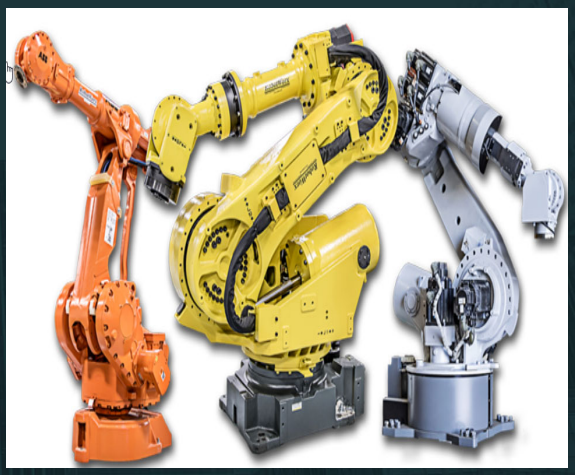
Industrial Robotic Safety

Student Materials
Level Two MTI Course
Consultation Education and Training (CET) Division
Michigan Occupational Safety and Health Administration
Michigan Department of Labor and Economic Opportunity
www.michigan.gov/miosha
517-284-7720

(Revised 02/24)

Industrial Robotic Safety



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MIOSHA
Michigan Occupational Safety and Health Administration

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Industrial Robotic Safety Objectives

- Review types of industrial robots and hazard sources.
- Review various robot installations and adjacent employee work areas.
- Discuss the employer responsibilities for employee training.
- Practice hazard recognition and risk assessment development to reduce worker exposure.
- Discuss protection means and/or methods for operator technicians and maintenance personnel.
- Explain protective devices safeguards, and hazardous energy control.
- Discuss international, national, and MIOSHA safety rules.

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Definition

Industrial robots are programmable multifunctional mechanical devices designed to move material, parts, tools, or specialized devices through variable programmed motions to perform a variety of tasks.

OSHA Tech Manual

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Definition

Automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications.

ANSI/RIA R15.06-2012

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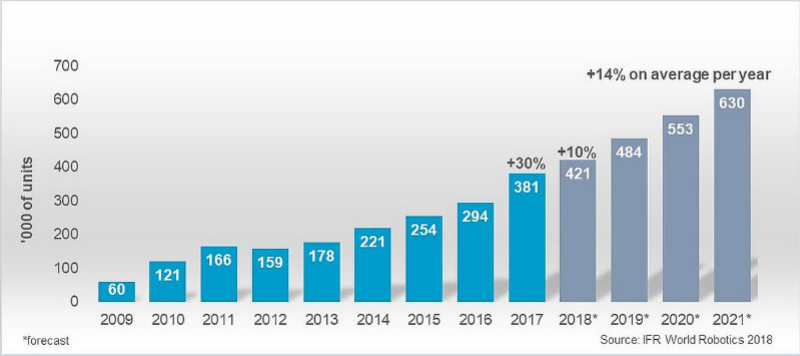
Robotic Growth Data

Estimated annual worldwide supply of industrial robots 2009-2017 and 2018*-2021*

IFR International Federation of Robotics



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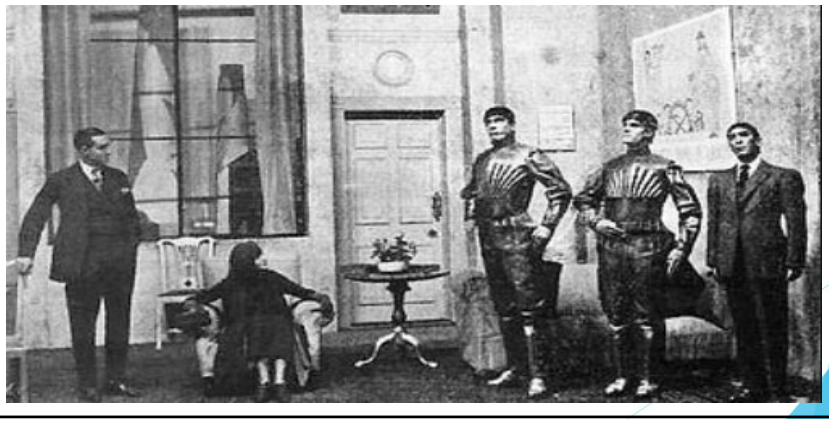
History of "Robot"

- In 1920 Karel Capek, Czech playwright wrote Rossumovi Universalni Roboti which when debuted in English translated for effect to Rossum's Universal Robots.
- In Czech robota is "forced labor"



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History of Industrial Robots

George Devol the inventor of the industrial robot is being served a drink by his creation, the "Unimate."

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History of Industrial Robots

In 1959, Physicist Joseph Engelberger and Inventor George Devol constructed the first prototype – the Unimate #001. GM installed the first one in 1961.

This picture shows a similar Unimate used at General Motors

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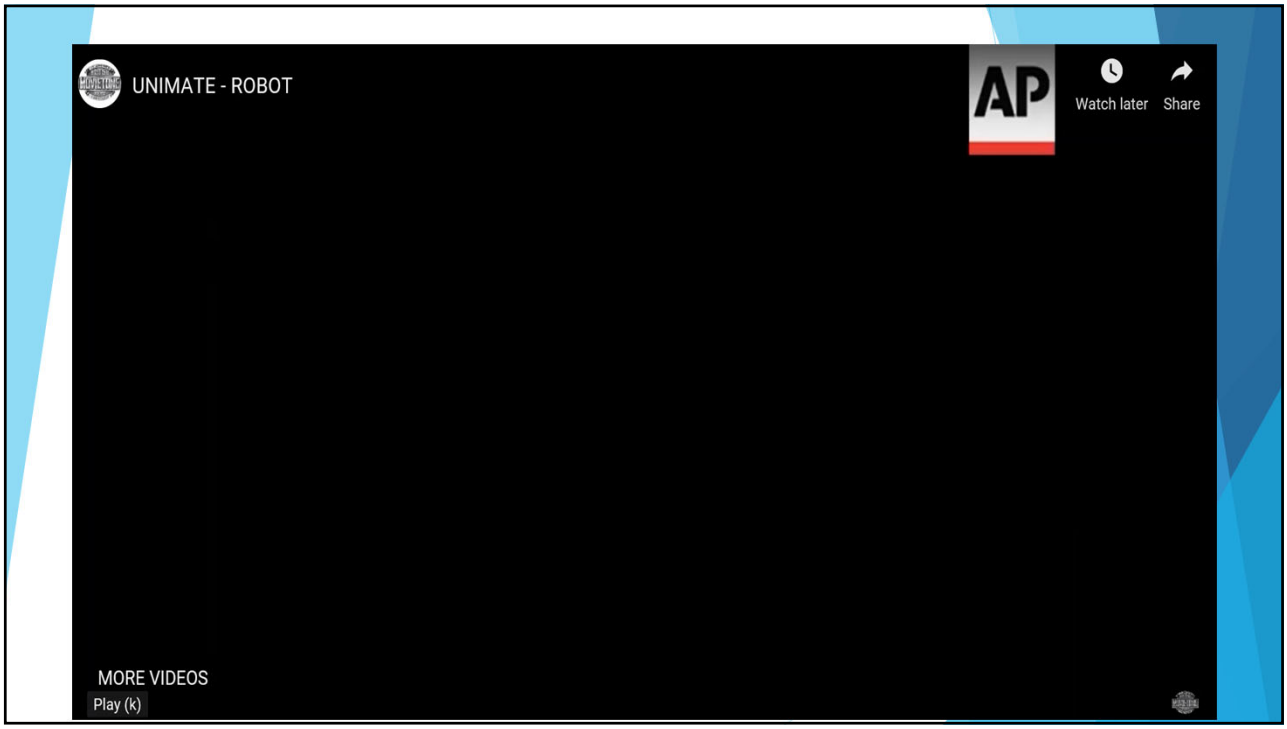

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History of Industrial Robots

1961 General Motors first robotic arm

1979 Michigan has world's first robot fatality

1981 Second fatality occurs in Japan

1984 Third fatality occurs again in Michigan

1992 ANSI R15.06-1992 Safety Standard for industrial robots and robot systems

1999 R15.06-1999 Industrial Robots and Robot Systems - Safety Requirements

2006 Employee dies in Pontiac, Michigan, crushed by a robot

2015 Journeyman Tech killed by robot in Ionia, Michigan

2012 ANSI R15.06-2012 updated safety requirements for robots.

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World's First Fatality from a Robot

On Jan. 25, 1979 a 25-year old employee at Ford Motor Company's Flat Rock, Michigan Casting Plant was crushed by a 5-story parts retrieval robot. The robot was giving false readings, and he was instructed to climb into the shelving units to determine how many parts were actually there. The robot cycled to the top and killed him instantly. His family was awarded a $10 million settlement against the manufacturer of the robot.

August 11, 1983 edition of the Ottawa Citizen

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History of Industrial Robots

Second fatality in Japan

"In 1981, Kenji Urada, a 37-year-old Japanese factory worker, climbed over a safety fence at a Kawasaki plant to carry out some maintenance work on a robot. In his haste, he failed to switch the robot off properly. Unable to sense him, the robot's powerful hydraulic arm kept on working and accidentally pushed the engineer into a grinding machine. His death made Urada the first recorded victim to die at the hands of a robot."

Technology Quarterly **Trust me, I'm a robot** June 8, 2006
From *The Economist* print edition

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History of Industrial Robots

World's third fatality in Jackson, Michigan

On July 21, 1984, a 34-year-old male worker was operating an automated die-casting system that included an industrial robot. At approximately 1:15 p.m., he was found pinned between the back end of the robot and a four-inch-diameter steel safety pole used to restrict undesired arm movement by the robot. The robot stalled, applying sustained pressure to the chest of the operator, who experienced cardiopulmonary arrest. After emergency rescue efforts by personnel from the company, the city fire department, and emergency medical service, the worker was admitted comatose to a local hospital, where he died five days later.

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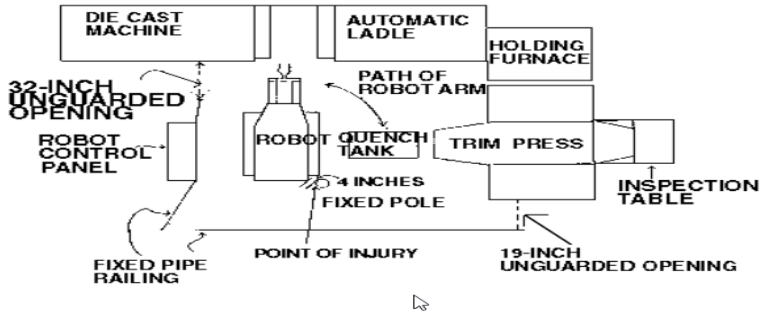

Figure 1. Diagram of Accident Site

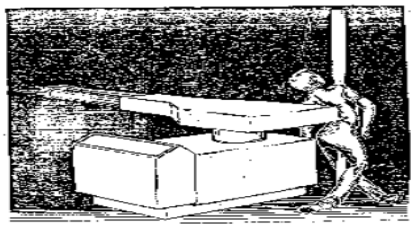

Figure 2. Artist's Rendition of Body Position While Pinned

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History of Industrial Robots

Fatality in Sterling Heights, Michigan

On December 15, 2012, Worker was crushed to death inside a robot work cell when he was struck from behind by a transfer robot.

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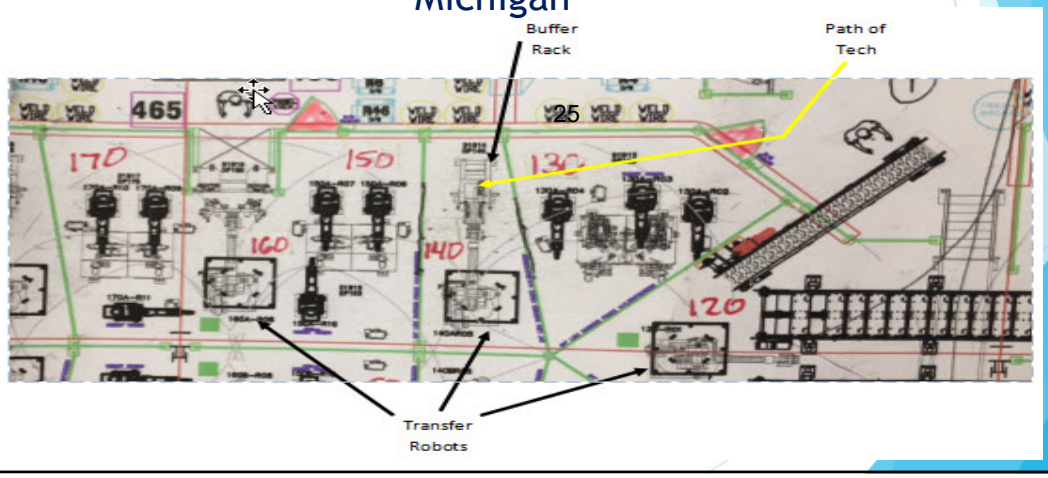
History of Industrial Robots

Fatality in Sterling Heights, Michigan



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History of Industrial Robots

Fatality in Ionia, Michigan

July 2015, a 57-year-old journeyman maintenance technician entered a robotic weld cell. The robot arm activated pinning/crushing the employee's head between a hitch plate and a metal fixture.

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Types of Industrial Robots

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Types of Industrial Robots

Defining parameters

Number of axes – two axes are required to reach any point in a plane; three axes are required to reach any point in space. To fully control the orientation of the end of the arm (i.e., the *wrist*) three more axes (roll, pitch and yaw) are required.

Kinematics – the actual arrangement of rigid members and joints in the robot, which determines the robot's possible motions.

Source: World Robotics 2004, IPA Stuttgart, ISO 8373

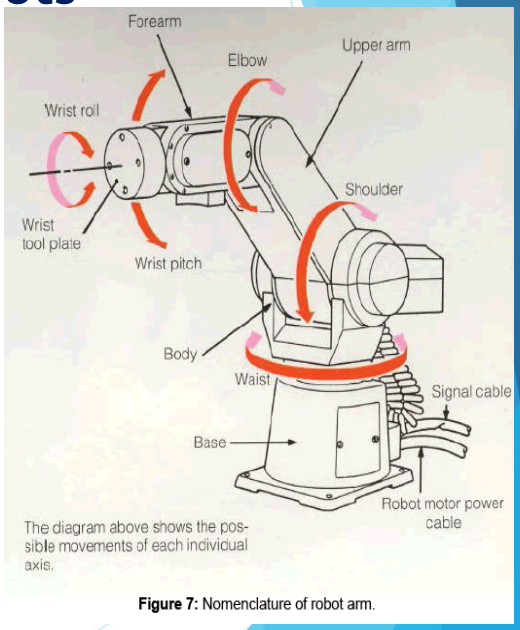

Figure 7: Nomenclature of robot arm.

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Types of Industrial Robots

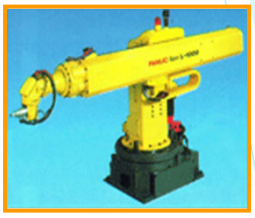
Classification of industrial robots by mechanical structure

Cartesian robot/ Gantry robot

Robot whose arm has three prismatic joints, whose axes are coincident with a Cartesian coordinator.

Cylindrical robot

Robot whose axes form a cylindrical coordinate system.



Spherical robot

Robot whose axes form a polar coordinate system.

Source: Source: World Robotics 2004, IPA Stuttgart, ISO 8373

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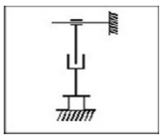
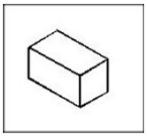
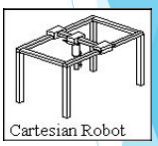
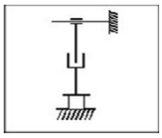
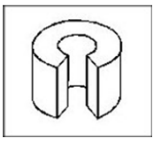
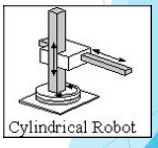
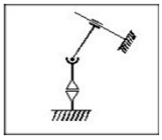
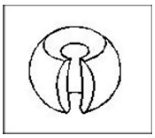
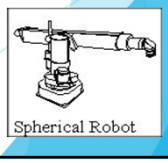
Types of Industrial Robots

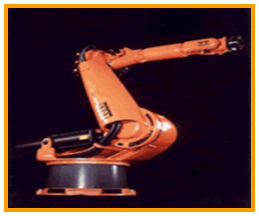
Photo	Kinematic structure	Workspace	Principle
			 Cartesian Robot
			 Cylindrical Robot
			 Spherical Robot

Types of Industrial Robots

Classification of industrial robots by mechanical structure

SCARA robot

Robot which has two parallel rotary joints to provide compliance in a plane.



Articulated robot

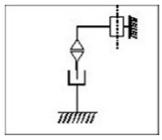
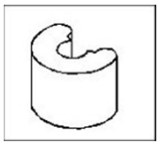
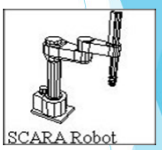
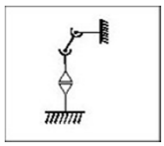
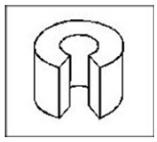
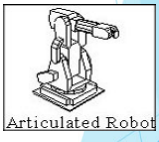
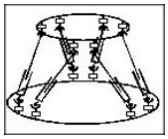
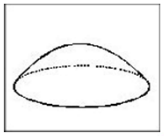
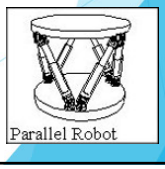
Robot whose arm has at least three rotary joints.

Parallel robot

Robot whose arms have concurrent prismatic or rotary joints.

Source: World Robotics 2004, IPA Stuttgart, ISO 8373

Types of Industrial Robots

Photo	Kinematic structure	Workspace	Principle
			 SCARA Robot
			 Articulated Robot
			 Parallel Robot

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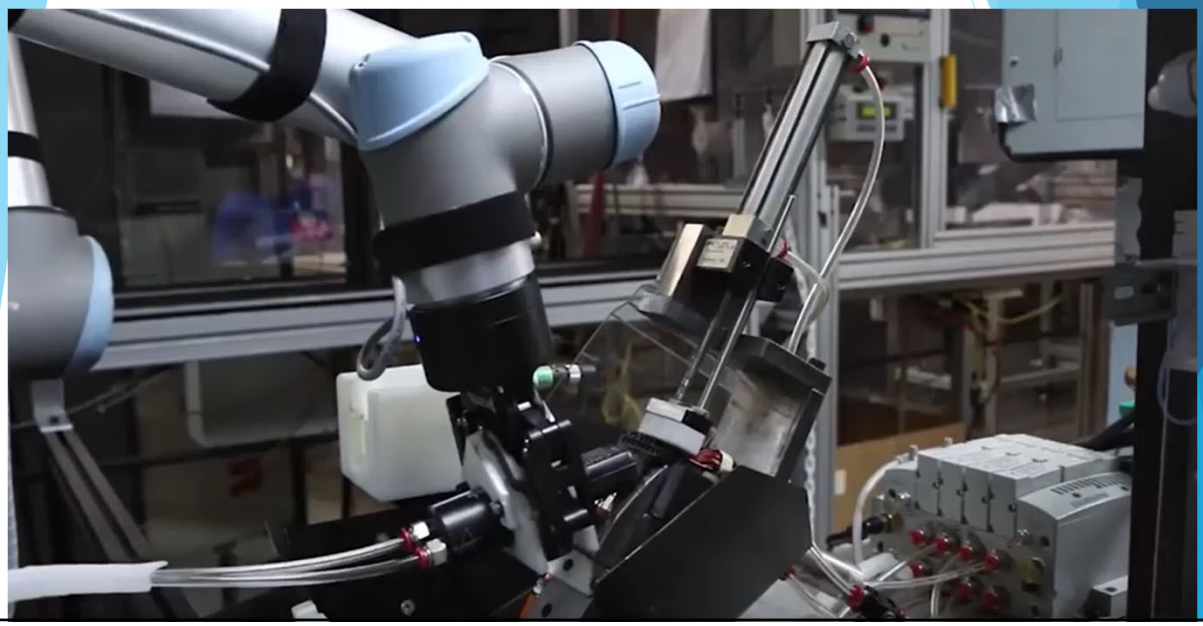
Collaborative Robots (Co-Bots)



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Co-Bots continued

- ANSI/RIA were not expecting where the industry has gone with co-bots or how fast the technology developed.
- Requirements for speed, separation, and force limiting monitoring are not in all co-bots.
- Many of these new features and safety systems are not fully understood yet.
- There is little data on power & force limiting robots, but those factors still do not apply to end effectors!
- Broadly collaborative robots require a good risk assessment team. It is not as easy as co-bot manufacturers claim to make them safe.
- They are NOT safe out of the box.

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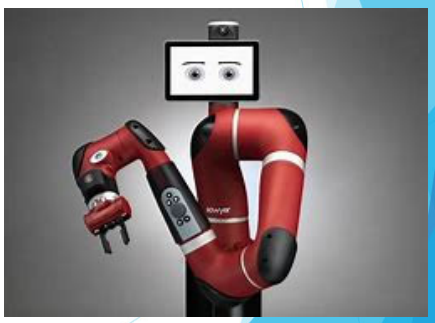
Co-Bots continued

Collaborative robots must include:

- Safety rated monitored stop
- Hand guided programming
- Speed and separation monitoring
- Power and force limited capacity



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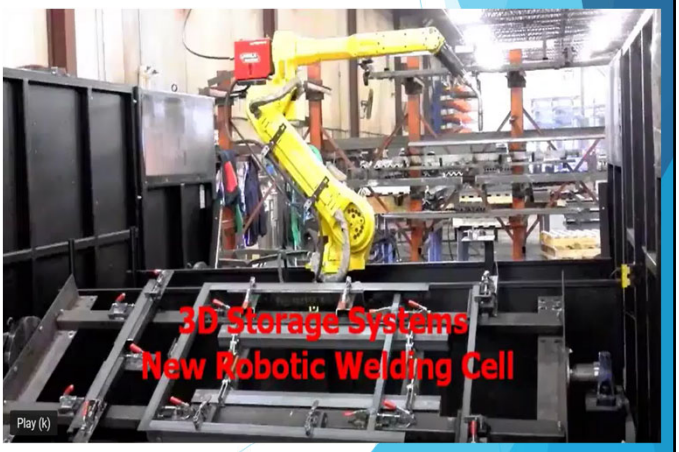
Industrial Robot Uses

Assembly

Welding



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Industrial Robot Uses

Repetitive
Dangerous/Hazardous
Dirty
Precision
Efficiency
Heavy Lifting

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Robotic Hazard Sources

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Robotic Hazard Sources

Human Errors – Prior programming, interfacing activated peripheral equipment, connecting live input-output sensors to the microprocessor or a peripheral can cause dangerous, unpredicted movement or action by the robot.

Mechanical Failures – Operating programs may not account for cumulative mechanical part failure; faulty or unexpected operation may occur.

ANYTHING MECHANICAL CAN AND WILL FAIL

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Robotic Hazard Sources

Control Errors – Faults within the control system of the robot, errors in software, electromagnetic interference, and radio frequency interference are control errors.

Unauthorized Access – Entry into a robot's safeguarded area is hazardous because the person involved may not be familiar with the safeguards in place or their activation status.

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Robotic Hazard Sources

Power Systems – Power sources that have malfunctioning control or transmission elements in the robot power system can disrupt electrical signals to the control and/or power supply lines. Fire risks are increased by electrical overloads or by use of flammable hydraulic oil.

Improper Installation – Inadequate design, requirements, and layout of equipment, utilities, and facilities of a robot or robot system. Such as automated turntables.

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Other Hazard Sources

Hazards Generated by Other Machines and Equipment:

- High pressure hoses from hydraulic fluids and air
- Transfer system components and mechanisms
- Conveyor system belts, chains and rollers
- Electrical devices
- Welding wires and tip cleaning

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Typical Tasks Performed

- Setup, teaching and programming
- Normal production, tip cleaning/changing, minor tool changes
- Fault clearance
- Housekeeping
- Maintenance, repair, troubleshooting

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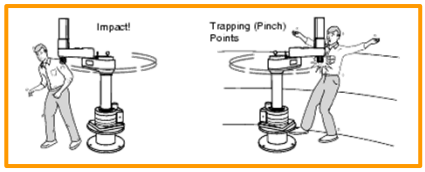
Types of Robot Accidents



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Types of Robot Accidents

Guidelines for Robotics Safety

"Recent studies in Sweden and Japan indicate that many robot accidents do not occur under normal operating conditions but rather during programming, adjustment, testing, cleaning, inspection, and repair periods. During many of these operations, the operator, programmer, or corrective maintenance worker may temporarily be within the robot work envelope while power is available to moveable elements of the robot system.

Federal OSHA STD 01-12-002 - pub 8-1.3 - Guidelines For Robotics Safety

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Types of Robot Accidents

- Impact or Collision – Unpredicted movements, component malfunctions, or unpredicted program changes related to the robot's arm or peripheral equipment can result in contact accidents.
- Crushing and Trapping – A worker's limb or other body part can be trapped between a robot's arm and other peripheral equipment, or the individual may be physically driven into and crushed by other peripheral equipment.

OSHA Tech Manual

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Types of Robot Accidents

- Mechanical Components – The breakdown of the robot's drive components, tooling or end effectors, peripheral equipment, or its power source is a mechanical accident. The release of parts, failure of gripper mechanism, or the failure of end effectors' power tools are a few types of mechanical failures.

Vacuum gripper

OSHA Tech Manual

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Types of Robot Accidents

Other – Hazardous energy forms connected to the robots

-electrical, hydraulic, pneumatic.

These could present arc flash, high pressure cutting streams or whipping hose hazards.

-Environmental hazards relating to what the robots are doing, weld fumes, dust, or metal spatter.

Federal OSHA "STD 01-12-002 - pub 8-1.3 - Guidelines For Robotics Safety

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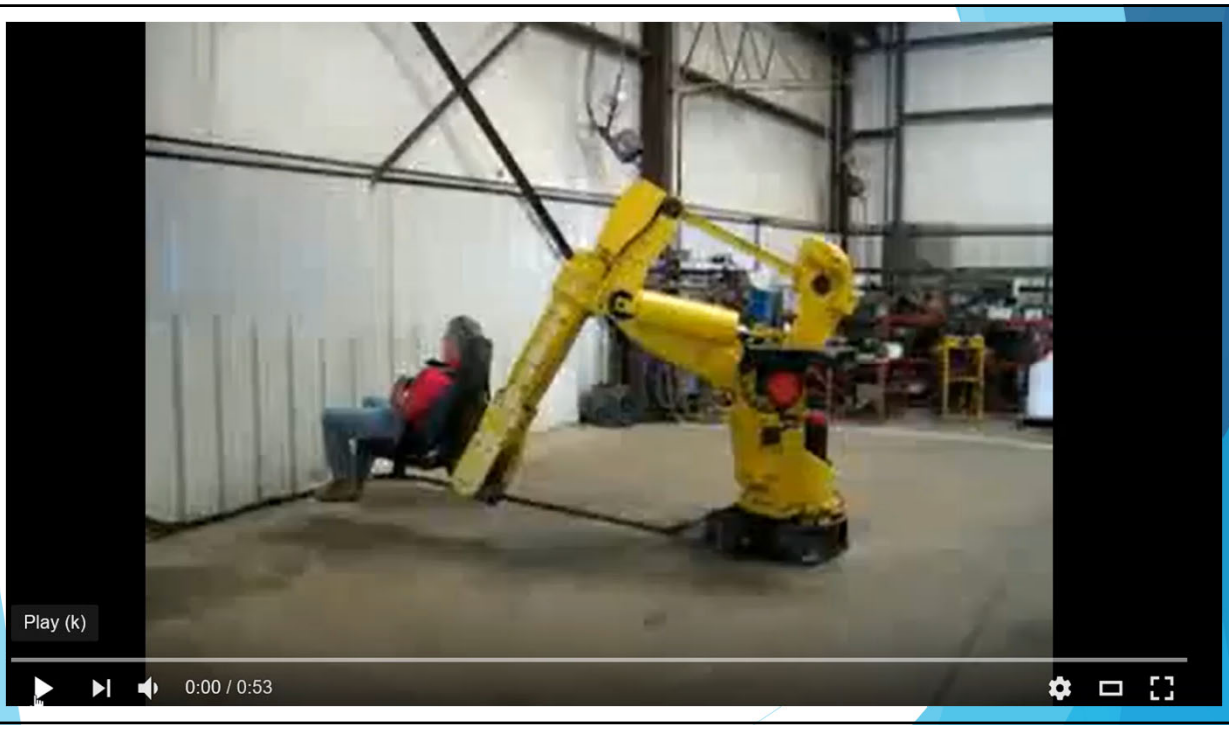

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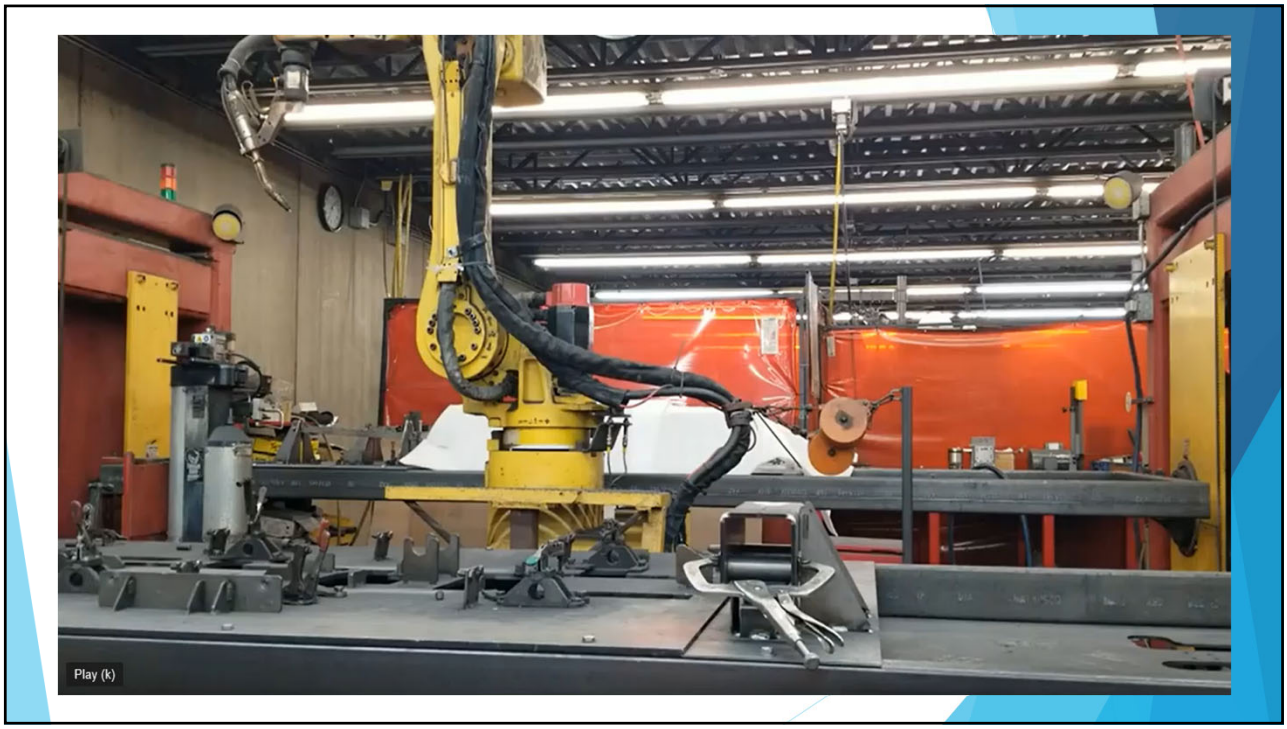
Play (k)

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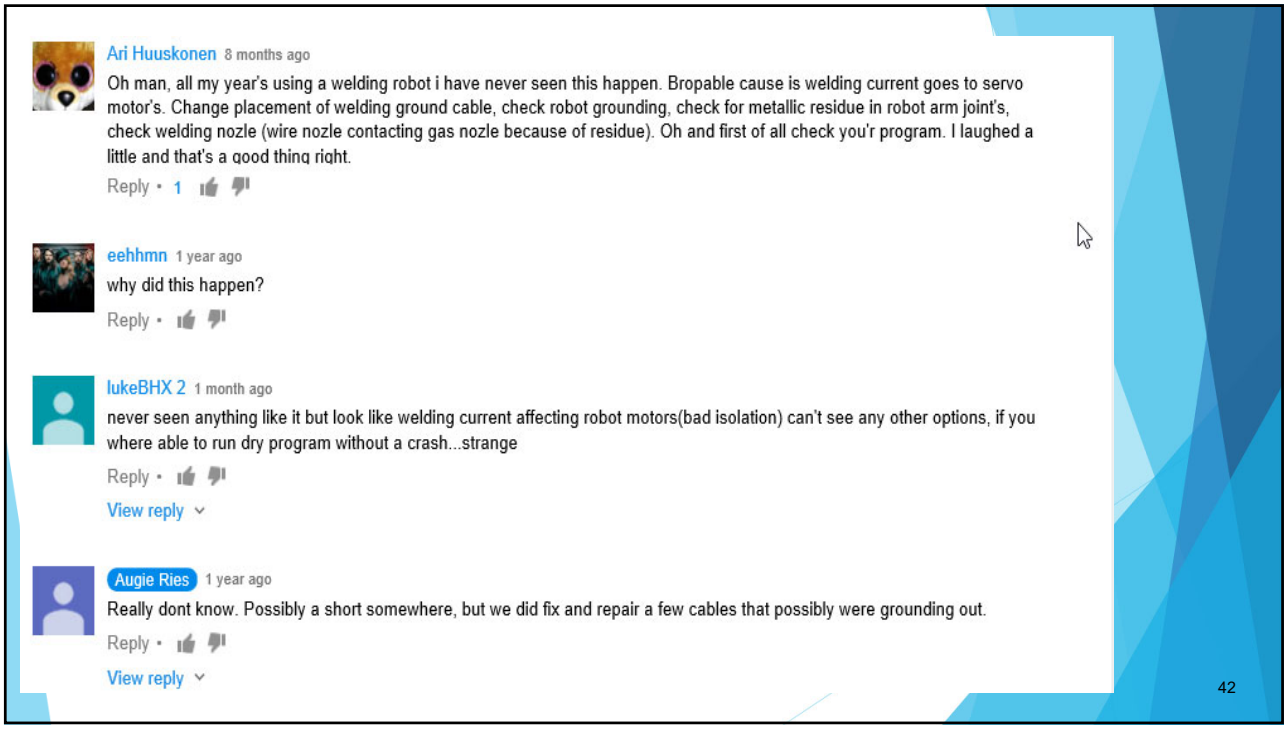
Ari Huuskonen 8 months ago
Oh man, all my year's using a welding robot i have never seen this happen. Bropable cause is welding current goes to servo motor's. Change placement of welding ground cable, check robot grounding, check for metallic residue in robot arm joint's, check welding nozle (wire nozle contacting gas nozle because of residue). Oh and first of all check you'r program. I laughed a little and that's a good thing right.
Reply • 1
eehhmn 1 year ago
why did this happen?
Reply •
lukeBHX 2 1 month ago
never seen anything like it but look like welding current affecting robot motors(bad isolation) can't see any other options, if you where able to run dry program without a crash...strange
Reply •
View reply
Augie Ries 1 year ago
Really dont know. Possibly a short somewhere, but we did fix and repair a few cables that possibly were grounding out.
Reply •
View reply
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Protective Devices and Safeguards

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Protective Devices and Safeguards

Operator Safeguards – The system operator should be protected from all hazards during operations performed by the robot. When the robot is operating automatically, all safeguarding devices should be activated, and at no time should any part of the operator's body be within the robot's safeguarded area.

OSHA Instruction Publication No. 8-1.3. 1987. *Guideline for Robotics Safety.* Occupational Safety and Health Administration, Washington, D.C.

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ANSI/RIA 15.06-2012 Part 2 5.8.2 Hazard Identification and Risk Assessment

It is necessary to identify the hazards and to assess the risks associated with the robot and its application.

Technical measures for the reduction of risk are based upon these fundamental principles:

a) the elimination of hazards by design or their reduction by substitution;

b) preventing operators coming into contact with hazards or controlling the hazards by achieving a safe state before the operator can come into contact with it;

c) the reduction of risk during interventions (e.g., teaching).

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Protective Devices and Safeguards

Maintenance and Repair Personnel –

Safeguarding maintenance and repair personnel is very difficult because their job functions are so varied. Troubleshooting faults or problems with the robot, controller, tooling, or other associated equipment is just part of their job.

OSHA Instruction Publication No. 8-1.3. 1987. *Guideline for Robotics Safety.* Occupational Safety and Health Administration, Washington, D.C.

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ANSI/RIA 15.06-2012 Part 2 5.8.2
Safeguarding Requirements for Maintenance

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

Maintenance should be performed from outside the safeguarded space. When it is necessary to perform maintenance within the safeguarded space, selection of the preferred means of safeguarding shall be as follows:

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ANSI/RIA 15.06-2012 Part 2 5.8.2
Safeguarding Requirements for Maintenance

Disconnect
Pressure relief valve

Complex robot system, complex procedure

a) the system shall be provided with the local means of controlling and isolating hazardous energy, Information for Use shall contain details about maintenance tasks that require energy control and isolation, and those that are anticipated when hazardous energy would be required;

All integrator changes must be noted, includes energy control

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ANSI/RIA 15.06-2012 Part 2 5.8.2
Safeguarding Requirements for Maintenance

Resembles OSHA 1910.147 MIOSHA Part 85

b) effective alternative protective measures shall be provided for minor servicing tasks that are anticipated and integral to production performed without energy isolation; control measures for control of hazardous energy or position monitoring include one or more of the following: (ANSI)

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ANSI/RIA 15.06-2012 Part 2 5.8.2
Safeguarding Requirements for Maintenance

1) Safeguard to allow safe performance of the task;

2) Placing the equipment in a predetermined safe monitored position or condition (deviations shall result in a protective stop condition);

3) Providing exclusive control for personnel entering the safeguarded space (procedures for exclusive control shall be defined and provided in the information for use);

4) Providing a specific operating mode meeting at least the requirements in 5.2.2 for specific identified tasks (system fails safe and is detectable). (ANSI)

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ANSI/RIA 15.06-2012 Part 2 5.7.3
Protective Devices and Safeguards

Control of simultaneous motion
A single pendant may control simultaneous motion of a system with multiple robots. Each robot shall be selected before it can be activated. To be selected, all robots shall be in the same operational mode (e.g., manual reduced speed). An indication of which robots will be activated (selected to be moved) shall be provided in accordance with Part 1. Only the selected robots shall be activated. Any robot in the system not selected shall not move and shall not present hazards by means in accordance with 5.2.2.

NOTE – This can be achieved by remaining in a protective stop condition.

(ANSI/RIA Standard R15.06 - 2012)

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ANSI/RIA 15.06-2012 Part 1 5.8.6
Protective Devices and Safeguards

Cableless or detachable teach controls

Where pendant or other teaching controls have no cables connecting to the robot control, or where they may be detached, the following shall apply:

a) A visual indication shall be provided to show that the pendant is active, e.g., at the teach pendant display.

b) Loss of communication shall result in a protective stop for all robots being controlled when in manual reduced-speed or manual high-speed modes. Restoration of communication shall not restart robot motion without a separate deliberate action.

(ANSI/RIA Standard R15.06 - 2012)

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ANSI/RIA 15.06-2012 Part 1 5.8.6
Protective Devices and Safeguards

Cableless or detachable teach controls...continued

c) Confusion between active and inactive emergency stop devices shall be avoided by providing appropriate storage or design. Information for use shall contain a description of the storage or design. (USA) See Part 2 for additional information on pendant storage.

d) When applicable, the maximum response times for data communication (including error correction) and for loss of communication shall be stated in the information for use.

(ANSI/RIA Standard R15.06 - 2012)

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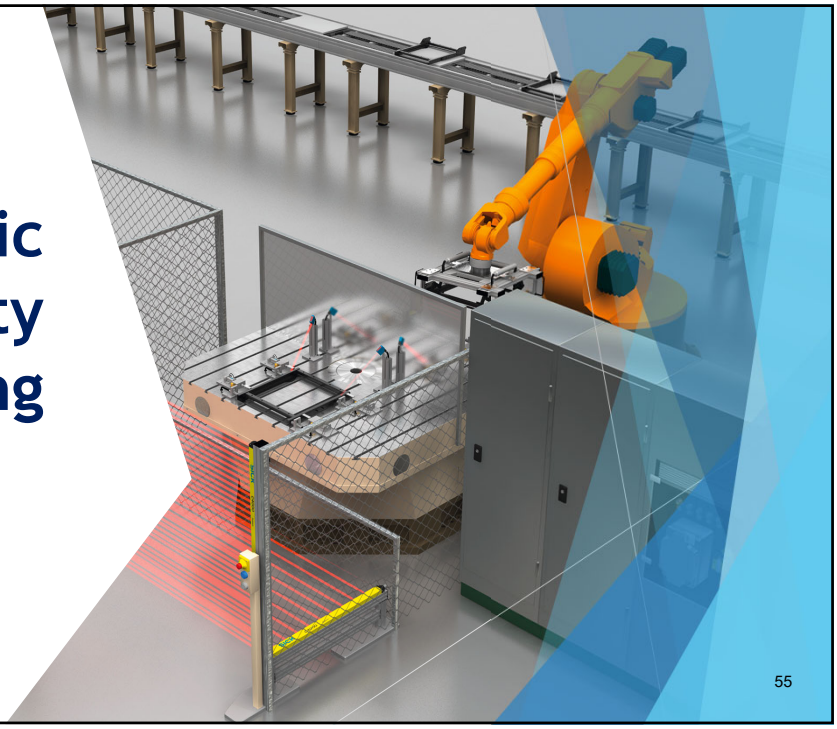
Robotic Safety Guarding



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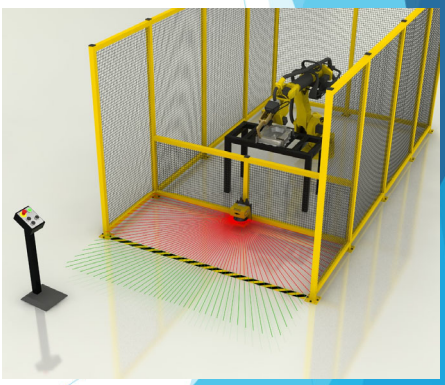
Robotic Safety Guarding

- Interlocked gates and fixed barrier guards
- Emergency stop devices
- Presence sensing devices (PSD)
- Engineering controls
- Teach pendants
- Lockout
- Safety rated PLCs and relay
- Functional Safety



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Fixed Barrier Guarding

Must be “A.U.T.O” which means employees cannot reach around, under, through, or over guarding.

ANSI/RIA requires guarding starts 7 inches (180 mm) off the floor and at least 55 inches (1,400mm) high unless end effectors create higher hazards.

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Door interlocks

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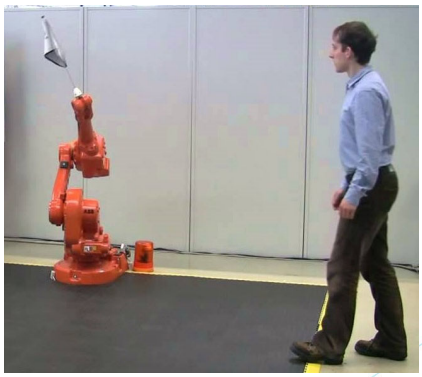
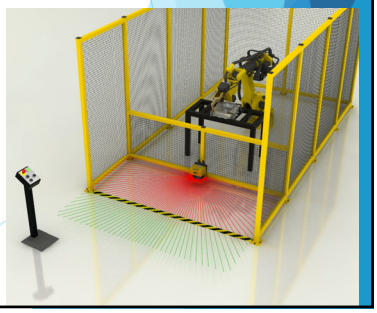
Presence Sensing Devices (PSD)

- Light Curtains
- Pressure mats



- Laser scanners



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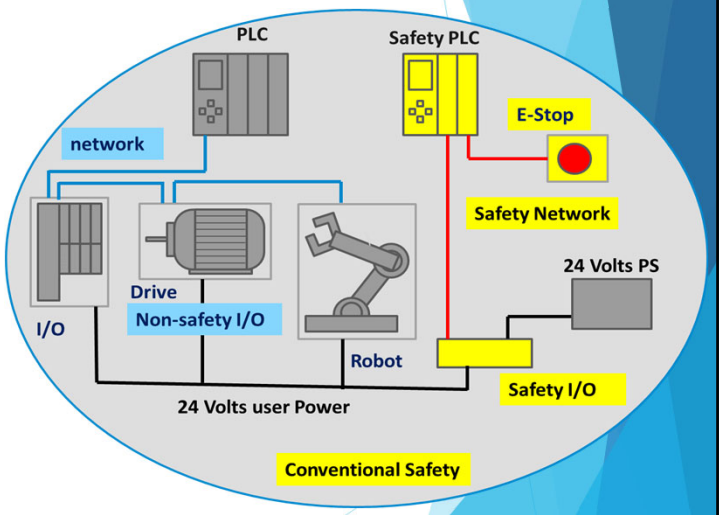
Control Reliability or Functional Safety

ANSI defines “Control reliability is the capability of the machine control system, the safeguarding, other control components and related interfacing to achieve a safe state in the event of a fault within their safety related functions.” Or simply every component is connected to fail safe

Employers must prove they have this with Risk Assessment



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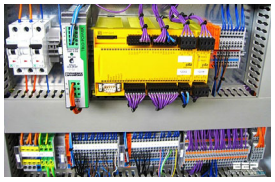

Programmable Logic Controller (PLC)

- The PLC is the brains of the operation - it’s **integrated** into the Robot.
- PLCs use Solid Stated Circuitry, semiconductors and relays that physically turn on and off.
- You need a Safety PLC to have a full working Safety System.
- The Safety PLC is what allows for the dual channel monitoring.

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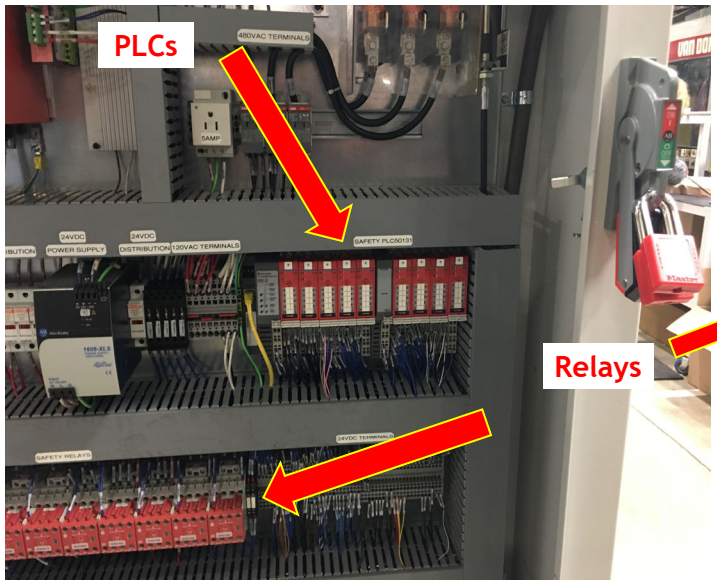

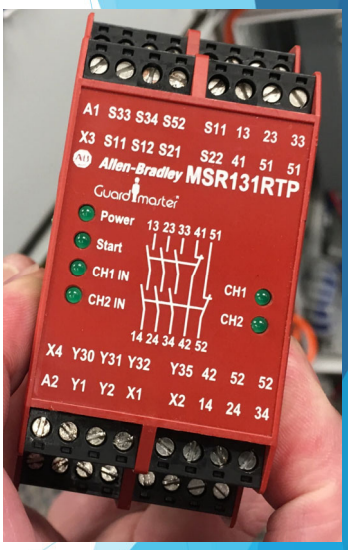

Safety PLC – Dual Channel System

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Functional Safety

For employee protection in robot cell. You could have:

- Multiple E-Stops
- 2 entry gates with interlocks
- 2 sets of light curtains
- A teach pendent
- Laser scanner area
- Pressure mats

These components need to be able to shut the robot down. Or if there is a fault, the entire system fails safe.

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Robotic Safety Guarding

Interlocked Gates and Barrier Guards

What would this area need to have?

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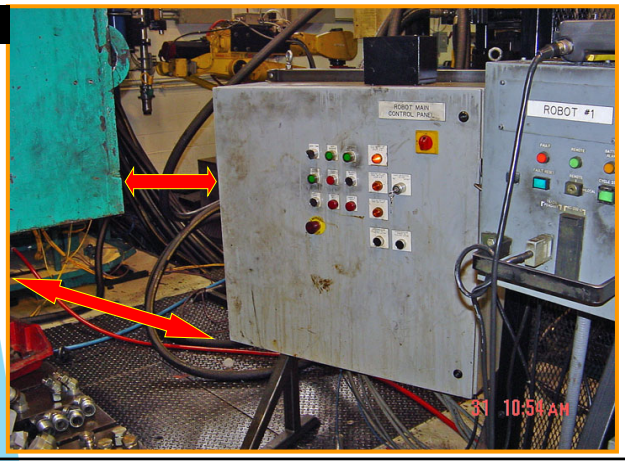
Robotic Safety Guarding

Does the gate allow access to the robot envelope without pulling the gate interlock? Could an employee enter openings not protected by barrier guards?

1



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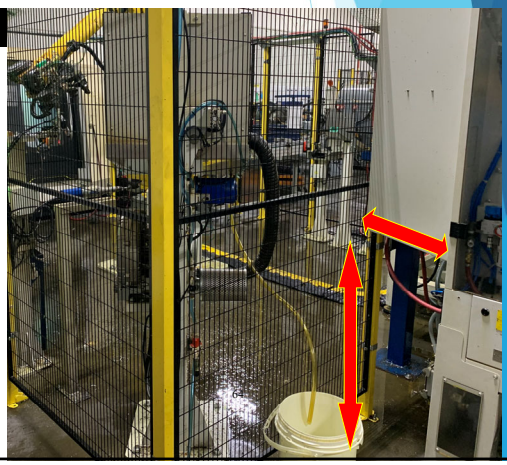

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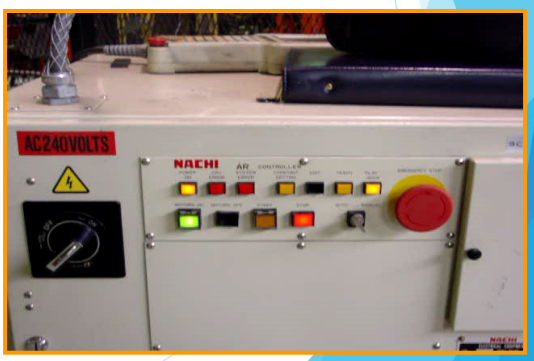
Robotic Safety Guarding

Emergency Stop Devices

Are they **RED** in color, mushroom shaped, and within easy reach?
Do they stop all hazardous motions?



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Robotic Safety Guarding

- Engineering Controls
- Two hand controls
- Barriers and Interlocks
- Risk Assessment and risk reduction (JSAs)
- Hard stops
- Presence sensing devices.

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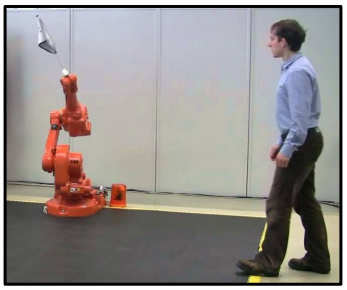
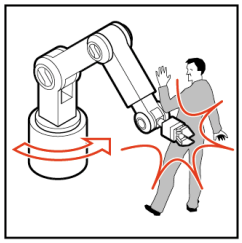


Hazard Recognition



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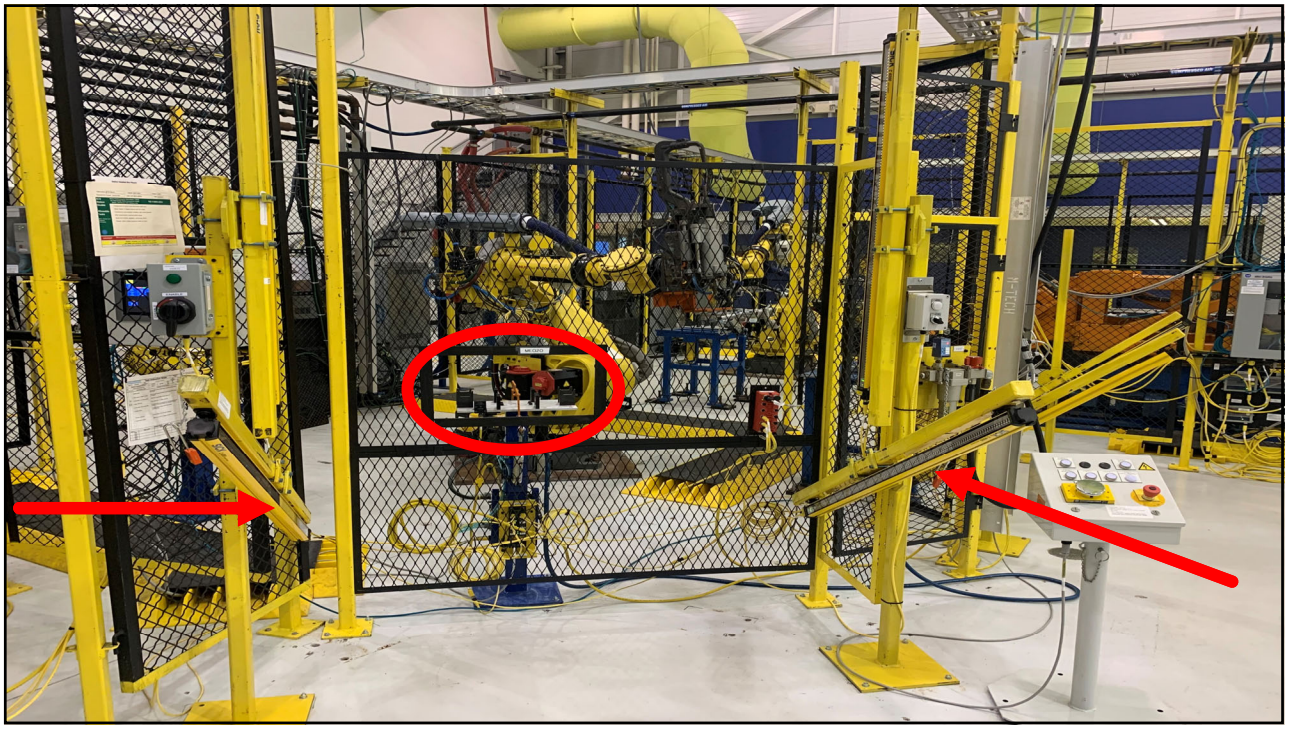

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Anything Wrong?

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Anything Wrong?

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Anything Wrong?

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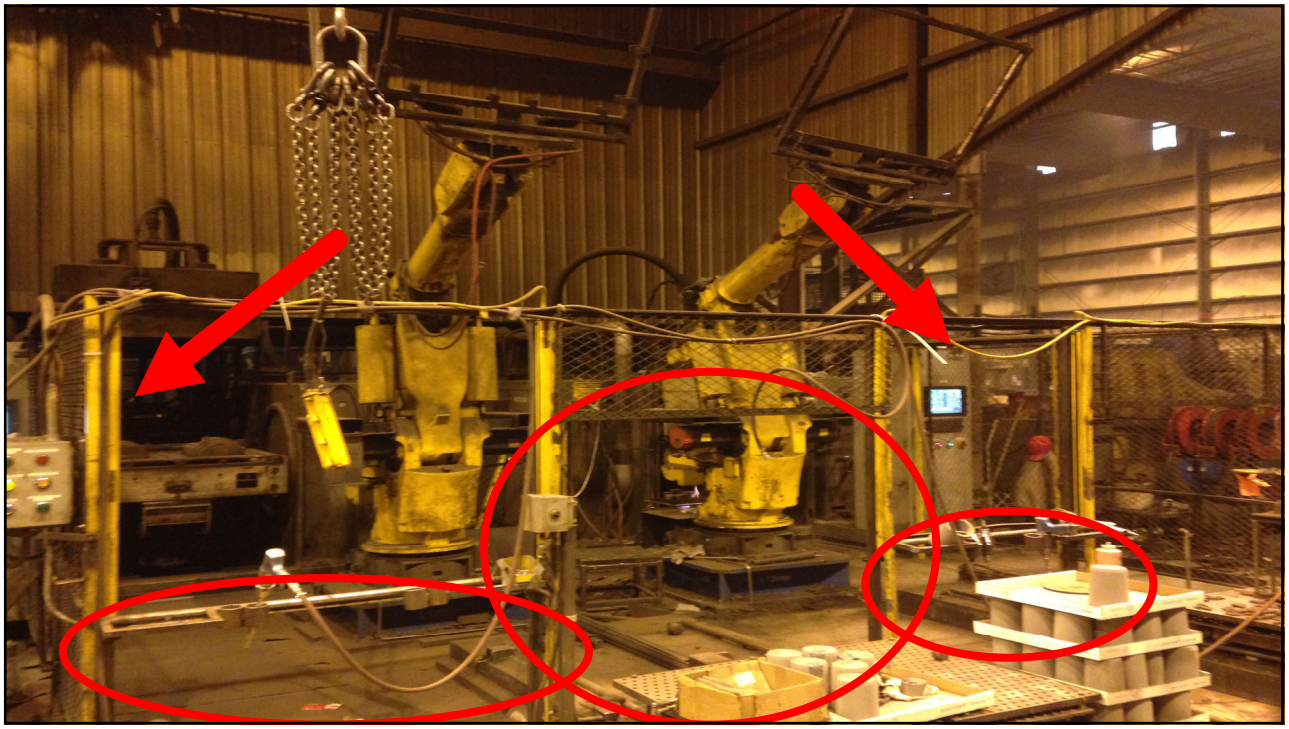

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General Industry Part 85 The Control of Hazardous Energy Sources

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1910.147(a) Scope, application, and purpose

This standard covers the servicing and maintenance of machines and equipment in which the unexpected energization or start up of the machines or equipment, or release of stored energy, could harm employees. This standard establishes minimum performance requirements for the control of such hazardous energy.

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Electrical

Hyldrauic

Pneumatic

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Activities that are typically considered service or maintenance

Construction	Adjusting	Modifying
Installing	Unjamming	Cleaning
Setting Up	Tool Changes	Inspecting

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The Rule, 1910.147(a)(2)(ii) reads: "Servicing and/or maintenance which take place during normal production operations are covered by this standard only when:

An employee is required to remove or bypass a guard or other safety device; or

An employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being proceeded (point of operation) or where an associated danger zone exists during a machine cycle.

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Exception to Lockout

Minor Tool Changes (MTC) and adjustments, and other minor servicing activities are not covered *if and only if* they meet *ALL of the following:*

Routine

-How long does task take?

-Is it minor in nature?

-Is it an operator task?

Repetitive

-With what frequency?

-Occurs on regular and predicable basis?

AND integral to production provided that…

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work is performed using **alternative measures which provide effective protection."**

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ROBOT LOCKOUT

OSHA Case Study

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CASE STUDIES

Case Study 2: Automotive Component Lubrication Robotics

At an employer's automotive component manufacturing facility, manufacturing operations make extensive use of robots located within fenced cages. At one location, suspension parts are transferred by rotating tables from station to station while greasing and other operations are performed on the parts by robots. If necessary, employees can gain access to the robots by entering the cages through electrically interlocked gates. When the gates are opened, the multiple energy sources that power the robots, rotating tables, and related machinery are turned off but are not deenergized or locked out. An employee who is inside a cage when a robot is activated could be struck by the robot arm or other machine parts and seriously injured.

An injury occurred when an employee, consistent with the employer's practices, entered the robot cage without deenergizing or locking out any equipment. The employee was attempting to unjam a robot arm. In freeing the arm, the employee tripped an electric eye, causing the robot arm to cycle. The employee's arm was struck by the robot and injected with grease. The employer contends that lockout procedures were not necessary because once the gate is opened, movement of the robot arm is impossible, and a maintenance worker inside the cage would have ample warning – by the closing of the interlocked gate – before the machinery started up, to avoid injury. According to the employer, once the interlocked gate is opened, it must first be closed and a number of buttons must be pushed before any machine movement can occur. The startup procedure would take some time and the person inside the robot area would be aware of the closing of the gate and the presence of another worker at the nearby control panel.

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OSHA
CASE STUDY

CASE STUDIES

Case Study 2: Automotive Component Lubrication Robotics

Question 1 for Case Study 2:

Does the unjamming operation take place during normal production operations?

- Yes
- No

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OSHA
CASE STUDY

CASE STUDIES

Case Study 2: Automotive Component Lubrication Robotics

Incorrect. In this case, it would not.

The unjamming of the robot arm does not meet each of the required criteria for the minor servicing exception; thus, this exception does not apply. Specifically, the unjamming operation does not take place during normal production operations, as specified in the minor servicing exception note to 29 CFR 1910.147 (a)(2)(ii). In addition, the unjamming operation does not use alternative measures which provide effective protection.

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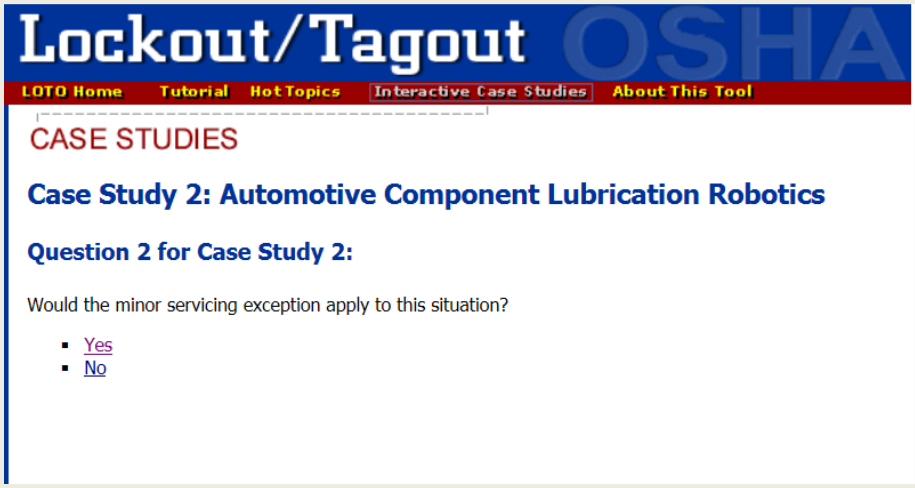
OSHA
CASE STUDY



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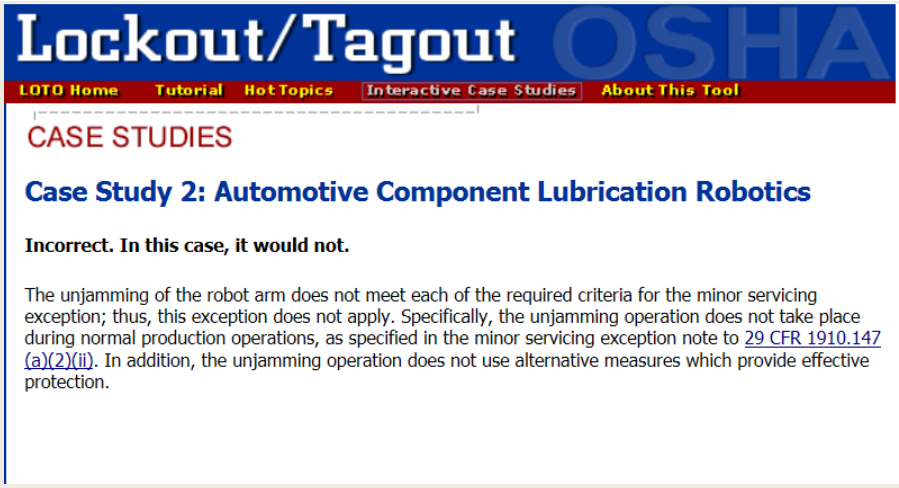
OSHA
CASE STUDY



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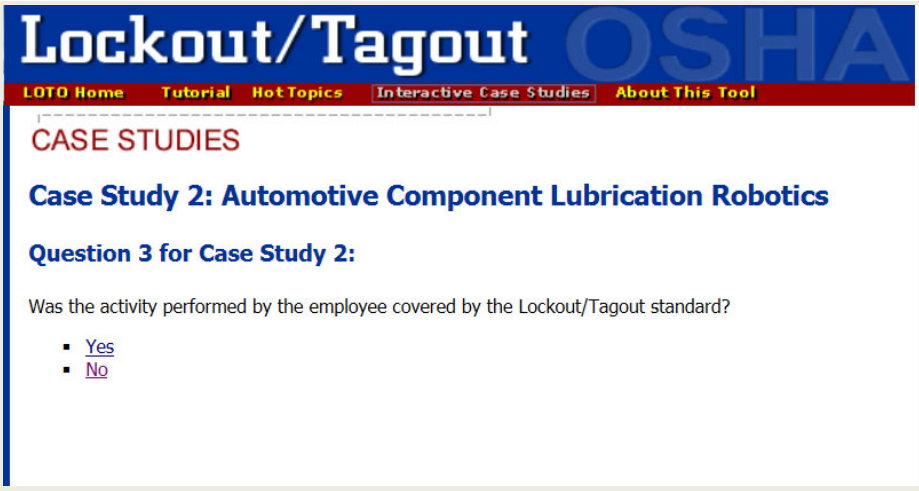
OSHA
CASE STUDY



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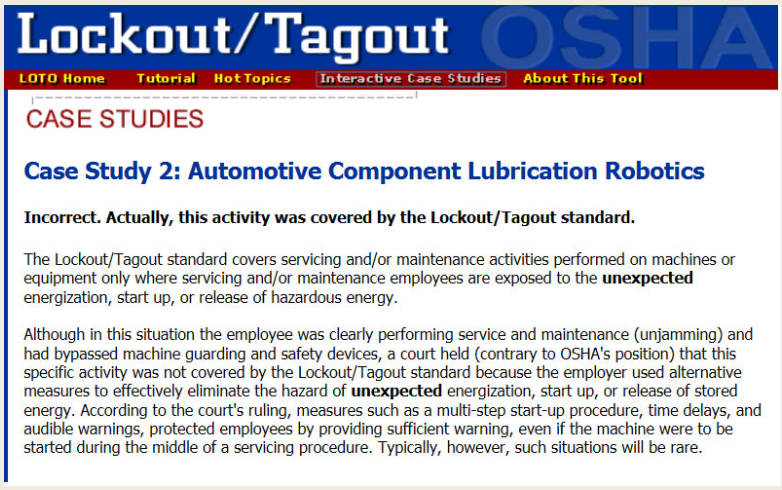
OSHA
CASE STUDY



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OSHA
CASE STUDY

CASE STUDIES

Case Study 2: Automotive Component Lubrication Robotics

Question 4 for Case Study 2:

In this situation, would the interlocked gate alone satisfy the employer's Lockout/Tagout obligations?

- Yes
- No

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OSHA
CASE STUDY

Lockout/Tagout OSHA

LOTO Home | Tutorial | Hot Topics | Interactive Case Studies | About This Tool

CASE STUDIES

Case Study 2: Automotive Component Lubrication Robotics

Incorrect.

The interlocked gate would not meet the requirements for an energy isolation device. In this case, the interlocked gate is considered to be control circuitry which is expressly prohibited by the rule. It does not protect employees who are inside the fenced area because it fails to de-energize the robot arm.

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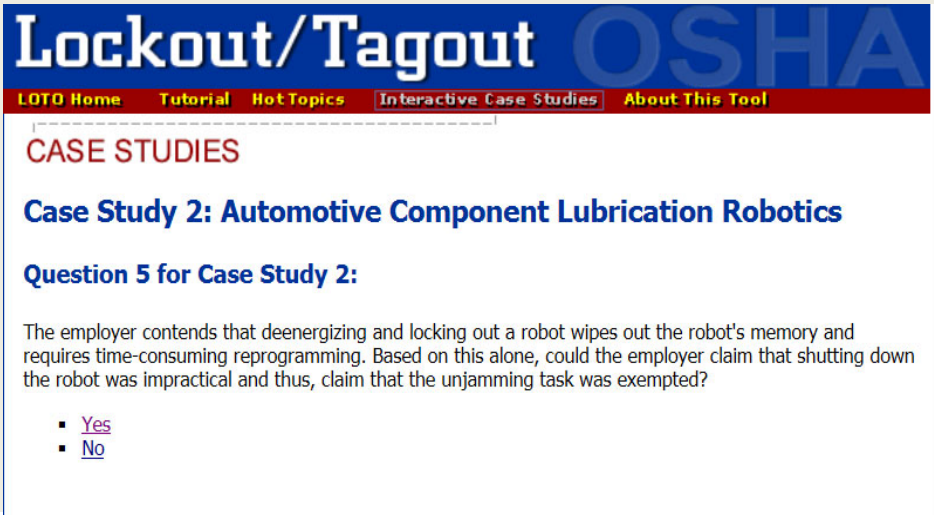
OSHA
CASE STUDY



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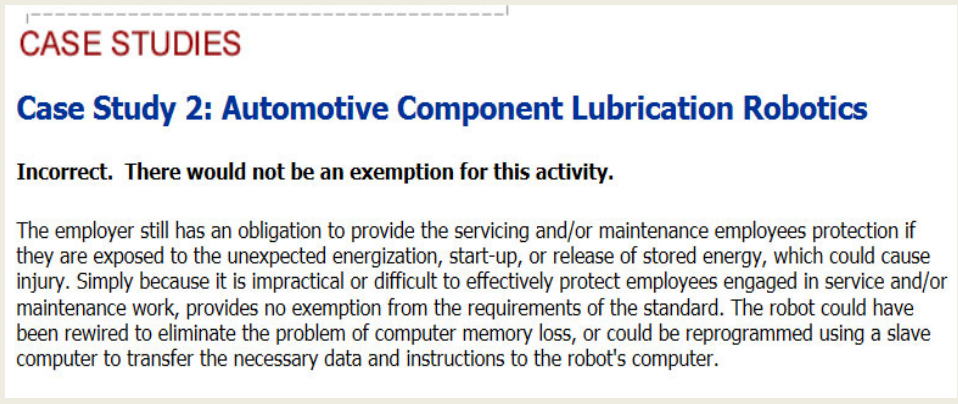
OSHA
CASE STUDY



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OSHA CASE STUDY

Questions?

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Robot Risk Assessment

Develop A Hazard List

1. Struck by the robot
2. Struck by a turntable
3. Pinch point on end effector
4. Pinch point between robot and turntable
5. Eye hazards
6. Slips/falls

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ANSI/RIA 15.06 Part 2 4.4

Robot Risk Assessment

Hazard identification is used to develop a Tasked Based Risk Assessment (TBRA) that can help employers and integrators develop appropriate safeguarding measures.

These are required by ANSI/RIA 15.06 – 2012 but will be necessary to show MIOSHA all hazards have been removed.

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Identify Hazards

- Study each step for existing or potential hazards
- Consider: flying particles, work positions, entanglement hazards, workflow, pinch points, balance, falls, lifting, lockout…
- Repeat job observation until all hazards have been identified

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Robot Risk Assessment

NOTE – The list in Table A.1 is derived from ISO 12100.
Table 1 — List of significant hazards (examples)

Mechanical Hazards

- Movements of any part of the robot arm ---------- Crushing/Shearing
- Movements of end effector ---------- Severing/Cutting
- Unintended release of tool /end effector failure ---- Friction/Abrasion

Electrical Hazards

- Contact with live parts or connections ---------- Electrocutions or shocks

Thermal Hazards

- Hot surfaces from end effector, equipment ---------- Burns or workpieces

Noise Hazards

- Long term exposures ---------- Hearing loss

(ANSI/RIA Standard R15.06 - 2012)

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Robot Risk Assessment

Develop A Hazard List (Continued)

7. Sharp edges or objects
8. Electric shock
9. Hot surface, hot water/metal
10. Fall from height (ladder)(platform)
11. Muscle strain from weight
12. Stored energy (lockout)

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Safe Procedures and Protections

1. Eliminate hazards
2. Define safer and better job steps
3. Provide means to be safe: guards, PPE, ventilation, procedures…
4. Be specific

NEVER – use general statements such as, "Be Careful"

Risk assessment shall be carried out on those hazards identified and shall give particular consideration to:

a) the intended operations at the robot, including teaching, maintenance, setting and cleaning;

b) unexpected start-up;

c) access by personnel from all directions;

d) reasonably foreseeable misuse of the robot;

e) the effect of failure in the control system; and

f) where necessary, the hazards associated with the specific robot application.

Courtesy ANSI/RIA R15.06-2012

Risk assessment cont.

1) Identify every foreseeable task and the associated hazards

2) Assess and score the initial risks for each task by rating the injury severity, exposure, and avoidance

Courtesy RIA TR R15.306-2016

Factor	Rating	Criteria (Examples) - choose most restrictive The decision process starts at the top
Injury Severity	Serious S3	Normally non-reversible: – fatality – limb amputation – long term disability – chronic illness – permanent health change If any of the above are applicable, the rating is SERIOUS
	Moderate S2	Normally reversible: – broken bones – severe laceration – short hospitalization – short term disability – loss time (multi-day) – finger tip amputation (not thumb) If any of the above are applicable, the rating is MODERATE
	Minor S1	First aid: – bruising – small cuts – no loss time (multi-day) – does not require attention by a medical doctor If any of the above are applicable, the rating is MINOR
Exposure	High E2	– Typically more than once per hour – Frequent or multiple short duration – durations longer than 5 minutes* (to prevent task creep and does not include teach) *LOTO should be considered for interventions lasting longer than 5 minutes If any of the above are applicable, the rating is HIGH
	Low E1	– Typically less than once per day or shift – Occasional short durations If either of the above are applicable, the rating is LOW
Avoidance	Not likely A2	– insufficient clearance to move out of the way – inadequate warning/reaction time – hazard is moving faster than reduced speed (250mm/s) – may not perceive the hazard exists If any of the above are applicable, the rating is NOT LIKELY
	Likely A1	– sufficient clearance to move out of the way – adequate warning/reaction time – hazard is moving at or less than reduced speed (250mm/s) If any of the above are applicable, the rating is LIKELY

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RIA/ANSI Sample From Standard

Most Effective	1) Elimination or Substitution	• eliminate human interaction in the process • eliminate pinch points (increase clearance) • automated material handling
↓	2) Engineering Controls (Safeguarding Technology)	• mechanical hard stops • barriers • interlocks • presence sensing devices • two hand controls
↓	3) Awareness Means	• lights, beacons and strobes • computer warnings • signs • restricted space painted on floor • beepers • horns • labels
↓	4) Training and Procedures (Administrative Controls)	• safe job procedures • safety equipment inspections • training • lockout
↓	5) Personal Protective Equipment	• safety glasses • ear plugs • face shields • gloves
Least Effective		

Table A.2 – Hierarchy of safeguarding controls

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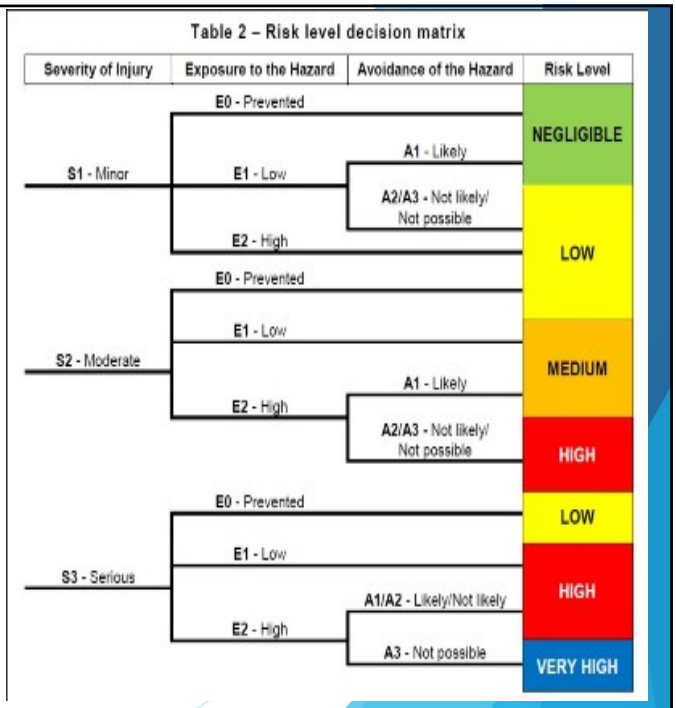
Risk assessment cont.

Injury Severity:
What is the reasonably estimated injury due to hazard contact while performing task?

Exposure:
What is the frequency/duration of EE exposure

Avoidance:
What is the EE's ability to sense and avoid a hazard?
-speeds under 250 mm/sec (@ 10"/sec) are considered avoidable

Courtesy RIA TR R15.306-2016



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SEQ	Task	Steps	Potential Hazards	Initial Risk Estimate				
				Without safeguarding	ANSI/RIA TR R15.306-			
					Severity	Exposure	Avoidance	Risk Level
1	roll cart to loader	cart with totes full of billets place next to billet loader	Slips / trips / falls / egress - debris	None.	S1	E1	A3	Low
2	place billet(s) in to loader by hand	Operator places billets into loader	Mechanical hazards - pinch points	None.	S1	E1	A3	Low
3	loader recogizes billet	loader prox switch reconizes part - (Internal to the cell, inside fencing)	Mechanical hazards - pinch points	None.	S1	E1	A3	Low
4	roll die heater next to press	operator rolls die heater into to press	Slips / trips / falls / egress - slippery surface (low coefficient of friction)	None.	S1	E1	A3	Low
5	run cord power cord from die heater to press	run power cord to outlet and plugs in cord	Electrical / electronic hazards - shorts / arcing / sparking	None.	S1	E1	A3	Low
6	allow die heater heat upper and lower dies to reach operation temp	dies are heated to required temp. Operator does other tasks not related to this operation	Fire and explosion - hot surfaces	None.	S1	E1	A3	Low
7	once dies reach temp remove die heater from press	dies are at temp die heater is rolled out of press area	Fire and explosion - hot surfaces	None.	S1	E1	A3	Low
8	start press operation	operator starts up press and operations	Electrical / electronic hazards - direct contact with normally energized machines	None.	S3	E1	A3	High
9	robot pic from billet loader	robot pic part from billet loader	Control Systems - failure to stop moving parts	None.	S2	E2	A3	High
10	robot place billet in to furnace	robot places billet into furnace	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High
11	robot pic billet from furnace	robot pics part of of the furnace	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High
12	robot place hot billet on to die	robot place hot billet on to die	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High

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ANSI/RIA TR R15.306-												ANSI/RIA TR R15.306-			
Risk Level	Control Circuit?	Minimum Functional Performance			Design	Safe Guarding	Administrative	Actions / Measures	Date Due	Responsible persons	Severity	Exposure	Avoidance	Risk Level
Low	Yes	c	2	—			X	Safety mat, PPE	Complete	Operator	S1	E0	A2	Negligible
Low	Yes	c	2	—			X	PPE, Signage	Complete	**Operator**	S1	E0	A2	Negligible
Low	Yes	c	2	—	X	X	X	Safety Fence, Signage	Complete	**Operator**	S1	E0	A2	Negligible
Low	Yes	c	2	—			X	Training, PPE	Complete	**Operator**	S1	E0	A3	Negligible
Low	Yes	c	2	—			X	PPE – Wear NFPA 70E required apparel	Complete	**Operator**	S1	E0	A3	Negligible
Low	Yes	c	2	—		X	X	Personal Protective Equipment – Heat Resistant Gloves, Safety Fence	Complete	**Operator**	S1	E0	A3	Negligible
Low	Yes	c	2	—			X	Personal Protective Equipment – Heat Reisistant Gloves, Safety Fence	Complete	**Operator**	S1	E0	A3	Negligible
High	Yes	d	3	Control Reliable		X	X	PPE – Wear NFPA 70E required apparel	Complete	**Operator**	S1	E0	A3	Negligible
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A3	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & Inerlock handle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & Interlock hndle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
Medium	Yes	d	2	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S3	E0	A3	Low
High	Yes	d	3	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S3	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
High	Yes	d	3	Control Reliable			X	PPE	Complete	**Operator**	S2	E0	A1	Low

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Sample Risk Assessment

SEQ	Task	Steps	Potential Hazards	Without safeguarding	ANSI/RIA TR R15.306-				Control Circuit?	Minimum Functional Performance			Design	Safe Guarding	Administrative	Actions / Measures	Date Due	Responsible persons	ANSI/RIA TR R15.306-			
					Severity	Exposure	Avoidance	Risk Level											Severity	Exposure	Avoidance	Risk Level
1	roll cart to loader	cart with totes full of billets place next to billet loader	Slips / trips / falls / egress - debris	None.	S1	E1	A2	Low	Yes	c	2	—			X	Safety mat, PPE	Complete	Operator	S1	E0	A2	Negligible
2	place billet(s) in to loader by hand	Operator places billets into loader	Mechanical hazards - pinch points	None.	S1	E1	A3	Low	Yes	c	2	—			X	PPE, Signage	Complete	**Operator**	S1	E0	A2	Negligible
3	loader recogizes billet	loader prox switch reconizes part - (Internal to the cell, inside fencing)	Mechanical hazards - pinch points	None.	S1	E1	A3	Low	Yes	c	2	—	X	X	X	Safety Fence, Signage	Complete	**Operator**	S1	E0	A3	Negligible
4	roll die heater nest to press	operator rolls die heater into to press	Slips / trips / falls / egress - slippery surface (low coefficient of friction)	None.	S1	E1	A3	Low	Yes	c	2	—			X	Training, PPE	Complete	**Operator**	S1	E0	A3	Negligible
5	run cord power cord from die heater to press	run power cord to outlet and plugs in cord	Electrical / electronic hazards - shorts / arcing / sparking	None.	S1	E1	A3	Low	Yes	c	2	—			X	PPE – Wear NFPA 70E required apparel	Complete	**Operator**	S1	E0	A3	Negligible
6	allow die heater heat upper and lower dies to reach operation temp	dies are heated to required temp. Operator does other tasks not related to this operation	Fire and explosion - hot surfaces	None.	S1	E1	A3	Low	Yes	c	2	—		X	X	Personal Protective Equipment - Heat Resistant Gloves, Safety Fence	Complete	**Operator**	S1	E0	A3	Negligible
7	once dies reach temp remove die heater from press	dies are at temp die heater is rolled out of press area	Fire and explosion - hot surfaces	None.	S1	E1	A3	Low	Yes	c	2	—			X	Personal Protective Equipment - Heat Resistant Gloves, Safety Fence	Complete	**Operator**	S1	E0	A3	Negligible
8	start press operation	operator starts up press and operations	Electrical / electronic hazards - direct contact with normally energized machines	None.	S3	E1	A3	High	Yes	d	3	Control Reliable		X	X	PPE – Wear NFPA 70E required apparel	Complete	**Operator**	S1	E0	A3	Negligible
9	robot pic from billet loader	robot pic part from billet loader	Control Systems - failure to stop moving parts	None.	S2	E2	A3	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A3	Low
10	robot place billet in to furnace	robot placed billet into furnace	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
11	robot pic billet from furnace	robot pics part of of the furnace	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
12	robot place hot billet on to die	robot place hot billet on to die	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock hndle on door	Complete	**Operator**	S2	E0	A1	Low
13	press cycles part	press cycles part	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
14	robot enetrs press cools part	robot eneters press cools part	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
15	robot removes part from press	robot removes part from press	Control Systems - failure to stop moving parts	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
16	robot placed part in basket	robot placed in basket	Control Systems - failure to stop moving parts	None.	S2	E2	A3	High	Yes	d	3	Control Reliable	X	X		Safety Fence & interlock handle on door	Complete	**Operator**	S2	E0	A1	Low
17	Maintenance - Housekeeping: cleaning floor, etc...	Maintenance - Housekeeping: cleaning floor, etc...	Slips / trips / falls / egress - debris	None.	S2	E1	A2	Medium	Yes	d	2	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S2	E0	A1	Low
18	Maintenance -on press	Maintenance -on press	Fire and explosion - electrical arcs	None.	S3	E1	A3	High	Yes	d	3	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S3	E0	A3	Low
19	Maintenance - electrical systems	Maintenance - electrical systems	Electrical / electronic hazards - arc flash hazard	None.	S3	E1	A3	High	Yes	d	3	Control Reliable		X	X	Interlocked enabling device & lockout tagged out	Complete	**Operator**	S3	E0	A1	Low
20	Maintenance - Robot	Maintenance - Robot	Mechanical hazards - crushing / impact	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
21	Maintenance - Robot	Maintenance - Robot	Mechanical hazards - entanglement	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
22	Maintenance - Robot	Maintenance - Robot	Mechanical hazards - head bump	None.	S2	E2	A2	High	Yes	d	3	Control Reliable	X	X		Interlocked enabling device & lockout tagged out, PPE	Complete	**Operator**	S2	E0	A1	Low
23	Maintenance - lube machine	Maintenance - lube machine	Chemical, material or substance hazard - handled by the machine (e.g., flammable, toxic, fine dust)	None.	S2	E2	A2	High	Yes	d	3	Control Reliable			X	PPE	Complete	**Operator**	S2	E0	A1	Low

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Risk Assessment Activity

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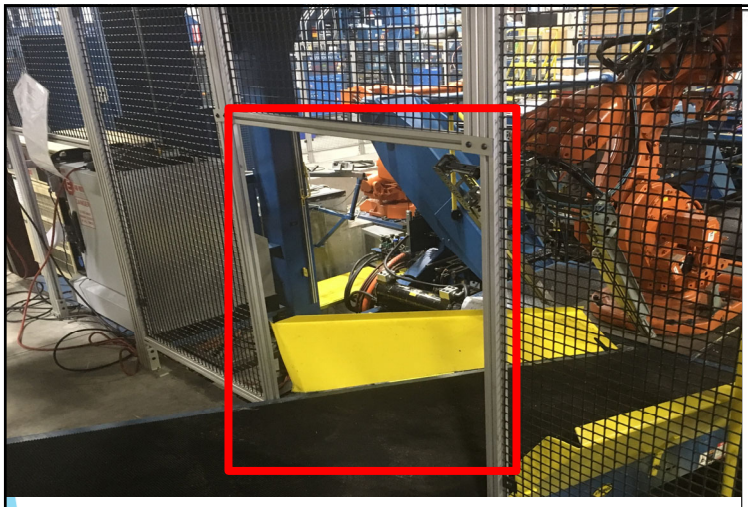

-Employees enter the cell to perform cleaning once a week for approximately 15 minutes.
-6 robots present with speeds of 600 mm/sec (@ 24”/sec)

Table 2 – Risk level decision matrix

Severity of Injury	Exposure to the Hazard	Avoidance of the Hazard	Risk Level
S1 - Minor	E0 - Prevented		NEGLIGIBLE
	E1 - Low	A1 - Likely	
		A2/A3 - Not likely/ Not possible	LOW
	E2 - High		
S2 - Moderate	E0 - Prevented		MEDIUM
	E1 - Low		
	E2 - High	A1 - Likely	
		A2/A3 - Not likely/ Not possible	HIGH
S3 - Serious	E0 - Prevented		LOW
	E1 - Low		HIGH
	E2 - High	A1/A2 - Likely/Not likely	
		A3 - Not possible	VERY HIGH

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-1 employee enters the cell to retrieve a fallen part once a week for approximately 10 seconds.
-Robot operates at 60 mm/sec (@ 2 ½ inches/sec)
-Only exposed to one robot

Table 2 – Risk level decision matrix

Severity of Injury	Exposure to the Hazard	Avoidance of the Hazard	Risk Level
S1 - Minor	E0 - Prevented		NEGLIGIBLE
	E1 - Low	A1 - Likely	
		A2/A3 - Not likely/ Not possible	LOW
	E2 - High		
S2 - Moderate	E0 - Prevented		
	E1 - Low		MEDIUM
	E2 - High	A1 - Likely	
		A2/A3 - Not likely/ Not possible	HIGH
S3 - Serious	E0 - Prevented		LOW
	E1 - Low		HIGH
	E2 - High	A1/A2 - Likely/Not likely	
		A3 - Not possible	VERY HIGH

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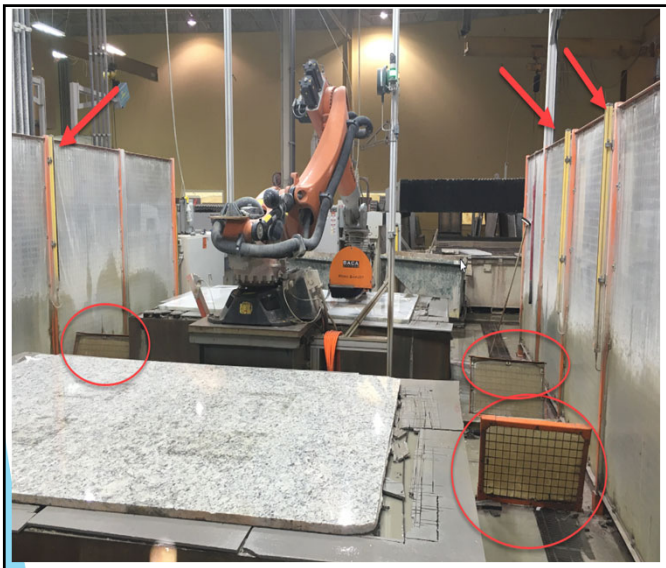

-Employees enter the cell and stand within 12 inches of robot's base
-Entries are made between *20-30 times per shift* for total of *3 hours*
-Robot moves at 900 mm/sec (@ 36"/sec)

Table 2 – Risk level decision matrix

Severity of Injury	Exposure to the Hazard	Avoidance of the Hazard	Risk Level
S1 - Minor	E0 - Prevented		NEGLIGIBLE
	E1 - Low	A1 - Likely	
		A2/A3 - Not likely/ Not possible	LOW
	E2 - High		
S2 - Moderate	E0 - Prevented		
	E1 - Low		MEDIUM
	E2 - High	A1 - Likely	
		A2/A3 - Not likely/ Not possible	HIGH
S3 - Serious	E0 - Prevented		LOW
	E1 - Low		HIGH
	E2 - High	A1/A2 - Likely/Not likely	
		A3 - Not possible	VERY HIGH

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Robotic Safety Training

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Robotic Safety Training

Who needs training?

- Managers / Supervisors
- Operators
- Engineers
- Programmers
- Maintenance personnel
- Bystanders

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Robotic Safety Training

What Training Is Needed?

- Safe operation
- Maintenance
- Proper set up (guards or devices)
- Emergency procedures
- Shut down controls

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Robotic Safety Training

What Training Is Needed?

- Inspection of safeguards
- Enforcement procedures
- Working with teams
- Applicable MIOSHA Standards – pinch points, belt and pulley guards, lockout, etc.

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National and International Robot Consensus Standards

Robot Standards – National Consensus

- *Robotic Industry Association (RIA)*
- *American National Standards Institute (ANSI)*
- *R15.06-2012*, ANSI/RIA Industrial Robots and Robot Systems - Safety Requirements.
- Provides requirements for industrial robot manufacture, remanufacture and rebuild; robot system integration/installation; and methods of safeguarding to enhance the safety of personnel associated with the use of robots and robot systems.

(R15.06 ANSI/RIA)

Robot Standards – National Consensus

American Welding Society (AWS)

D16.1M/D16.1M:2004, Specification for Robotic Arc Welding Safety

D16.2M/D16.2:2007, Guide for Components of Robotic and Automatic Arc Welding Installations

D16.3M/D16.3:2009, Risk Assessment Guide for Robotic Arc Welding

D16.4M/D16.4:2005, Specification for the Qualification of Robotic Arc Welding Personnel

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Robot Standards – National Consensus

Canadian Standards Association (CSA)

Z434:2014, Industrial Robots and Robot Systems.

Adopted the ISO 10218-1 and -2 with their own national deviations.

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Robot Standards – International Consensus

International Organization for Standardization (ISO)

International Robot Safety Standard reviewed by Jeff Fryman, Director, Standards Development
Robotic Industries Association

The ISO 10218-1:2011 International Standard for industrial robot safety published this decade long effort by representatives from ten countries over three continents. It was the first all new and complete International robot safety standard since 1992. This milestone achievement put the effort to revise the current R15.06 National standard for robot safety into high gear.

(ISO 10218 was published in July 2012)

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Applicable MIOSHA Standards

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Applicable MIOSHA Rules

MIOSHA Act 154 General Duty Clause

During a MIOSHA inspection, if protection is found to be lacking on any robotic operation, and employees are exposed to hazards that are causing or likely to cause, death or serious physical harm, then a violation of the *General Duty Clause*, from The MIOSHA Act 154 of the Michigan Occupational Safety and Health Act, may be proposed. These will be issued for guarding deficiencies if employees are exposed.

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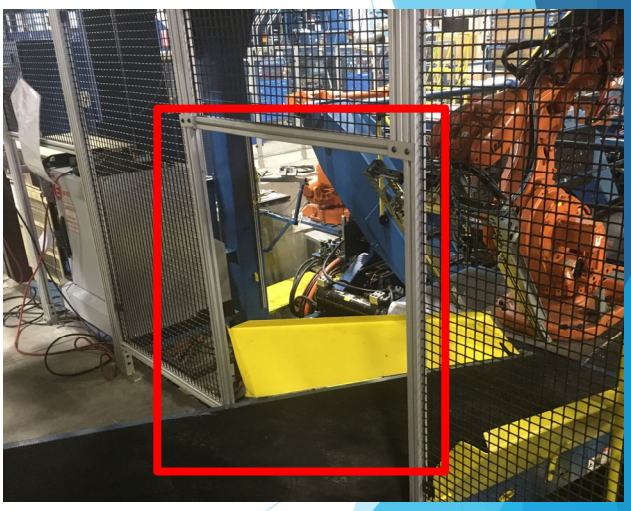
Applicable MIOSHA Rules

MIOSHA Act 154 General Duty Clause

Recommended citation: "There were inadequate **fixed barrier guards** with excessive openings that allowed employees access to the hazards of being caught or struck by intended or unintended motion of the robot."



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Applicable MIOSHA Rules

The MIOSHA Enforcement Division has additional safety and health rules that apply to robot operations where other machines and equipment are used with the robot during the production process.

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Applicable MIOSHA Rules

Other standards that could be used in citation for robot cells might be:

Part 1 General Provisions
Part 1A Abrasive Wheels
Part 2 Walking & Working Surfaces
Part 6 Fire Exits
Part 7 Guards For Power Transmission
Part 12 Welding and Cutting

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Applicable MIOSHA Rules

Others MIOSHA Rules (continued)

Part 14 Conveyors
Part 18 Overhead and Gantry Cranes
Part 26 Metal Working Machinery
Part 33 Personal Protective Equipment
Part 39 Design Safety Standards For Electrical Systems
Part 40 Safety Related Work Practices

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Applicable MIOSHA Rules

Others MIOSHA Rules (continued)

Part 76 Spray Finishing with Flammable and Combustible Materials
Part 85 The Control Of Hazardous Energy Sources

Part 380 Occupational Noise Exposures
Part 529 Welding, Cutting and Brazing
Part 520 Ventilation Control

Depending on the process, other safety and health standards may apply.

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Industrial Robot Recycling

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Industrial Robot Recycling

Computers, computer accessories, cell phones, older televisions, and industrial robots all entail careful handling at the end of their life cycle.
Electronics can contain beryllium, nickel, zinc, chromium, cadmium, mercury, lead, and brominated flame retardants.
If electronics are not discarded or recycled properly, toxic materials can expose potential problems.

Robot Recycling and Environment Articles Used-Robots.com

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Industrial Robot Recycling

Cadmium - found in chip resistors, infrared detectors, semiconductors, and robotic batteries and cables.

Lead - found in the glass panels of computer monitors, in lead soldering of printed circuit boards, and semi-conductors found in industrial robotics.

Mercury - found in cables connected to industrial robots, thermostats, position sensors, relays and switches on printed circuit boards, discharge lamps, and batteries.

Industrial Robot Recycling

Hexavalent Chromium or Chromium VI- can be used to protect against corrosion of untreated and galvanized steel plates and can be found in robotic semi-conductors, and robotic welding smoke.

Plastics – found in circuit boards, some industrial robot covers, automotive parts and much more

Industrial robots can be hazardous to the environment if not disposed of or recycled properly.

The Future of Robots

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Assessment

- The purpose of this assessment is to validate the knowledge learned in class.
- Passing score of 70% correct is required.
- Class reference materials/books are not allowed to be used during the assessment.
- Collaboration/discussion with others is not allowed during the assessment.
- Answers will be reviewed after everyone completes and submits their assessment.

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Thank you.
Don’t Forget to Take the Survey
MIOSHA
Michigan Occupational Safety and Health Administration

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Industrial Robotic Safety

Student Resources

MIOSHA Standards:

Part 1. General Provisions

Part 2. Walking-Working Surfaces

Part 7. Guards for Power Transmission

Part 14. Conveyors

Part 85. Control of Hazardous Energy Sources

MIOSHA Standards Index/Order Form

MIOSH Act 154

MIOSHA Publications:

Job Safety Analysis (SP #32)

Lockout Compliance Guide (SP #27)

Other Resources:

Robotics (OSHA webpage)

OSHA Technical Manual (OTM) Section IV: Chapter 4

OSHA Control of Hazardous Energy - Enforcement Policy and Inspection Procedures

MIOSHA Training Institute (MTI) Resources:

www.michigan.gov/mti

MIOSHA Training Calendar:

www.michigan.gov/mioshatraining

MIOSHA Homepage:

www.michigan.gov/miosha

Michigan Department of Labor and Economic Opportunity
Michigan Occupational Safety and Health Administration
Consultation Education and Training Division
525 W. Allegan St., P.O. Box 30643
Lansing, Michigan 48909-8143

For further information or to request consultation, education and training services
call 517-284-7720
or
visit our website at www.michigan.gov/miosha

www.michigan.gov/leo