

## Robot

### Safety Guide

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## Revision History

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Revision code	Date	Revised Content
01	April, 2016	Original release
02	February, 2018	Minor updates.
03	September, 2018	Updates and corrections.
04	August, 2020	Updates for NJ-series Robot Integrated CPU Unit.
05	October, 2020	Updates for i4L robot and controller.





# Chapter 1: Alerts and Special Information

## Alert Levels

There are three levels of alert notation used in our manuals. In descending order of importance, they are:



**DANGER:** Identifies an imminently hazardous situation which, if not avoided, is likely to result in serious injury, and might result in death or severe property damage.



**WARNING:** Identifies a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, and might result in serious injury, death, or significant property damage.



**CAUTION:** Identifies a potentially hazardous situation which, if not avoided, might result in minor injury, moderate injury, or property damage.

## Alert Icons

The icon that starts each alert can be used to indicate the type of hazard. These will be used with the appropriate signal word - Danger, Warning, or Caution - to indicate the severity of the hazard. The text following the signal word will specify what the risk is, and how to avoid it.

Icon	Meaning	Icon	Meaning
	This is a generic alert icon. Any specifics on the risk will be in the text following the signal word.		This identifies a hazardous entanglement situation.
	This identifies a hazardous electrical situation.		This identifies an explosion risk.
	This identifies a hazardous burn-related situation.		

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## Special Information

There are several types of notation used to call out special information.

**IMPORTANT:** Information to ensure safe use of the product.

**NOTE:** Information for more effective use of the product.

**Additional Information:** Offers helpful tips, recommendations, and best practices.

**Version Information:** Information on differences in specifications for different versions of hardware or software.

# Chapter 2: Operational Safety

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## 2.1 What to Do in an Emergency or Abnormal Situation

Press any E-Stop button (a red push-button on a yellow background) and then follow the internal procedures of your company or organization for an emergency or abnormal situation. If a fire occurs, use CO<sub>2</sub> to extinguish the fire.

### Releasing the Brakes

In case of an emergency or abnormal situation, the robot joints can be manually moved. However, only qualified personnel who have read and understood this manual and the robot user's guide should manually move the robot joints. The brakes on joints that have brakes can be released with a brake release button. This requires 24 VDC power, and an E-Stop must be pressed on the robot.

### Releasing an E-Stop



**CAUTION: INJURY OR PROPERTY DAMAGE RISK.**

If the robot's E-Stop is triggered, ensure that the cause of the E-Stop is resolved, and all surrounding areas are clear before releasing the E-Stop.

After the E-Stop button has been manually released, the robot controller will wait until the motors are manually enabled.

## 2.2 Definitions

### Industrial Robot

An industrial robot is an automatically controlled, programmable, multi-purpose, manipulative machine with several degrees of freedom, for use in industrial automation applications. It may be either fixed in place or mobile.

### Controller

The control system provides the commands for robot movement and the actual power to drive the robot's motors. A controller can be an NJ-series Robot Integrated CPU Unit, SmartController EX, or PLC for control, and an iCS-ECAT, iCS-ENET, eCS-ECAT, eAIB or an eMB-40 or eMB60 amplifier for motor control. A controller can also be a standalone eAIB, eMB-40, or eMB-60. For these three devices, no separate amplifier is needed.

## 2.3 Compliance and Intended Use

### Compliance

The installation and use of OMRON products must comply with all safety instructions and warnings in this guide and any user or reference guides for the equipment. Installation and

use must also comply with all applicable local and national requirements and safety standards.

### Intended Use

OMRON robots are not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- In the presence of ionizing or non-ionizing radiation
- In life-support systems
- In residential installations
- Where the robot will be subject to extremes of heat or humidity
- Without appropriate guarding, to prevent people from coming into contact with it



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**  
The instructions for operation, installation, and maintenance given in this guide and the robot user's guide must be strictly observed.

Non-intended use of OMRON robots can:

- Cause injury to personnel
- Damage the robot or other equipment
- Reduce system reliability and performance

If there is any doubt concerning the application, ask your local OMRON support to determine if it is an intended use or not.



**DANGER: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**  
An industrial robot can cause serious injury or death, or damage to itself and other equipment, if the following safety precautions are not observed.

- All personnel who install, operate, teach, program, or maintain the system must read all applicable and associated documentation and complete a training course for their responsibilities in regard to the robot.
- All personnel who design the robot system must read all applicable and associated documentation and must comply with all local and national safety regulations for the location in which the robot is installed.
- The robot system must not be used for purposes other than described in Intended Use. Contact your local OMRON support if you are not sure of the suitability for your application.
- The user is responsible for providing safety barriers around the robot to prevent anyone from accidentally coming into contact with the robot when it is in motion.

- Power to the robot and its power supply must be locked out and tagged out before any maintenance is performed.

## 2.4 Risk Assessment

Safety standards in many countries require appropriate safety equipment to be installed as part of the system. Safeguards must comply with *all* applicable local and national standards for the location where the robot is installed.

We have performed Risk Assessments for OMRON robots, based on the intended applications of the robot. The conclusions are summarized in this section.

The performance level (PL) calculation for safety functions of the OMRON robot mechanisms are based on the ISO 13849-1 evaluation for the following products:

- eAIB controller
- eMB-40 controller
- eMB-60 controller
- iCS-ECAT controller
- iCS-ENET controller
- eCS-ECAT controller
- SmartControllerEX controller
- Cobra robots
- eCobra robots
- Quattro robots
- Hornet robots
- Viper robots
- i4L robots
- T20 pendant

The contained safety functions are provided in the table below.

No.	Safety Function Name	PL Achieved	PFH [1/h]
1	Emergency Stop	e	3.03E-8
2	Teach Mode Velocity Monitor	d	1.90E-7
3	E-Stop Output Indicator	e	2.91E-8
4	Emergency Stop for Use with Customer-Provided Switch	e	3.39E-8
5	E-Stop Output Indicator for Use with Customer-Provided Switch	e	3.10E-8

Safety functions 4 and 5 are provided for use with an end-user supplied external E-Stop, door guard switch, or device tied to the E-Stop output indicator connection. The end user is responsible for calculating the overall PL, inclusive of user-supplied components, and performing a final risk assessment.

## Exposure

When High Power is on, all personnel must be kept out of the robot workcell by interlocked perimeter barriers. It is up to the customer to determine if teaching the robot in Manual Mode, by a skilled programmer (see Qualification of Personnel on page 21), wearing safety equipment and carrying a pendant, is allowable under local regulations.

## Severity of Injury

Provided that skilled personnel who enter the robot workcell are wearing protective headgear, eyeglasses, and safety shoes, it is likely that injuries caused by the robot would be slight (normally reversible). The risk of severe injury increases as the size of the robot and payload increase.

## Avoidance

If the customer determines that teaching the robot in Manual Mode is allowable, the programmer must always carry the pendant when inside the workcell, as the pendant provides both E-Stop and Enabling switch functions.

For *normal* operation (AUTO mode), user-supplied interlocked guarding must be installed to prevent any person entering the workcell while High Power is on.



### **DANGER: PERSONAL INJURY RISK.**

The robot system must be installed with user-supplied interlock barriers. The interlocked barriers must open the E-Stop circuit in the event of personnel attempting to enter the workcell when High Power is enabled. Failure to install suitable guarding or interlocks could result in injury or death.

The following circuits are all dual channel, and classified as category 3, PL-d:

- Front panel
- T20 Pendant
- Safety door (mute gate)
- External (user or line) E-Stop

The Risk Assessment for *teaching* an OMRON robot depends on the application. If the customer determines that teaching the robot in Manual Mode is allowable, the programmer may need to enter the robot workcell while High Power is enabled. Other programming methods can be used so that the programmer does not have to enter the workcell while High Power is on.

Examples of alternative methods of programming include:

- Programming from outside the safety barrier
- Programming with High Power off
- Copying a program from another (master) robot
- Off-line or CAD programming

## Safety System Behavior

The standard control system is fully-hardened to all EMI influences. In addition, a hardware-based reduced-speed mode has been incorporated to limit speed and impact forces on an Operator and production tooling when the robot is operated in Manual Mode.

## 2.5 Transportation

Always use adequate equipment to transport and lift robots. See the Installation chapter of the robot user's guide for more information on transporting, lifting, and installing.

## 2.6 Environment

**IMPORTANT:** The equipment must be stored in a temperature-controlled environment. See the Installation chapter of the robot user's guide for more information.

### Safety Barriers



**DANGER: PERSONAL INJURY RISK.**

We strictly prohibit installation, commissioning, or operation of any robot without adequate safeguards. These must be compliant with applicable local and national standards.

Safety barriers must be provided that prevent personnel from entering the workcell whenever power is applied to the equipment. OMRON robot systems are computer-controlled and may activate remote devices under program control at times or along paths not anticipated by personnel. It is critical that safeguards be in place to prevent personnel from entering the workcell whenever high power to the equipment is present.

The user must ensure that adequate safeguards, safety barriers, light curtains, safety gates, safety floor mats, etc., are installed. The robot workcell must comply with applicable local and national standards.

The height and the distance of the safety barrier from the robot must ensure that personnel cannot reach the work envelope of the robot.



**DANGER: PERSONAL INJURY RISK.**

Never remove any safeguarding and never make changes in the system that will decommission a physical safeguard.

The OMRON control system has features that aid the user in constructing system safeguards, including customer emergency-stop circuitry and digital input and output lines. The emergency power-off circuitry is capable of switching external power systems and can be interfaced to the appropriate user-supplied safeguards. Refer to the robot manual(s) and the controller manual(s) for additional information.

## Impact and Trapping Points

OMRON robots are capable of moving at high speeds. If a person is struck by a robot (impacted) or trapped (pinched) serious injury could occur. Robot configuration, joint speed, joint orientation, and attached payload all contribute to the total amount of energy available to cause injury.

## Hazards from Expelling a Part or Attached Tooling

Any tooling, fixtures, end-effectors, etc., mounted to the tool flange, or one of the other axes of the robot, must be attached by sufficient means to resist being expelled from the robot. Additionally, any payload must be held by the end-effector in a manner that prevents the payload from being expelled accidentally.

The safety barrier constructed around the robot must be designed to withstand the impact of any item expelled accidentally from the robot. Projectile energy can be calculated using the formula  $E = \frac{1}{2}mv^2$ .

**Additional Information:** In the Projectile energy formula above:

E = Energy

m = Mass

v = Velocity

## 2.7 Installation

### General Precautions

Take precautions to ensure that the following situations do not occur:

- Improper installation or programming of the robot system
- Use of non-original cables or modified components in the system



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Do not attempt to lift the robot at any points other than the eyebolt(s) or slots, if provided. Do not attempt to extend the inner or outer joints of a SCARA, or articulated robot until the robot has been secured in position. Failure to comply could result in the robot falling and causing either personal injury or equipment damage.

**NOTE:** For the two following WARNINGS, UL 1740 2.45 defines: **SINGLE POINT OF CONTROL** - The ability to operate the robot such that initiation of robot motion from one source of control is only possible from that source and cannot be overridden from another source.



**WARNING: PERSONAL INJURY RISK.**

Do not wire user-supplied Manual/Automatic contacts in parallel with the Front Panel switch contact. This would violate the “Single Point of Control” principle and might allow Automatic (high speed) mode to be selected while an operator is in the cell.

**WARNING: PERSONAL INJURY RISK.**

To fulfill the “Single Point of Control” requirement, do not place the Manual/Automatic and High Power On controls in multiple locations. After putting the robot into Manual mode, the operator should remove and keep the key until the cell is ready to be put back into automatic mode. The system should not be wired so that a PLC or another operator can put the system back into Automatic mode.

**WARNING: PERSONAL INJURY RISK.**

Disconnect robot air lines before running the Commissioning wizard until the procedure is complete to prevent unsecured pneumatic lines from accidentally injuring personnel.

**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Not only the robot, but all equipment that operates in conjunction with the robot must be stopped by the same emergency stop switch.

**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

The enable switch of the robot and the equipment must be located outside of the safety barrier. The operator must carefully check the entire work cell when operating the enable switch.

**WARNING: PERSONAL INJURY RISK.**

Before starting work in the safety barrier when the robot is activated, create a procedure to secure safety and operation under abnormal conditions. Educate all the operators to understand the procedure before they enter the workspace. When more than one robot is installed in the safety barrier, the power to the other robots should be locked out to prevent any except the active robot from being turned on.



**WARNING:** The mounting structure for the robot must be rigid enough to prevent vibration and flexing during robot operation.

**IMPORTANT:** Avoid applying excessive power, pressure, or strain to the wiring, pneumatic tubing, and connections to prevent damaging them.

**IMPORTANT:** Do not remove the encoder cable connectors from their sockets. If they are removed, the calibration data will be lost, requiring factory recalibration of the robot.

**IMPORTANT:** The base casting of the robot is aluminum and can easily be dented if bumped against a harder surface.

### Electrical Precautions



**DANGER: ELECTROCUTION RISK.**

AC power installation must be performed by a skilled and instructed person, as defined in this Guide. During installation, unauthorized third parties must be prevented from turning on power through the use of fail-safe lockout measures.



**DANGER: ELECTROCUTION RISK.**

Failing to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or death of a person touching the end-effector when an electrical fault condition exists.



**WARNING: ELECTROCUTION RISK.**

Appropriately sized Branch Circuit Protection and Lockout/Tagout Capability must be provided in accordance with the National Electrical Code and any local codes. Ensure compliance with all local and national safety and electrical codes for the installation and operation of the robot system.



**WARNING: UNEXPECTED ROBOT MOVEMENT.**

Make sure you select a 24 VDC power supply that meets the specifications given. Using an underrated supply can cause system problems and prevent your equipment from operating correctly.

### Safety Requirements for Additional Equipment

- Additional equipment used with the OMRON robots (end-effectors, conveyor belts, etc.) must not reduce the workcell safeguards
- Emergency stop switches must be accessible at all times.
- All components in the robot workcell must comply with all local and national safety requirements

## 2.8 Robot Modifications

It is sometimes necessary to modify the robot in order to successfully integrate it into a workcell. Unfortunately, many simple modifications can either cause a robot failure, or reduce the robot's performance, reliability, or lifetime. The following information is provided as a guideline to modifications.

## Acceptable Modifications

In general, the following modifications do not cause problems, but may affect performance:

- Attaching tooling, utility boxes, solenoid packs, vacuum pumps, cameras, lighting, etc., to the robot tool flange
- Attaching hoses, pneumatic lines, or cables to the robot

These should be designed so they do not restrict joint motion or cause robot motion errors.

## Unacceptable Modifications



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**  
For safety reasons, it is prohibited to make certain modifications to OMRON robots.

**IMPORTANT:** The modifications listed below may damage the robot, reduce system safety and reliability, or shorten the life of the robot. The warranty of the entire robot, or certain parts, may be voided.

**NOTE:** Contact your local OMRON support if you are considering any of the following modifications:

- Modifying any of the robot harnesses or robot-to-controller cables
- Modifying any robot access covers or drive system components
- Modifying, including drilling or cutting, any robot surface
- Modifying any robot electrical component or printed-circuit board
- Routing additional hoses, air lines, or wires through the inside of the robot
- Modifications that compromise EMC performance, including shielding

## 2.9 Operation

This guide and the robot user's guide must be read by all personnel who install, operate, or maintain the system, or who work within or near the workcell.

A moving robot can cause serious injury.

- Do not enter the workcell during automatic operation
- Push the emergency stop button before entering the workcell
- Do not defeat any aspect of the safety E-Stop system
- Do not defeat an interlock so that an operator can enter a workcell with High Power ON
- Take precautions to prevent ejection of a work piece (Hazards from Expelling a Part or Attached Tooling on page 16)

OMRON robots have a Manual and an Automatic (AUTO) operating mode. While in Automatic Mode, personnel are not allowed in the workcell.

If the customer determines that teaching the robot in Manual Mode is allowable under local regulations, operators with additional safety equipment may work in the robot workcell. For safety reasons the operator should, whenever possible, stay outside of the robot workcell to prevent injury. The maximum speed and power of the robot is reduced, but it could still cause injury to the operator.

The type of safety equipment required for operators working within a workcell must be determined by the user, based on industry standards and their installation. Safety glasses, protective headgear (hard hat), and safety shoes are examples to be considered.

Warning signs must be posted around the workcell to ensure that anyone working around the robot system knows they must wear safety equipment.



**WARNING: PERSONAL INJURY RISK.**

During the Commissioning wizard, the robot will move. Ensure that personnel stay clear of the robot work area during commissioning.



**DANGER: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Do not operate a robot system when the physical safeguard is decommissioned. Failure to do this could cause death, or serious injury or equipment damage.



**DANGER: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

After installing the robot, you must test it before you use it for the first time. Failure to do this could cause death, serious injury, or equipment damage.



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Before starting the operation of equipment, always confirm that the safety equipment of the robot works properly. If a malfunction of the safety equipment is detected, follow the procedure for abnormal conditions.



**CAUTION: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Any moving robot requires some distance to stop. When stopping a robot, make sure that there is no interference with other equipment. This requires more distance at high operating speeds or heavier payloads.



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Use the total weight of the end-effector and the payload to stay within the payload rating of the robot. Ensure that the system never exceeds that maximum payload.

## Qualification of Personnel

This guide assumes that all personnel have attended an OMRON training course and have a working knowledge of the system. The user must provide the necessary additional training for all personnel who will be working with the system.

As noted in this guide, certain procedures should be performed only by skilled or instructed persons. For a description of the levels of qualification, we use the standard terms:

- **Skilled persons** have technical knowledge or sufficient experience to enable them to avoid the dangers, electrical and/or mechanical
- **Instructed persons** are adequately advised or supervised by skilled persons to enable them to avoid the dangers, electrical and/or mechanical

All personnel must observe industry-prescribed safety practices during the installation, operation, and testing of all electrically-powered equipment. To avoid injury or damage to equipment, always remove power by disconnecting the AC power from the source before attempting any repair or upgrade activity. Use appropriate lockout procedures to reduce the risk of power being restored by another person while you are working on the system.



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**  
Before working with the robot, every entrusted person must confirm that they:

- Have received the guides (both this guide, and the robot user's guide)
- Have read the guides
- Understand the guides
- Will work in the manner specified by the guides

## Protection Against Unauthorized Operation

The system must be protected against unauthorized use. The user or operator must restrict access to the keyboard and the pendant by locking them in a cabinet or using another adequate method.

### 2.10 Sound Emissions

The sound emission level of the OMRON robots depends on the speed and payload. The maximum value is 90 dB. (This is at maximum AUTO-mode speed.)



**WARNING: HEARING DAMAGE RISK.**  
Acoustic emission from these robots may be up to 90 dB (A) under worst-case conditions. Typical values will be lower, depending on payload, speed, acceleration, and mounting. Appropriate safety measures should be taken, such as ear protection and display of a warning sign.

### 2.11 Thermal Hazard

The following warning applies to both the base and joints for SCARA robots. It applies to the base for parallel robots, and all joints for articulated robots.



**WARNING: BURN RISK.**

You can burn yourself. Do not touch the robot after it has been running at high ambient temperatures (40 to 50° C, 104 to 122° F) or at fast cycle times (over 60 cycles per minute). The robot surface temperature can exceed 85° C (185° F).

## 2.12 Maintenance

Before performing maintenance in the workcell of the robot, High Power must be switched off and the power supply of the robot must be switched off and locked and tagged out. After these precautions, a skilled person is allowed to perform maintenance on the robot.

Only skilled persons with the necessary knowledge about safety and operating the equipment are allowed to maintain the robot system.



**WARNING: ELECTROCUTION RISK.**

During maintenance and repair, the power of the equipment must be turned off. User-supplied lockout/tagout measures must be used to prevent unauthorized personnel from turning on power.



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Before starting the operation of equipment, always confirm that the safety equipment of the robot works properly. If a malfunction of the safety equipment is detected, follow the procedure for abnormal conditions.



**WARNING: PERSONAL INJURY RISK.**

After removing all power and before starting maintenance or inspections of any robot equipment, ensure that all parts have stopped moving, and allow enough time for residual air pressure and electrical charge to dissipate.



**WARNING: PERSONAL INJURY OR PROPERTY DAMAGE RISK.**

Releasing a brake may cause the joint, tool flange, end-effector, and payload to drop. To prevent possible injury to personnel or damage to the equipment, make sure that the joints being released are supported when releasing the brake and verify that the end-effector and payload are clear of all obstructions.



**CAUTION: PROPERTY DAMAGE RISK.**

Using improper lubrication products on the robot may cause damage to the robot.

**IMPORTANT:** Follow appropriate ESD procedures during the removal and installation procedures.

## 2.13 Risks That Cannot Be Avoided

The control system includes devices that disable High Power if a system failure occurs. However, certain residual risks or improper situations could cause hazards. The following situations may result in risks that cannot be avoided:

- Failure of software or electronics that may cause high-speed robot motion in Manual Mode
- Failure of hardware associated with an enabling device or E-Stop system

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- Programmable Logic Controllers (PLC) • Temperature Controllers • Remote I/O

**Robotics**

- Industrial Robots • Mobile Robots

**Operator Interfaces**

- Human Machine Interface (HMI)

**Motion & Drives**

- Machine Automation Controllers (MAC) • Motion Controllers • Servo Systems
- Frequency Inverters

**Vision, Measurement & Identification**

- Vision Sensors & Systems • Measurement Sensors • Auto Identification Systems

**Sensing**

- Photoelectric Sensors • Fiber-Optic Sensors • Proximity Sensors
- Rotary Encoders • Ultrasonic Sensors

**Safety**

- Safety Light Curtains • Safety Laser Scanners • Programmable Safety Systems
- Safety Mats and Edges • Safety Door Switches • Emergency Stop Devices
- Safety Switches & Operator Controls • Safety Monitoring/Force-guided Relays

**Control Components**

- Power Supplies • Timers • Counters • Programmable Relays
- Digital Panel Meters • Monitoring Products

**Switches & Relays**

- Limit Switches • Pushbutton Switches • Electromechanical Relays
- Solid State Relays

**Software**

- Programming & Configuration • Runtime