

Robot

Safety Guide



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Even if it conforms to all instructions in this safety guide, it isn't possible to guarantee that a robot system will be free from an accident resulting in injury or death or considerable damage to property caused by the industrial robot. It is the customer's responsibility to implement appropriate security measures based on their own risk assessment.

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Chapter 1: Alert Notation

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



DANGER: This indicates an imminently hazardous electrical situation which, if not avoided, will result in death or serious injury.



DANGER: This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.



WARNING: This indicates a potentially hazardous electrical situation which, if not avoided, could result in serious injury or major damage to the equipment.



WARNING: This indicates a potentially hazardous situation which, if not avoided, could result in serious injury or major damage to the equipment.



CAUTION: This indicates a situation which, if not avoided, could result in minor injury or damage to the equipment.



Precautions for Safe Use: This indicates precautions on what to do and what not to do to ensure safe product use.

Chapter 2: Fixed Robots

2.1 Definition

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.

2.2 Compliance and Intended Use

Compliance

The installation and use of Omron Adept Technologies, Inc. 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 Adept Technologies, Inc. robots are not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- In life-support systems
- In residential installations
- Where the robot will be subject to extremes of heat or humidity.



WARNING: 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 Adept Technologies, Inc. robots can:

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

All persons that install, commission, operate, or maintain the robot must:

- Have the necessary qualifications
- Read and precisely follow the instructions in this safety guide
- Read and precisely follow the instructions in the robot user's guide

If there is any doubt concerning the application, ask Omron Adept Technologies, Inc. to determine if it is an intended use or not.



DANGER: 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 the Robot Safety Guide, User's Guide, Quick Setup Guide and complete a training course for their responsibilities in regard to the robot.
- All personnel who design the robot system must read the Robot Safety Guide, User's Guide, Quick Setup Guide 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 us 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.

2.3 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 Adept Technologies, Inc. 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 Adept Technologies, Inc. robot mechanisms are based on the ISO 13849-1 evaluation for the eAIB or eMB electronics with optional SmartController EX and the optional T20 pendant.

The robots covered include:

- Cobra – All models
- Quattro – All models
- Hornet – All models
- Viper - 650 and 850

Contained Safety Functions:

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 Arm 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 19), 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 Arm Power is on.



DANGER: 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 Arm 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 Adept Technologies, Inc. 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 Arm Power is enabled. Other programming methods can be used so that the programmer does not have to enter the workcell while Arm Power is on.

Examples of alternative methods of programming include:

- Programming from outside the safety barrier
- Programming with Arm 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 software-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.

2.4 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.

2.5 Safety Barriers



CAUTION: 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 Adept Technologies, Inc. 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 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.



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

The Omron Adept Technologies, Inc. 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 user's guide and the SmartController User's Guide for additional information.

Impact and Trapping Points

Omron Adept Technologies, Inc. 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 $E = \frac{1}{2}mv^2$.

NOTE: In the Projectile energy formula above:

E = Energy

M = Mass

V = Velocity

2.6 Robot Modifications

It is sometimes necessary to modify the robot in order to successfully integrate it into a work-cell. 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 robot modifications do not cause problems, but may affect robot 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



CAUTION: For safety reasons, it is prohibited to make certain modifications to Omron Adept Technologies, Inc. robots.

NOTE: 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.

Contact Omron Adept Technologies, Inc. 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

2.7 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: 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: 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: Do not attempt to lift the robot at any points other than the eyebolt or slots, if provided. Do not attempt to extend the inner or outer links of a Cobra or Viper robot until the robot has been secured in position. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.



WARNING: 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: 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: To fulfill the “Single Point of Control” requirement, do not place the Manual/Automatic and High Power On controls in multiple locations. After put-

ting 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.



Precautions for safe use: Do not remove the encoder cable connectors from their sockets. If they are removed, the calibration data will be lost and the robot must be run through a factory recalibration process, which requires special software and tools.



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



Precautions for safe use: The base casting of the robot is aluminum and can easily be dented if bumped against a harder surface.



Precautions for safe use: 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.



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



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



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



WARNING: Not only the robot but equipment which operates in conjunction with the robot must be stopped by the same emergency stop switch.



DANGER: 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.

Safety Requirements for Additional Equipment

- Additional equipment used with the Omron Adept Technologies, Inc. robots (grippers, 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 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 arm can cause serious injury.

- Do not enter the safety fence 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 13)

Omron Adept Technologies, Inc. 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: During the Commissioning wizard, the robot will move. Ensure that personnel stay clear of the robot work area during Commissioning.



DANGER: 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: 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.



CAUTION: Use the total weight of the gripper and the payload to stay within the payload rating of the robot. Ensure that the system never exceeds that maximum payload.



CAUTION: 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.



WARNING: 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.

Qualification of Personnel

This guide assumes that all personnel have attended an Omron Adept Technologies, Inc. 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 level 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: 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.

2.9 Sound Emissions

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



WARNING: Acoustic emission from this robot 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.

2.10 Thermal Hazard

The following warning applies to both the base and links for eCobra robots. It applies to the base for the Quattro and Hornet robots, and all links for Viper robots.



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

2.11 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.



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



WARNING: 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: 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: Pressing the Brake Release button may cause the tool flange, gripper, and payload to drop. To prevent possible injury to personnel or damage to the equipment, make sure that the parts being released are supported when releasing the brake and verify that the end-effector and payload are clear of all obstructions.



Precautions for safe use: Using improper lubrication products on the robot may cause damage to the robot.



Precautions for safe use: Follow appropriate ESD procedures during the removal and replacement phases.



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

2.12 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

2.13 What to Do in an Emergency or Abnormal Situation

Press any E-Stop button (a red push-button on a yellow background/field) and then follow the internal procedures of your company or organization for an emergency or abnormal situation. If a fire occurs, use CO₂ to extinguish the fire.

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