlet and attach grease nipple during pushing the extension adapter to prevent it from rotating. Hold the width across flat by a wrench etc. and do not loosen grease inlet parts when attaching and removing the seal bolt, the taper plug and the grease nipple.
6 Keep greasing until the new grease pushes out the old grease and comes out from each grease outlet.
7 In case of J1, attach the cover.
8 Release remaining pressure using the procedure given in Subsection 7.3.3.3.

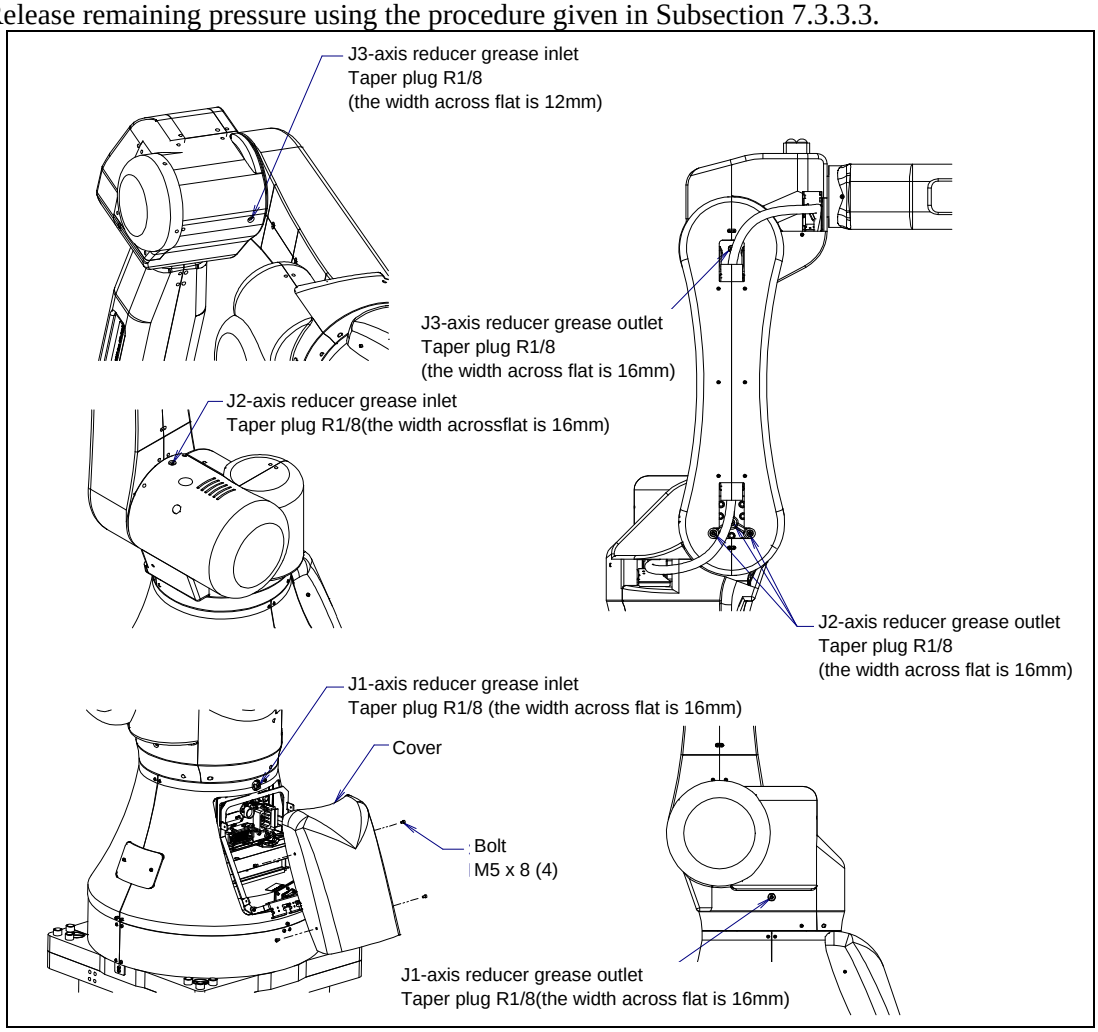


Fig. 7.3.3.1 Greasing point of J1 to J3-axis reducer

Table 7.3.3.1 (c) Specification of the taper plug

Parts name	Specification
taper plug (R1/8)	A97L-0001-0436#1-1D

7.3.3.2 Grease replacement procedure for J4,J5-axis gearbox

⚠ CAUTION

Failure to supply grease correctly may cause an increase of the internal pressure of the grease bath. Such pressure increase will then damage the seal, which in turn leads to grease leakage and abnormal robot operation.
When performing greasing, therefore, observe the following precautions.

1 Before starting to grease, remove the seal bolt or the taper plug grease out.
2 Supply grease slowly, using a manual pump. (once per two seconds)
3 Whenever possible, avoid using an air pump, which is powered by the factory air supply.
  If the use of an air pump is unavoidable, supply grease with the pump at a pressure lower than or equal to the gun tip pressure (see Table 7.3.3.2 (a)).
4 Use grease only of the specified type. Grease of a type other than that specified may damage the reducer or lead to other problems.
5 After greasing, release remaining pressure from the grease bath using the procedure given in Subsection 7.3.3.4, and then close the grease outlet.
6 To prevent the accident like slipping, fire, remove all the excess grease from the floor and robot.
7 Do not loosen grease inlet & outlet parts when attaching and removing the seal bolt, the taper plug and the grease nipple.

Table 7.3.3.2 (a) Grease name and amount (J4,J5-axis gearbox)

Grease supplying position	Amount of grease to be applied	Gun tip pressure	Specified grease
J4-axis gearbox	1100g (1220ml)	0.1MPa or less (NOTE)	Kyodo Yushi VIGOGREASE RE0 (Specification: A98L-0040-0174)
J5-axis gearbox	1000g(1110ml)		

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

Table 7.3.3.2 (b) Grease supplying posture (J4,J5-axis gearbox)

Greasing points	Posture					
	J1	J2	J3	J4	J5	J6
J4-axis gearbox greasing posture	Arbitrary	Arbitrary	0°	Arbitrary	Arbitrary	Arbitrary
J5-axis gearbox greasing posture	Arbitrary	Arbitrary	-90°			

1 Move the robot to the greasing posture described in Table 7.3.3.2 (b).
2 Turn off the controller power.
3 Remove the seal bolt. Hold the width across flat by a wrench etc. and do not loosen grease outlet parts when removing the seal bolt. (Fig. 7.3.3.2)
  J4-axis : 1 location (seal bolt M6X8)
  J5-axis : 1 location (bolt M8X12 + seal washer)
4 Remove the taper plug or the bolt and the seal washer from grease inlet and attach grease nipple. Hold the width across flat by a wrench etc. and do not loosen grease inlet parts when attaching and removing the seal bolt, the taper plug and the grease nipple.
5 Keep greasing until the new grease pushes out the old grease and comes out from each grease outlet.
6 Release remaining pressure using the procedure given in Subsection 7.3.3.4.

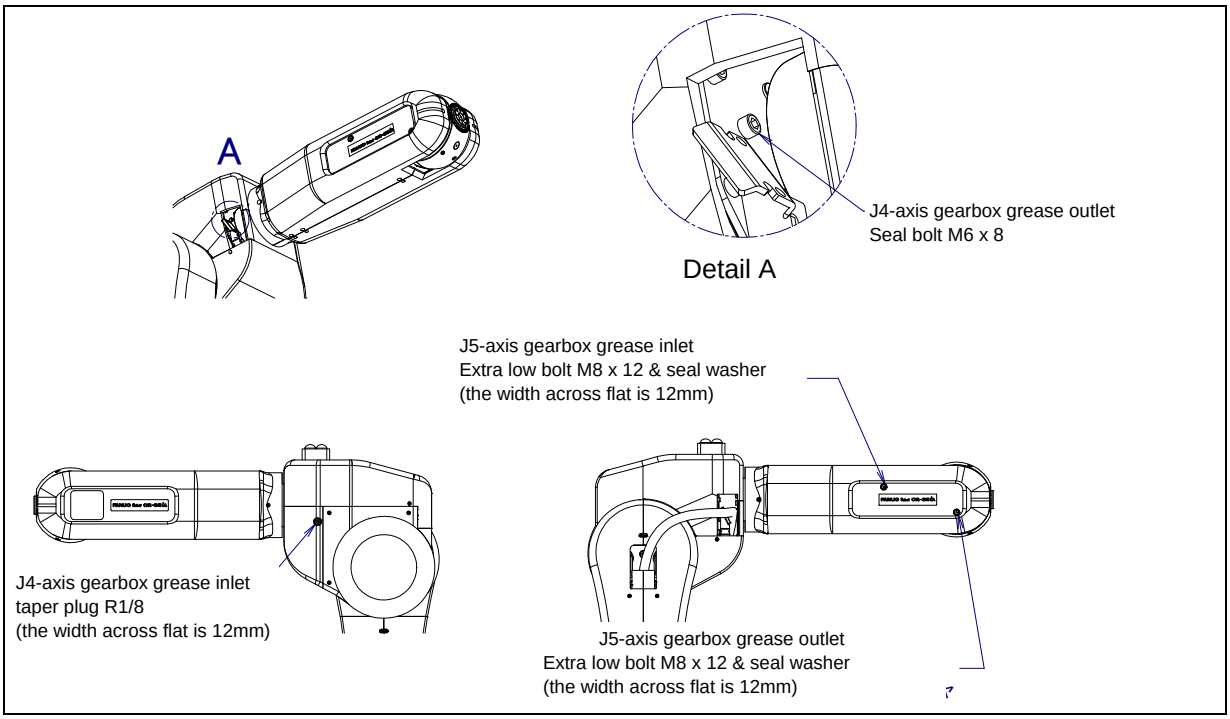


Fig. 7.3.3.2 Greasing point of J4,J5-axis gearbox

Table 7.3.3.2 (c) Spec. of the taper plug, the seal bolt and the seal washer

Parts name	Specification
Taper plug (R1/8)	A97L-0001-0436#1-1D
Seal bolt (M6X8)	A97L-0218-0417#060808
Seal washer (M8)	A30L-0001-0048#8M

7.3.3.3 Procedure for releasing remaining pressure from the grease bath (J1 to J3-axis)

After applying grease, operate the robot as instructed below with the plug of the grease inlet and outlet uncapped for 80 minutes or more to release the remaining pressure within the grease bath. In case of J2-axis, there are three seal bolts for grease outlet. Attach a recovery bag below the grease inlet and outlet to prevent output grease from splattering.

Operating axis / Grease replacement part	J1-axis	J2-axis	J3-axis	J4-axis	J5-axis	J6-axis
J1-axis reducer	Axis angle of 60° or more OVR 100%	Arbitrary				
J2-axis reducer	Arbitrary	Axis angle of 60° or more OVR 100%	Arbitrary			
J3-axis reducer	Arbitrary		Axis angle of 60° or more OVR 100%	Arbitrary		

If the above operation cannot be performed due to the environment of the robot, prolong the operating time so that an equivalent operation can be performed. (When the maximum allowable axis angle is 30°, perform the twice operation for 160 minutes or more.) After completion of the operation, attach the plug to the grease inlets and outlets. If you grease multiple axes, you can exercise multiple axes at the same time. If the plug and grease nipple are reused, use the seal tape by necessity. Hold the width across flat by a wrench etc. and do not loosen grease inlet & outlet parts when attaching the seal bolt, the taper plug.

After replacing grease, grease bath may rise if robot is operated again under frequent inversion movement or high temperature environment. In these cases, you can return internal pressure by releasing grease out let just after operation of robot. (When opening grease outlet, pay attention grease is not scattered.)

7.3.3.4 Procedure for releasing remaining pressure from the grease bath (J4 to J6-axis)

To release remaining pressure, perform the procedure below.
(For the J4-axis)
Operate the robot as described in the table below for at least 80 minutes, with the seal bolts removed from the grease inlet and outlet.

(For the J5-axis gearbox)
- After greasing, remove the grease nipple from the grease inlet.
- Move the robot to J3=-90°, perform ±90° repeating operation during 40 minutes for only J5-axis. Make wait time between 2 points 0, perform the running with position pass is fine.
- After 40 minutes, confirm about 50ml grease is pulled out. (just as volume of 2 golf balls.)
- Attach the bolts and seal washers of grease inlet and outlet.

(For the J6-axis)
Operate the robot as described in the table below for at least 80 minutes, with the extra low bolts and seal washers removed from the grease inlet and outlet.

Attach a recovery bag below the grease inlet and outlet to prevent output grease from splattering.

<table>
<tr><th>Operating axis / Grease replacement part</th><th>J1-axis</th><th>J2-axis</th><th>J3-axis</th><th>J4-axis</th><th>J5-axis</th><th>J6-axis</th></tr>
<tr><td>J4-axis gearbox</td><td colspan="3">Arbitrary</td><td>Axis angle of 60° or more OVR 100%</td><td colspan="2">Arbitrary</td></tr>
<tr><td>J5-axis gearbox</td><td colspan="4">Arbitrary</td><td>Axis angle of 180° or more OVR 100%</td><td>Arbitrary</td></tr>
<tr><td>J6-axis reducer</td><td colspan="5">Arbitrary</td><td>Axis angle of 60° or more OVR 100%</td></tr>
</table>

If the above operation cannot be performed due to the environment of the robot, prolong the operating time so that an equivalent operation can be performed. (When the maximum allowable axis angle is 30 degrees, perform the twice operation for 20 minutes or more.) When you supply grease to plural axes, you can run the plural axes at the same time. After completion of the operation, attach the taper plug , seal bolts or bolts and seal washers to the grease inlets and outlets. When reusing the seal bolts or the taper plug, be sure to seal them with seal tape. Hold the width across flat by a wrench etc. and do not loosen grease inlet & outlet parts when attaching the seal bolt, the taper plug.

After replacing grease, grease bath may rise if robot is operated again under frequent inversion movement or high temperature environment. In these cases, you can return internal pressure by releasing grease out let just after operation of robot. (When opening grease outlet, attention grease is not scattered.)

7.4 STORAGE

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

8 MASTERING

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

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 is required under the following conditions:

- 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 are gone dead. Replace the batteries in the controller and mechanical units periodically. Alarm will alert decreasing the battery voltage.

Types of Mastering

There are following mastering methods.

Table 8.1 Type of mastering

Fixture position mastering	Mastering which performed with the mastering fixture before shipping.
Zero-position mastering (witness mark mastering)	Mastering which 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	Mastering which performed at a user-specified position. The corresponding count value is obtained from the rotation speed 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	Mastering which performed at a user-specified position for one axis. The corresponding count value is obtained from the rotation speed 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	Mastering which performed for one axis at a time. The mastering position for each axis can be specified by the user. Useful in performing mastering on a specific axis.
Mastering data entry	Enter the Mastering data 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 mastering data entry. For fixture position mastering zero-position mastering, quick mastering, quick mastering for single axis and single-axis mastering, contact your local FANUC representative.

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

8.2 RESETTING ALARMS AND PREPARING FOR MASTERING

Before performing mastering, required to display the positioning menu and release the relevant alarm once replacing parts like motors.

Alarm displayed

"Servo 062 BZAL" or "Servo 075 Pulse not established"

Procedure

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

2 To reset the "Servo 062 BZAL" alarm, follow steps 1 to 5.
  1 Press [MENU] key.
  2 Press [0 NEXT] and select [6 SYSTEM].
  3 Press F1 [TYPE], and select [Master/Cal] from the menu.
  4 Press the F3 RES_PCA, then press F4 [YES].
  5 Turn off the controller power and on again.

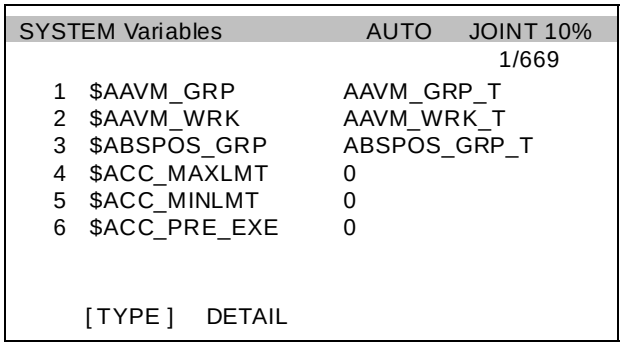
3 To reset the "Servo 075 Pulse not established" alarm, follow steps 1 to 2.
  1 When the controller power is switched on again, the message "Servo 075 Pulse not established" appears again.
  2 Move the axis for which the message mentioned above has appeared till alarm disappears when press [FAULT RESET]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

8.3 MASTERING DATA ENTRY

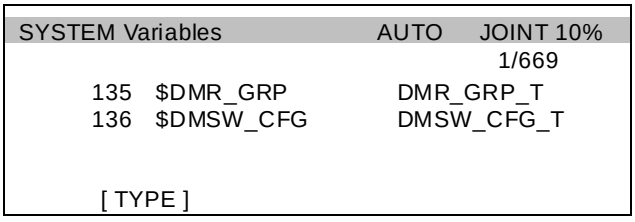
This function enables mastering data values to be assigned directly to a system variable. It can be used if mastering data has been lost but the pulse count is preserved.

Mastering data entry method

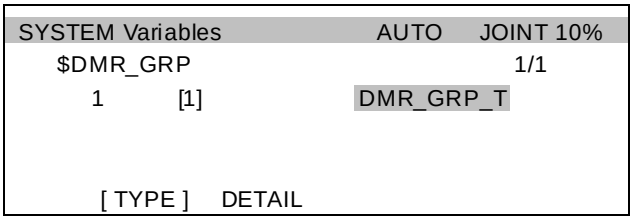
1 Press [MENU] key, then press [0 NEXT] and select [6 SYSTEM].
2 Press F1 [TYPE]. Select [Variables]. The system variable screen appears.

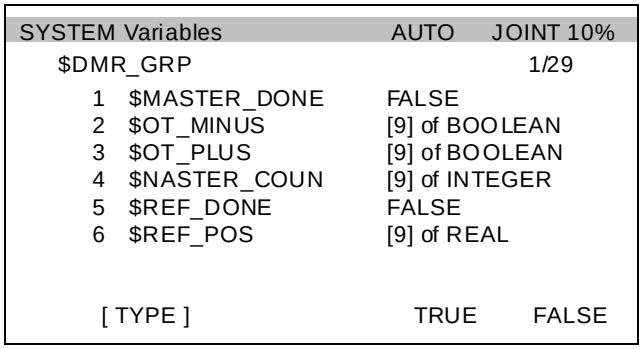


3 Change the mastering data.
The mastering data is saved to the $DMR_GRP.$MASTER_COUN system variable.

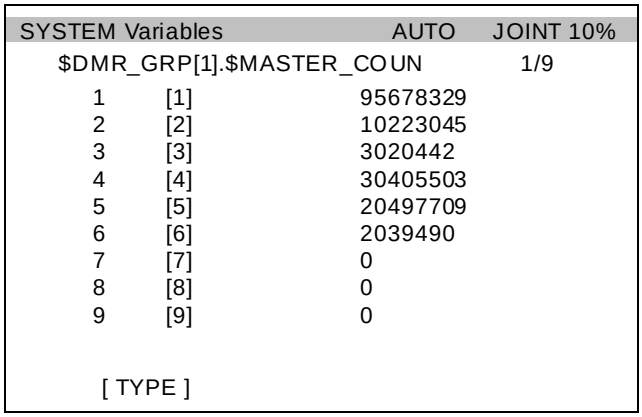


4 Select $DMR_GRP.

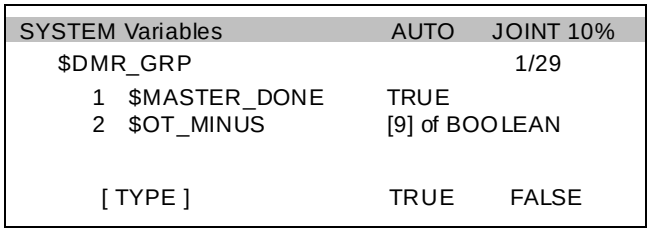




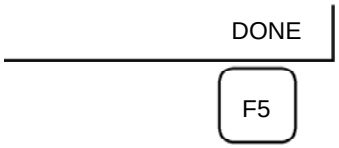
5 Select $MASTER_COUN, and enter the mastering data you have recorded.



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].



8.4 CHECKING THE MASTERING

1 How to check the robot mastered properly.
Normally, the positioning will be performed automatically when the power is on. To check whether mastering has been performed correctly, compare the actual robot position with the displayed position. Follow the procedure described below.
(1) Reproduce a particular point in a program. Check whether the point agrees with the specified position.

If the displayed and actual positions do not match, the counter value for a Pulsecoder may have been invalidated as a result of an alarm described in 8.2. 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 turn off the controller power on again 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 major troubleshooting that may occur in the mechanical unit and their probable causes. If you cannot pinpoint a failure cause or which measures to take, contact your local FANUC representative.

Table 9.1 (a) TROUBLESHOOTING

Symptom	Description	Cause	Measure
Vibration Noise	- The J1 base lifts off the base plate as the robot operates. - There is a gap between the J1 base and base 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 base plate. - Probable causes are a loose bolt, an insufficient degree of surface flatness, or foreign material caught between the base plate and floor plate. - If the robot is not securely fastened to the floor plate, the J1 base lift from the ground. Thus may cause the collision, and lead to vibration.	- If a bolt is loose, apply LOCTITE and tighten it to the appropriate torque. - Adjust the base plate surface flatness to within the specified tolerance. - If there is any foreign material between the J1 base and base plate, eliminate them. - Apply adhesive between the J1 base and base plate.
	- 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 is in 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 heavier 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 or not. If the robot is overloaded, reduce the load, or modify the robot control program. - Vibration can be reduced by re-modifying the robot control program; reducing speed or acceleration with minimizing the influence 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 exchanged for a long period. - There is vibration or unusual sound just after replacing grease or parts. - 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 tooth surface or rolling contact surface of a bearing, or reducer. - It is likely that prolonged use of the robot while overloaded caused fretting of the tooth surface or rolling contact surface of a bearing, or reducer due to resulting metal fatigue. - It is likely that foreign matter caught in a gear, bearing, or within a reducer caused damage on the tooth surface or rolling contact surface of the bearing, or reducer. - It is likely that foreign matter 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 tooth surface or rolling contact surface of a bearing, or reducer due to metal fatigue. - There is a possibility of grease has not been exchanged accurately. The amount of grease may be insufficient.	- 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. - Regularly changing the grease with a specified type can help prevent problems. - If vibration can no be removed by replacing grease, perform continuous operation before replacing grease, then it may be improved.
	- 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.

Symptom	Description	Cause	Measure
Vibration Noise (Continued)	- There is an unusual sound after replacement of grease. - There is an unusual sound after a long period. - There is an unusual sound during operation at low speed.	- There may be an unusual sound when using other than the specified grease. - Even for the specified grease, there may be an unusual sound during operation at low speed immediately after replacement or after a long period.	- Use the specified grease. - When there is an abnormal noise even when using the specified grease, operate for one or two days as an experiment. Generally, any abnormal noise will disappear.
	- 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. - Pulsecoder defect may be the cause of the vibration as the motor cannot propagate the accurate position to the controller. - If the motor becomes defective, vibration might occur because the motor cannot deliver its rated performance. - If a power line in a movable cable of the mechanical unit has an intermittent break, vibration might occur because the motor cannot accurately respond to commands. - If a Pulsecoder wire in a movable part of the mechanical unit has an intermittent break, vibration might occur because commands cannot be sent to the motor accurately. - If a connection cable between the mechanical unit and the controller has an intermittent break, vibration might occur. - If the power supply cable is about to be snapped, vibration might occur. - If the power source voltage drops below the rating, vibration might occur. - It may vibrate when the invalid value parameter was set.	- Refer to the Controller Maintenance Manual for troubleshooting related to the controller and amplifier. - Also, replace the motor of the axis that is vibrating, and check whether vibration still occurs. For the method of replacement, refer to Chapter 4. - If vibration occurs only when the robot assumes a specific posture, it is likely that a cable in the mechanical unit is broken. - Shake the movable part cable while the robot is at rest, and check whether an alarm occurs. If an alarm or any other abnormal condition occurs, replace the mechanical unit cable. - Check whether the sheath of the cable connecting the mechanical unit and controller is damaged. If so, replace the connection cable, and check whether vibration still occurs. - Check whether the sheath of the power cable 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 FANUC for further information if necessary.

Symptom	Description	Cause	Measure
Rattling	- While the robot is not supplied with power, pushing it with the hand causes tottering part of the mechanical unit. - 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 the following retaining bolts tightness for each axis. If any of these bolts is loose, apply LOCTITE and bolt down with appropriate torque. - Motor - Reducer - Reducer shaft - Base - Arm - Casting - End effector
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.	- The teach pendant can be used to monitor the average current. Check the average current when the robot control program is running. The allowable average current is specified for the robot according to its ambient temperature. Contact FANUC for further information. - Relaxing the robot control program and conditions can reduce the average current, thus preventing overheating. - Reducing the ambient temperature is the most effective means of preventing overheating. - Having the surroundings of the motor well ventilated enables the motor to release heat efficiently, thus preventing overheating. Using a fan to direct air at the motor is also effective. - If there is a source of heat near the motor, it is advisable to install shielding to protect the motor from heat radiation.
	- 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.	- Input an appropriate parameter as described in CONTROLLER OPERATOR'S MANUAL.

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.)tor problems] - It is likely that motor brake failure locked on the break, and cause the motor overloaded. - It is likely that a failure of the motor prevented it from delivering its rated performance, thus causing an excessive current to flow into the motor.	- Repair the mechanical unit referring to the above descriptions of vibration, noise, and rattling. - Check that, when the servo system is energized, the brake is released. If the brake remains applied to the motor all the time, replace the motor. - Judgment is possible if the average current decreased after replacing the motor, the former motor had been defected.

Grease leakage	- Grease leaks 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.
		- The casting may crack with excessive force caused in collision.
		- An O-ring can be damaged if it is trapped or cut during disassembling or re-assembling.
		- An oil seal may be damaged if extraneous dust scratches the lip of the oil seal.
		- A loose seal bolt may allow grease to leak along the threads.
		- Problems with the grease nipple or threads.
			- If the casting cracks, sealant can be used as a quick-fix to prevent further grease leakage. However, the component must be replaced as soon as possible, as the crack will widen.
			- O-rings are used in the locations listed below.
			  - Motor coupling section
			  - Reducer (case and shaft) coupling section
			  - Wrist connecting part
			  - J3 arm coupling section
			  - Inside the wrist
			- Oil seals are used in the locations stated below.
			  - J1-axis cable pipe
			  - Inside the reducer
			  - Inside the wrist
			- Seal bolts are used in the locations stated below.
			  - Grease outlet
			  - For fixation of the covers

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

Symptom	Description	Cause	Measure
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 causes are a failure in the drive mechanism or a loose bolt, and so on. - If the repeatability is stable, it is likely that collision by an excessive load caused slip on the fasting surface of each axis arm, and 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 occur 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 overwritten, and the origin had misaligned.	- Re-enter the previous optimal mastering data. - If optimal mastering data is unavailable, perform mastering again.
BZAL alarm displayed	- BZAL is displayed on the teach pendant screen	- It is likely that the voltage of the memory backup battery is low. - It is likely that the Pulsecoder cable is defective.	- Replace the battery. - Replace the cable.
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.

Symptom	Description	Cause	Measure
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.

Table 9.1 (b) Allowable drops

At power off	5mm
At emergency stop	5mm

NOTE
Each value indicates the amount by which an end effector mounting face may fall.

APPENDIX

A PERIODIC MAINTENANCE TABLE

FANUC Robot CR-35*i*A **Periodic Maintenance Table**

		Items \ Working time (H)	Maintenance time	Grease amount	First check 320	3 months 960	6 months 1920	9 months 2880	1 year 3840	4800	5760	6720	2 years 7680	8640	9600	10560
Mechanical unit	1	Check for external damage or peeling paint	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	2	Check damages of the cable protection sheaths	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	3	Check for water	0.2H	—		○	○	○	○	○	○	○	○	○	○	○
	4	Check the force sensor *1	0.1H	—		○	○	○	○	○	○	○	○	○	○	○
	5	Check the mechanical cable. (Damaged or twisted)	0.2H	—		○			○				○			
	6	Check the end effector (hand) cable	0.2H	—		○			○				○			
	7	Check the motor connector. and exposed connector (Loosening)	0.2H	—		○			○				○			
	8	Tighten the end effector bolt.	0.2H	—		○			○				○			
	9	Retightening external main bolts	2.0H	—		○			○				○			
	10	Clean spatters, sawdust and dust	1.0H	—		○			○				○			
	11	Replacing battery	0.1H	—					●				●			
	12	Supply grease of J6-axis reducer	0.5H	44ml					●				●			
	13	Replacing grease of J1 axis reducer	0.5H	1110ml												
	14	Replacing grease of J2 axis reducer	0.5H	940ml												
	15	Replacing grease of J3 axis reducer	0.5H	380ml												
	16	Replacing grease of J4 axis gearbox	0.5H	1220ml												
	17	Replacing grease of J5 axis gearbox	0.5H	1110ml												
	18	Check the green covers	0.2H	—					○				○			
	19	Replacing cable of mechanical unit	4.0H	—												
	20	Replacing the force sensor	8.0H	—												
Controller	21	Check the robot cable, teach pendant cable and robot connecting cable	0.2H	—		○			○				○			
	22	Cleaning the ventilator	0.2H	—	○	○	○	○	○	○	○	○	○	○	○	○
	23	Replacing battery *2	0.1H	—												

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

*2 Refer to “REPLACING UNITS Chapter of MAINTENANCE ” of the following manuals.
R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL (B-83195EN)

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

3 years 11520	12480	13440	14400	4 years 15360	16320	17280	18240	5 years 19200	20160	21120	22080	6 years 23040	24000	24960	25920	7 years 26880	27840	28800	29760	8 years 30720	Item
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		1
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		2
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		3
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		4
○				○				○				○				○					5
○				○				○				○				○					6
○				○				○				○				○					7
○				○				○				○				○					8
○				○				○				○				○					9
○				○				○				○				○					10
●				●				●				●				●					11
●				●				●				●				●					12
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○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		22
				●																	23

Overhaul

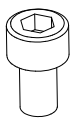
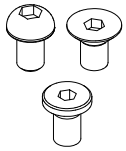
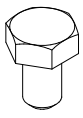
B MOUNTING BOLT TORQUE LIST

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 the oil on the engaging section. Make sure that there is no solvent left in the threaded holes. In this case, remove all the excess LOCTITE when you are finished screwing the bolts into the threaded holes.

Use the following strength bolts. Comply with any bolt specification instructions as specified.
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 are not specified.

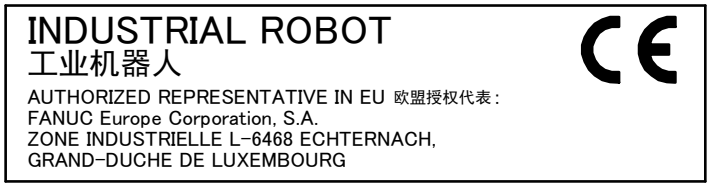
Recommended bolt tightening torques **Unit: Nm**

Nominal diameter	Hexagon socket head bolt (steel)		Hexagon socket head bolt (stainless)		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 EC DECLARATION OF CONFORMITY

For FANUC robot series (for CE marking : both of the following labels are attached), EC 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
EC declarations of conformity
for Machinery Directive
(2006/42/EC)

Item	Contents
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 EN 60204-1
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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02	Feb., 2019	· Addition of R-30*i*B Plus Controller · Correction of errors
01	Sep., 2015	

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