FANUC Robot

SAFETY HANDBOOK

MARUCSFTY04071E REV. E

FANUC Robotics America, Inc.
3900 W. Hamlin Road
Rochester Hills, Michigan 48309–3253

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This manual can be used with controllers labeled R-30*i*A or R-J3*i*C. If you have a controller labeled R-J3*i*C, you should read R-30*i*A as R-J3*i*C throughout this manual.

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FANUC Robotics conducts courses on its systems and products on a regularly scheduled basis at the company's world headquarters in Rochester Hills, Michigan. For additional information contact

FANUC Robotics America, Inc.
Training Department
3900 W. Hamlin Road
Rochester Hills, Michigan 48309-3253
www.fanucrobotics.com

For customer assistance, including Technical Support, Service, Parts & Part Repair, and Marketing Requests, contact the Customer Resource Center, 24 hours a day, at 1-800-47-ROBOT (1-800-477-6268). International customers should call 011-1-248-377-7159.

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Patents

One or more of the following U.S. patents might be related to the FANUC Robotics products described in this manual.

FRA Patent List
4,630,567 4,639,878 4,707,647 4,708,175 4,708,580 4,942,539 4,984,745 5,238,029 5,239,739 5,272,805 5,293,107 5,293,911 5,331,264 5,367,944 5,373,221 5,421,218 5,434,489 5,644,898 5,670,202 5,696,687 5,737,218 5,823,389 5,853,027 5,887,800 5,941,679 5,959,425 5,987,726 6,059,092 6,064,168 6,070,109 6,086,294 6,122,062 6,147,323 6,204,620 6,243,621 6,253,799 6,285,920 6,313,595 6,325,302 6,345,818 6,356,807 6,360,143 6,378,190 6,385,508 6,425,177 6,477,913 6,490,369 6,518,980 6,540,104 6,541,757 6,560,513 6,569,258 6,612,449 6,703,079 6,705,361 6,726,773 6,768,078 6,845,295 6,945,483 7,149,606 7,149,606 7,211,978 7,266,422 7,399,363

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Conventions

WARNING

Information appearing under the "WARNING" caption concerns the protection of personnel. It is boxed and bolded to set it apart from the surrounding text.

CAUTION

Information appearing under the "CAUTION" caption concerns the protection of equipment, software, and data. It is boxed and bolded to set it apart from the surrounding text.

Note Information appearing next to NOTE concerns related information or useful hints.

- **Original Instructions**

Before using the Robot, be sure to read this manual and understand the content.

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

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

GENERAL PRECAUTIONS

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 workplace that allows for the safe application, use, and operation of FANUC system.
Additionally, as the owner, employer, or user of a robotic system, 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 your robotic system and to be aware of the recommended operating procedures for your particular application and robot installation.
FANUC therefore, recommends that all personnel who intend to operate, program, repair, or otherwise use the robotics system be trained in an approved FANUC training course and become familiar with proper operation of the system.
Persons responsible for programming the system including the design, implementation, and debugging of application programs must be familiar with the recommended programming procedures for your application and robot installation.

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.

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

The system designer is responsible for designing the robot system to comply with Annex I of Machinery Directive, EN ISO 10218 (or ANSI RIA ISO 10218), and EN ISO 12100 standards.

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1 FANUC ROBOT SYSTEM

1.1 PURPOSE OF ROBOT

FANUC Robot series can be used for the following applications.
- ARC welding
- Spot welding
- Handling
- Deburring
- Assembling
- Sealing
- Painting

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 operator and the people in the premises.

- Use of robot in flammable atmosphere
- Use of robot in explosive atmosphere
- Use of robot in radioactive environment
- Use of robot 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)
- 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.

1.2 CONFIGURATION OF ROBOT SYSTEM

The following elements has been verified their safety.
- Robot
- Robot controller and Teach pendant

The following elements must be prepared by the user according to system configuration.
- Safeguard
- Interlocked gate and Interlocking device

FANUC Robot has an interface to connect interlocking devices.

However, the following elements are not considered, due to wide variety of its design and safety measures.
- End effector
- Workpiece
- Other peripheral equipment

The designer of a robot application system must design the robot system according to EN ISO 10218 (ANSI RIA ISO 10218) and Annex I of Machinery Directive.

1.3 WORKING PERSON

The personnel can be classified as follows.

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

Programmer or teaching operator:
- Operates the robot
- Teaches robot inside the safety fence

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

- An operator cannot work inside the safety fence.
- A programmer, Teaching operator and maintenance engineer can work inside the safety fence. The workings inside safety fence are lifting, setting, teaching, adjusting, maintenance, etc.
- To work inside the fence, the person must be trained for the robot.

Table 1 lists the workings of outside the fence. In this table, the symbol "○" means the working allowed to be carried out by the personnel.

Table 1.3 List of workings outside the fence

	Operator	Programmer or Teaching operator	Maintenance engineer
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			○

In operating, programming and maintenance, the programmer, teaching operator and maintenance engineer take care of their safety using the following safety protectors, for example.

- Use adequate clothes, uniform, overall for operation
- Put on the safety shoes
- Use helmet

1.3.1 Robot Training

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

- Safety,
- Practice of jog feed,
- Practical training of manual operation and teaching of robot,
- 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 outline of programming and program example,
- Explanation of automatic operation,
- Explanation of interface between robot and peripheral device,
- Explanation and practice of check item when trouble occur,
- Explanation of periodical inspection and exchange of consumable,
- Explanation and practice of basic operation,
- Explanation and practice of display for maintenance,
- Explanation and practice of handling of floppy cassette,
- Explanation and practice of initial setting,
- Explanation and practice of controller,
- Explanation and practice of checking item on trouble,
- Explanation and practice of troubleshooting by error code,
- Explanation and practice of servo system,
- Explanation and practice of mastering, and
- Explanation and practice of disassemble and assemble.

Some training courses for these items for the maintenance engineer or system engineer are provided in the robot school and each technical service center.
Please refer to Chapter 7 for contacts.

1.4 RELEVANT STANDARDS FOR CE MARKING

FANUC robot series (for CE marking) meets following standards.

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

⚠NOTE
For EN 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	CIP Safety	
R-30*i*A R-30*i*A Mate	[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
	[7DA1-7DA4] Cat.4	[7DA1-7DA4] Cat.3	[7DA1-7DA4] None		EN 954-1:1996
R-J3*i*B	Cat. 4 or Cat. 3 (*)	None			
R-J3*i*B Mate	Cat. 3 (*)	None			
(*) Evaluation was included into total safety assessment by third party. (No independent certificate based on this standard)					

[For EMC Directive]
- EN 61000-6-4
- EN 55011 (Group 1, Class A)
- EN 61000-6-2

For the above standards, FANUC robot systems have been certified by the third party (TÜV Rheinland Japan).

2 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 2.5.
About safety fence, safety gate and other protection devices, please refer to 3.4 and 3.5.

2.1 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 operator's physical dimensions, strength and stamina,
- providing enough space for movements of the parts of the 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 operators.

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

2.2 PLACEMENT OF EQUIPMENT

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

- 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.

- The risk assessment must determine the additional space 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,
  - 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, and
  - where no dangerous situation is created by operating it.

- 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 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 system.

- 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 the safety fence, especially for maintenance and inspection, must be designed to protect the operator 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.

- Robot systems 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.
- This rule does not apply to associated equipment in order to allow it to perform its task.

- When T2 mode is used, the robot system must be installed to provide a minimum clearance from the restricted space of 0.45m 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 to stop robot motion while personnel are within 0.45m of the trapping or pinch hazard must be provided.

- When a limitation of the restricted space, by limiting the range of motion of the primary axes, is required by the plan, limiting devices must be provided. They must comply with one of the following.
  - Mechanical stops which are capable of stopping the robot at any adjusted position when it is carrying its rated load at maximum velocity.
  - 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 stops.
    This may include using the robot controller and limit switches according to IEC/EN 60204-1.

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

- When it is intended that 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 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 bi designed for the installation of seats.

- The operator's seat must enable him to maintain a stable position. Furthermore, the seat and its distance from the control devices 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.

2.3 POWER SUPPLY AND PROTECTIVE EARTH CONNECTION

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

- 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 hazardous and the must have a lockout/tagout capability.

2.4 OTHER PRECAUTIONS

- Shut down (removal of power) to the robot system or any associated 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 panel or the teach pendant.
  - The operator can easily make sure that nobody is inside the safety fence.
  - 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) is used before robot starts moving.
  - A measure for the person inside the fence to stop the robot system or a measure for the person to evacuate outside the fence.
  - 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 can be used 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).

- It is recommended that adjustment, 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.

- For robot systems that can be operated from a remote location (e.g. over a communications network), a means must be provided (e.g. a key operated switch) to ensure that no commands can initiate hazardous conditions from the remote location when in local control.

- 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 Annex I of Machinery Directive.

- The requirements in Annex I of Machinery directive and EN ISO 10218 (ANSI/RIA/ISO 10218) must be considered when a robot application system is designed.

2.5 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 the 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 or result in a hazardous condition, and
  - the static and dynamic forces created by the load and the end effector together are within the load capacity and dynamic response of the robot.
- If it is equipped with a tooling 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 safety measures must be provided.
- If the workpiece is extreme high or low temperature, safety measures must be provided to avoid personnel from touching or getting too close to it.

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.
- Measures must be provided 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, an air valve which shuts off the air supply to the robot must be installed.
- If a power source other than the electricity (e.g. pneumatic, water, heat) is used in the system, appropriate risk-assessment must be performed, and appropriate safety measures must be provided.
- Safety measures must be provided to avoid swapping of components that cause unsafe conditions, by
  - design to avoid swapping,
  - indication of necessary information on the parts.
- Safety measures must be provided to avoid inferior contacts, by
  - design,
  - displaying the information on the connectors, pipes, cables.
- Safety measures must be provided to avoid an unsafe condition by touching an extremely high/low temperature parts (if any).
- Safety measures must be provided to avoid fire or explosion through sufficient amount of investigation.
- Vibration and sound noise must be kept to a minimum.
- 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 SAFETY DEVICES

3.1 STOP TYPE OF ROBOT

The following three robot stop types exist:

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

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

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)

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

-: Not stop

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

Option	R-30*i*A		R-30*i*A Mate	
	RIA type	CE type	RIA type	CE type
Standard	A	A	A	A
Stop type set (Stop pattern C) (A05B-2500-J570)	C	C	C	C

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.

"Stop type set (Stop pattern C)" option

"Stop type set (Stop pattern C)"(A05B-2500-J570) is an optional function. When this option is loaded, 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*A controller)
SRVO-194 Servo disconnect	Servo disconnect input (SD4-SD41, SD5-SD51) is open. (R-30*i*A controller)
SRVO-218 Ext.E-stop/Servo Disconnect	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*A Mate 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.

This function is available only in CE or RIA type hardware.

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.

3.2 EMERGENCY STOP

This robot has following emergency stop devices.

- emergency stop button
- external emergency stop (input signal)

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

3.3 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.

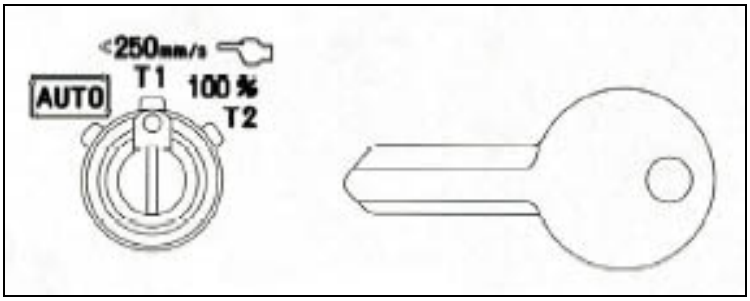


Fig.3.2 Mode Select Switch

3.3.1 Operating Modes

There are two or three operating modes.

AUTO: Automatic Mode

- The operator's panel/box becomes enable.
- The robot program can be started by the operator's panel/box start button or peripheral device I/O.
- Safety fence is enabled.
- The robot can be operated at the specified maximum speed.

T1: Test Mode 1

- Program can be activated from the teach pendant only.
- The robot cannot be operated at speeds higher than 250mm/sec.
- Safety fence is disabled.

T2: Test Mode 2(Optional)

- Program can be activated from the teach pendant only.
- The robot can be operated at the specified maximum speed.
- Safety fence is disabled.

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

3.4 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.

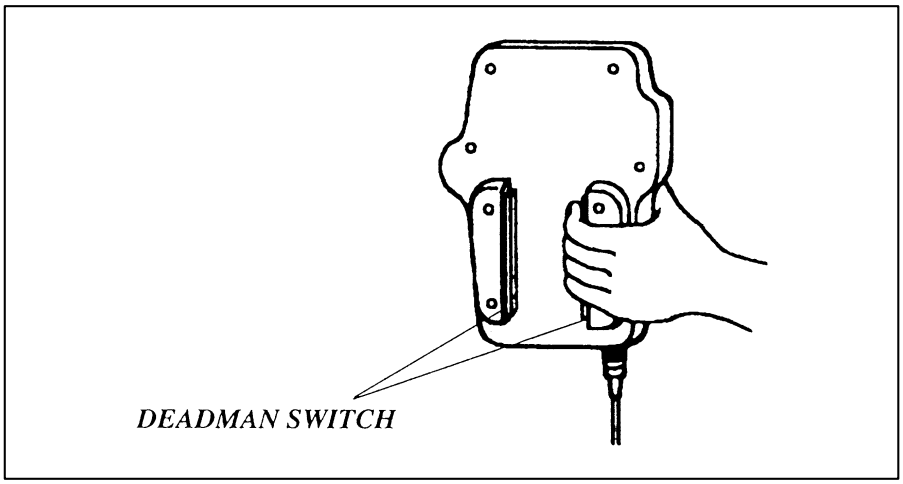


Fig.3.4 Deadman Switch

3.5 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 10218 (ANSI/RIA/ISO 10218) and Annex I of Machinery Directive standard.
This section describes the basic requirements for these devices.
Please refer to EN ISO 10218 (ANSI/RIA/ISO 10218) and Annex I of Machinery Directive standard for detail.

Note that these safety devices must be fitted to the robot system by the system house, etc.

3.5.1 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.

- EN294 (ISO 13852)
- EN811 (ISO 13853)
- EN349 (ISO 13854)
- EN547 (ISO 15534)

3.5.2 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 EN1088 (ISO 14119) and related standards for detail of interlocking system.

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).

3.5.3 Other Protection Devices

Protection devices must be designed and incorporated into the control system 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,
- 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.

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 or 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.
- Resumption of robot motion must require the removal of the sensing field interruption. This must not be the control to restart automatic operation.

3.6 OPERATION INSIDE OF THE SAFETY FENCE

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

- Make sure that the robot system has been completely stopped before entering into the safety fence.
- Never enter into 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 into the safety fence. 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 into the safety fence from the safety gate.
- Set "Safe speed" signal enabled.
- When more than one worker collaborates for their operation, a person in charge should be equipped with teach pendant, and other workers have to follow his order.
  Any operations from the external interface and robot controller operation panel without his order have to be prohibited.
- All workers 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 operator who is readily accessible to the E-stop SW keeps watch from the outside of the safety fence.
- Make sure that deadman SWs 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 motion range of robot or peripheral devices, when operation inside of the safety fence has been finished.

3.7 THE SAFETY SEQUENCE FOR FENCE ENTRY

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

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

Entering into the SAFETY FENCE

 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.
4. Remove the plug2 from socket2.
   Open the gate of the safety fence, and put the plug2 to socket4.

5. Remove the plug1 from socket1

6. Enter inside of the safety fence, and put the plug1 to socket3.

Please refer to Fig.3.5 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.

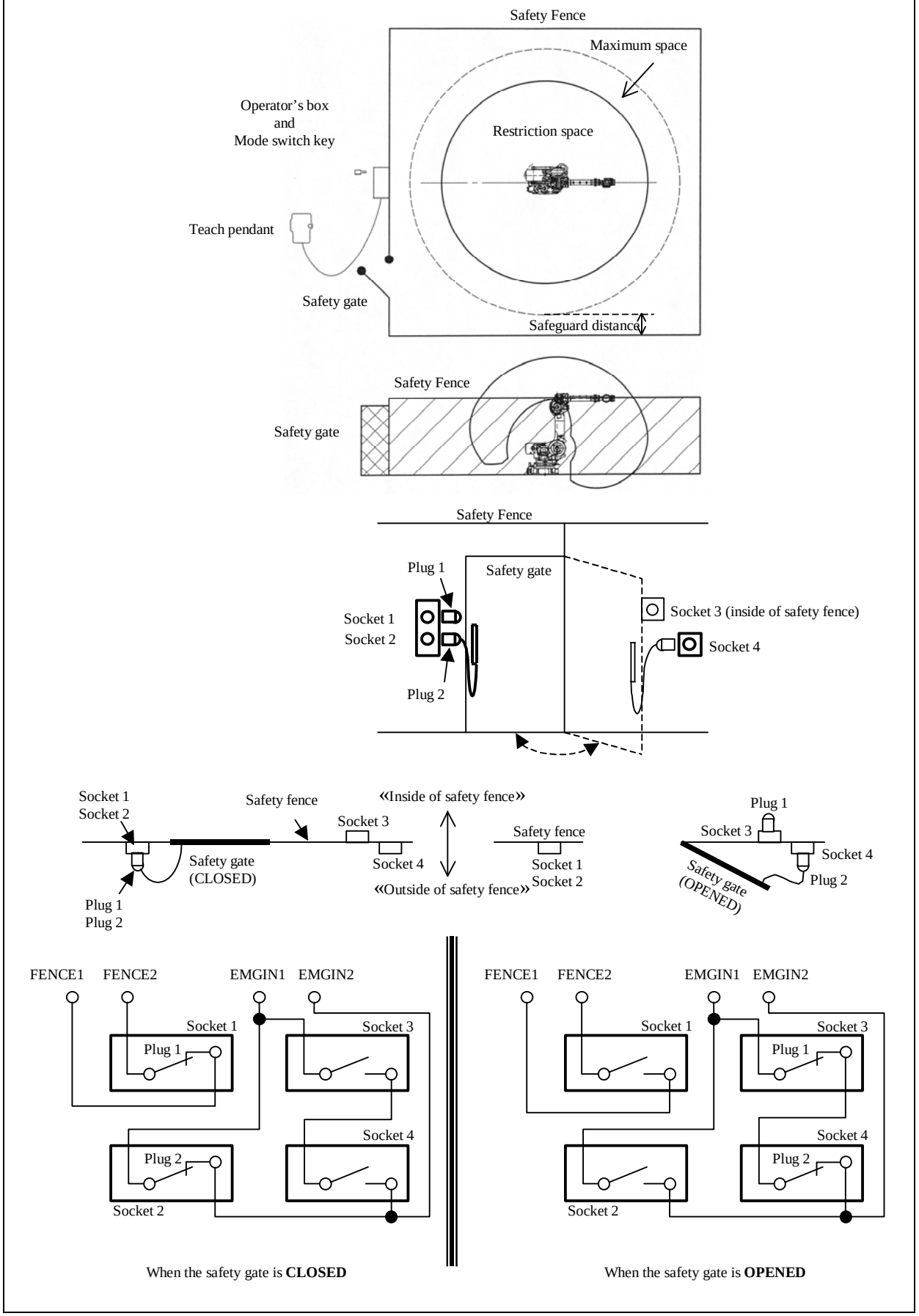


Fig.3.7 SAFETY FENCE and SAFETY GATE example

4 GENERAL CAUTIONS

In this chapter, the requirements for safety during the following situations are described:

- Installation (4.1)
- Commissioning and functional testing (4.2)
- Programming (4.3)
- Program verification (4.4)
- Trouble shooting (4.5)
- Saving programmed data (4.6)
- Automatic operation (4.7)
- Maintenance (4.8)
- Dismantling / scrapping (4.9)
- Other cautions (4.10)

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.

4.1 INSTALLATION

The robot system must be installed 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.

4.2 COMMISSIONING AND FUNCTIONAL TESTING

During the testing of robots or robot systems after installation or relocation, the following procedures must be followed. 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.

4.2.1 Designation of the Restricted Space

When the safeguarding methods are not in place prior to commissioning and functional testing, interim means of designating the restricted space must be in place before proceeding.

4.2.2 Restriction of Personnel

During the commissioning and functional testing, personnel must not be allowed in the safeguarded space until the safeguards are functional.

4.2.3 Safety and Operational Verification

At the initial start-up, the following procedure must be included (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,
- it is possible to disconnect and isolate the external power sources,
- the teach and playback facilities function correctly,
- the safeguards and interlocks function as intended,
- 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.

4.2.4 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.

4.3 PROGRAMMING

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

4.3.1 Prior to Programming

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.
- Where required for programming, the teach pendant must be tested to ensure proper operation.
- Any faults or failures must be corrected prior to entering the safeguarded space.

Before entering the safeguarded space, the programmer must ensure that all necessary safeguards are in place and functioning.

The programmer must set the operating mode T1 (or T2) from AUTO prior to entering the safeguarded space.

4.3.2 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. (When T1 or T2 mode is selected, the robot can be moved only by the teach pendant.)
- 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.
- Movement of other equipment in the safeguarded space which can present a hazard must either be prevented or under the sole control of the programmer. When under control of the programmer, it must require deliberate action on the part of the programmer separate from the action to initiate robot motion.
- All robot system emergency stop devices must remain functional.

4.3.3 Returning to Automatic Operation

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

4.4 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. When it is necessary to perform program verification with personnel inside the safeguarded space, the following must apply.

- Program verification must initially be performed at reduced speed.
- When it is necessary to examine the movement of the robot at full (operational) speed, the following requirements must apply:
  - suspension of the reduced speed by the operation mode switch (T2 mode) must be done by the programmer only;
  - an enabling device or a device with an equivalent safety level must be used by personnel within the safeguarded space;
  - safe working procedures are established to minimize the exposure of personnel to hazards within the safeguarded space.

4.5 TROUBLE SHOOTING

Trouble shooting must be performed from outside the safeguarded space. When this is not practicable, and the design of the robot system has taken into account the necessity of performing trouble shooting from within the safeguarded space, the following requirements must apply:

- personnel responsible for trouble shooting are specifically authorized and trained for these activities;
- personnel entering the safeguarded space must use the teach pendant (deadman switch) to allow motion of the robot;
- safe working procedures are established to minimize the exposure of personnel to hazards within the safeguarded space.

4.6 SAVING PROGRAMMED DATA

Whenever possible, a record of the task programs together with any modifications should be maintained.

Programmed data can be stored on file I/O devices (e.g. memory card, floppy disk, etc.) The media to which programmed data are saved must be stored in a suitably protected environment when not in use.

Please refer to robot controller "Operator's Manual" for detail.

4.7 AUTOMATIC OPERATION

Automatic operation must only be permissible when
- the intended safeguards are in place and functioning,
- no personnel are present within the safeguarded space, and
- proper safe working procedures are followed.

4.8 MAINTENANCE

The 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 by placing the robot arm in a predetermined position.

The following is the safety procedure of entering into safeguarded space for maintenance when it is necessary to perform maintenance within the safeguarded space.

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 3.7 "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.

⚠WARNING
Note that the motors of the robot may have heated just after its movement. Please be careful not to touch them, if possible. If it is needed to touch the motors for maintenance, etc., care should be taken in touching them. Otherwise, you could injure yourself.

4.9 Dismantling / scrapping

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

4.10 OTHER CAUTIONS

Some robot models have axes without brakes which prevent moving during their power being cut off. So their axes without brakes may be moved by the force of gravity when the servo power is cut off.
Please be careful of their movement, especially for their wrist joints, in the above operations.

5 DAILY MAINTENANCE

5.1 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
- Emergency stop functions
- Effectiveness of deadman switch on teach pendant
- Safety gate interlocks
- Vibration, noise by the robot movement
- Functions of peripheral devices
- Fixtures of robot and peripheral devices

5.2 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.

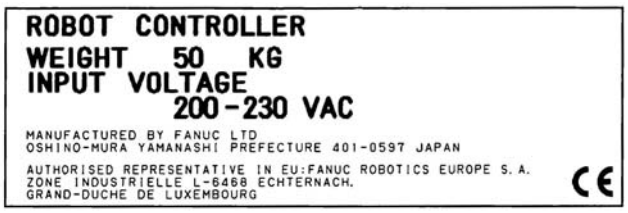
(b) After service operation
At the end of service operation, return the robot to the proper position, then turned off the controller. Clean each part, and check for any damage or cracks.
If the ventilation port and the fan motor of the controller are dusty, wipe off the dust.

6 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 LTD.
Address of the manufacturer	3580 Komanba, Shibokusa Oshino-mura, Minamitsuru-gun Yamanashi Prefecture, 401-0597 Japan
Model Designation	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."
Applied standards	EN ISO 10218-1 EN 60204-1
Importer/Distributor in EU	FANUC Robotics Europe S.A. Zone Industrielle L-6468 Echternach, Grand-Duche de Luxembourg
Date	Date of manufacture (to be written in EC declaration of conformity attached for each robot system)

7 CONTACTS

	ADDRESS	PHONE
FANUC LTD	Oshino-mura, Yamanashi Prefecture 401-0597, Japan	TEL:81-555-84-5555 FAX:81-555-84-5512
FANUC Robotics America, Inc. Headquarters	3900 W. Hamlin Road Rochester Hills, Michigan 48309-3253	TEL:01-248-377-7000 TOLLFREE:01-800-47-ROBOT (76268) FAX: 01-248-276-4133
FANUC Robotics America Southeast Office	13245 Reese Blvd.#140 Campbell Building Huntersville, NC 28078	TEL: 01-704-596-5121
FANUC Robotics America Midwest Office	1800 Lakewood Blvd. Hoffman Estates, IL 60192	TEL:01-847-898-6000 FAX: 01-847- 898-6010
FANUC Robotics America Central and Northeast Office	7700 Innovation Way Mason, OH 45040	TEL:01-513-754-2400 FAX:01-513-754-2440
FANUC Robotics America Toledo Office	1445 Timberwolf Drive Holland, OH 43528	TEL:01-419-866-0788
FANUC Robotics America West Office	25951 Commercentre Drive Lake Forest, CA 92630	TEL:01-949-59 5-2700 FAX:01-949-595-2750
FANUC Robotics do Brazil, LTDA	Rua Matteo Forte, 22- Áqua Branca São Paulo, SP Brasil CEP 05038-160	TEL: 55-11-3619-0599
FANUC Robotics Canada, Ltd.	6774 Financial Drive Mississauga, Ontario L5N 7J6	TEL: 01-905-812-2300 TOLLFREE:01-800-47-ROBOT
FANUC Robotique du Canada, Ltee.	Succursale du Quebec 1096 Rue Levis, Suite #6 Lachenaie, Quebec J6W 4L1	TEL: (450) 492-9001 TOLLFREE:01-800-47-ROBOT
FANUC Robotics Mexico, S.A. de C.V.	Circuito Aguascalientes Norte 136 Parque Industrial del Valle de Aguascalientes 20355 Aguascalientes, Ags. Mexico	TEL:52-449-922-8000 TOLLFREE: 01-800-47-ROBOT
FANUC Robotics Europe S.A.	Zone Industrielle L-6468 Echternach, Grand-Duche de Luxembourg	TEL:352-7277771 FAX:352-727777403
FANUC Robotics Deutschland GmbH	Bernhauser Strasse 22, D-73765 Neuhausen, Germany	TEL:49-7158-187-250 FAX:49-7158-187-253
FANUC Robotics France SARL	4, du Bois-Chaland C.E. 2904 Lisses F-91029 Evry Cedex, France	TEL:33-1-69897000 FAX:33-1-69897001
FANUC Robotics UK Ltd.	Seven Stars Industrial Estate Quinn Close Whitley, Coventry CV3 4LB Great Britain	TEL:+44 2476 63 96 69 FAX:+44 2476 30 43 33
FANUC Robotics Italia s.r.l.	Viale delle Industrie 1/A 20020 ARESE (MI), Italy	TEL:+39-02.93.45.60.1 FAX:+39-02.93.58.15.98
FANUC Robotics Iberica S.L.	Ronda Can Rabadá, n° 23 P. I. "El Camí Ral", Nave n° 12 08860 Castelldefels (Barcelona) Spain	TEL:+34 93 664 13 35 FAX:+34 93 665 76 41
FANUC Robotics Czech s.r.o.	V Parku 2308/8 CZ-148 00 Praha 4 – Chodov Czech	TEL:+420 234 072 900 FAX:+420 234 072 910
FANUC Robotics Switzerland	Grenchenstrasse 7 CH-2500 Biel/Bienne Switzerland	TEL: +41 32 344 46 46 FAX: +41 32 344 46 47
FANUC Robotics Benelux VBR	Generaal De Wittelaan 15 B-2800 Mechelen Belgium	TEL: +32 15 20 71 57 FAX: +32 15 20 71 92
FANUC Robotics Hungary	Cirn: 2040 Budaors, Szabadsag ut 117 Hungary	TEL: +36 23 507 400 FAX: +36 23 507 400
FANUC Robotics Polska	Strzegomska 2-4 53-611 Wroclaw Poland	TEL: +48 717766160 FAX: +48 71 7766169

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