ROBOT SAFETY & Integration

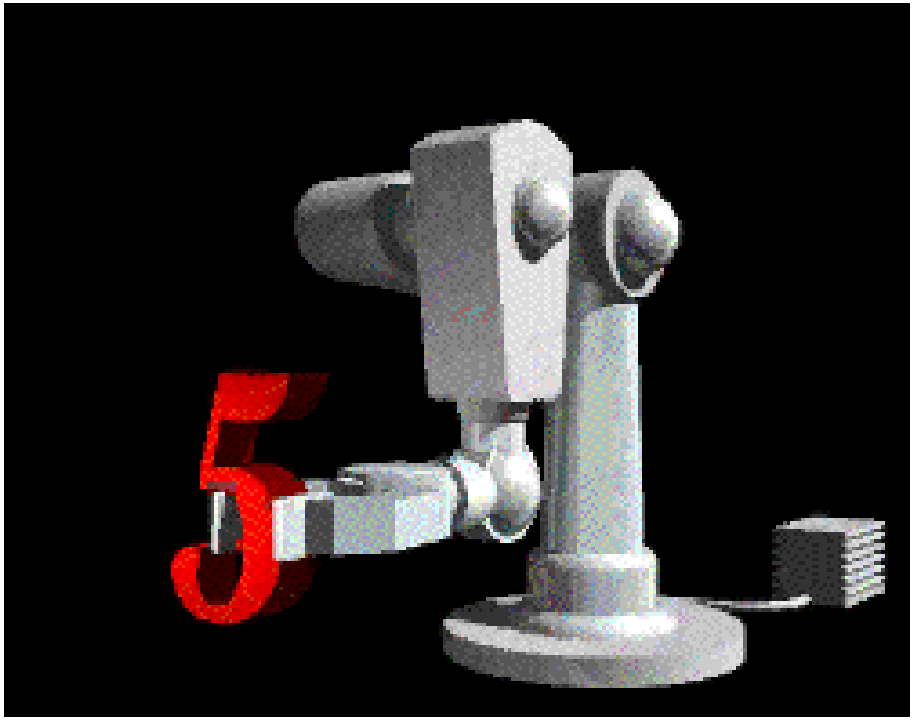
PMA Robot Safety

"Credentials"

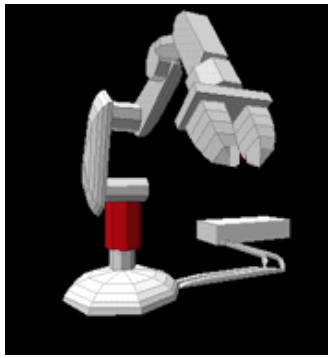
- Involved in Automation, Safety & Service of Controls
  - 27+ years Experience
- Integration of safety between presses and robotics
- Coordinator with safety committee for robotics
- Thousands of Successful "Safe" Installations Running
  - LINK Systems, Clearing - Niagara - Bliss, Piranha – Allsteel, Tennsmith, SEYI
- Safety Committee for Precision Metalforming Association
- Speaker and Author of hundreds of safety presentations and articles
- Toured many North American Manufacturers & Stampers
- Toured Asian, Middle Eastern & European Press Users & Builders

What are the parts of a robot?

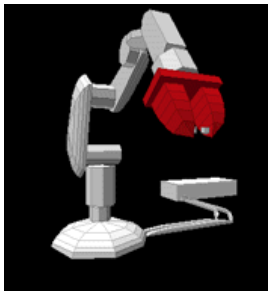
- Manipulator
- Pedestal
- Controller
- End Effectors
- Power Source



Manipulator

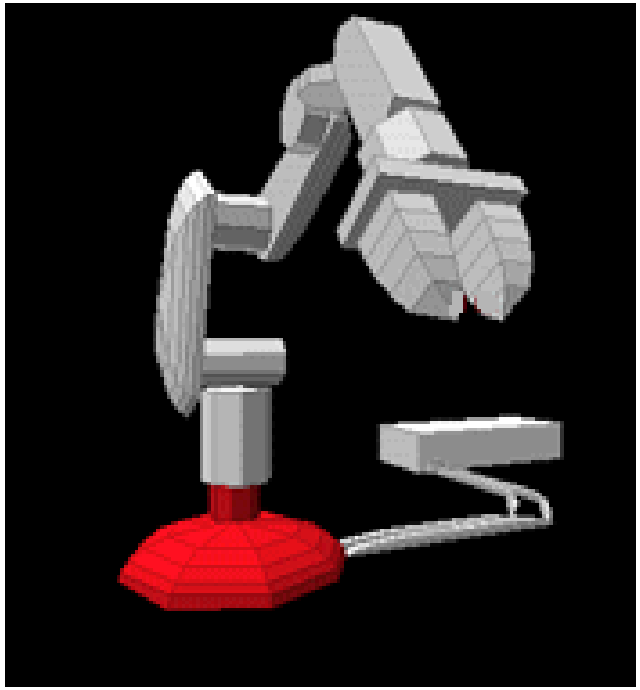


- Base
- Appendages
  - Shoulder
  - Arm
  - Grippers



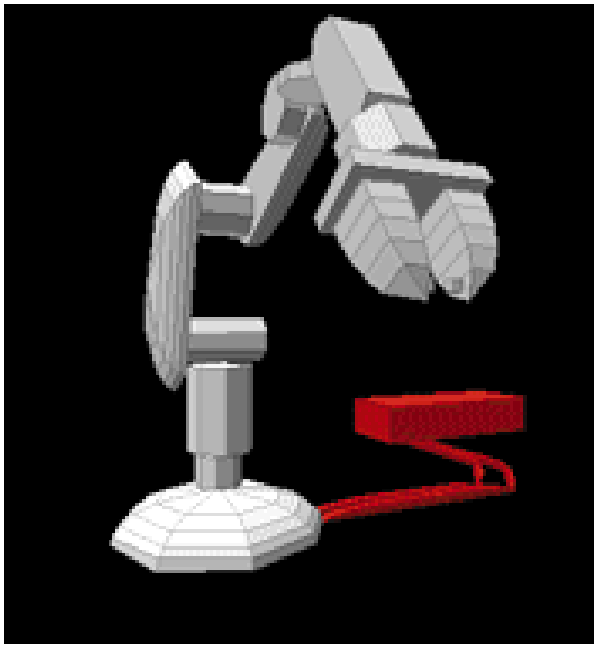
Pedestal

(Human waist)



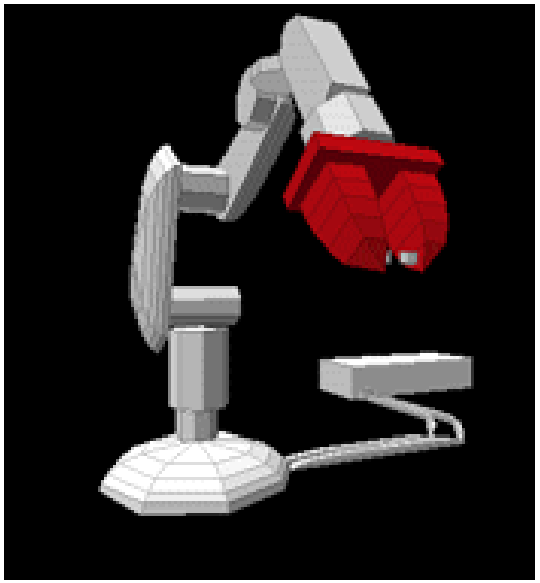
- **Supports the manipulator.**
- **Acts as a counterbalance.**

Controller (The brain)



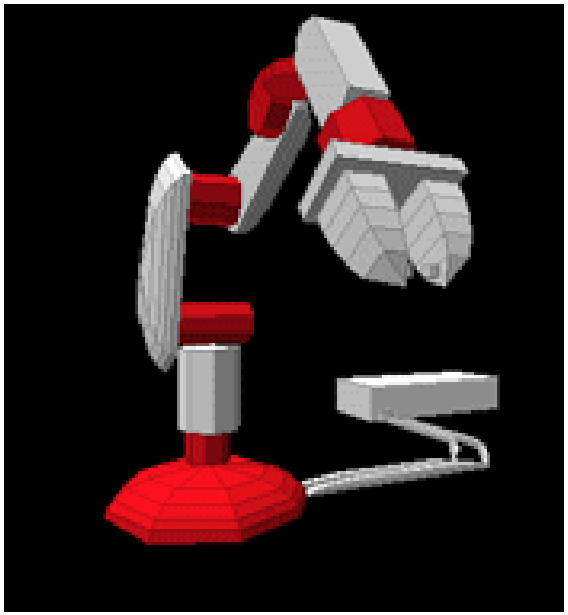
- Issues instructions to the robot.
- Controls peripheral devices.
- Interfaces with robot.
- Interfaces with humans.

End Effectors (The hand)



- Spray paint attachments
- Welding attachments
- Vacuum heads
- Hands
- Grippers

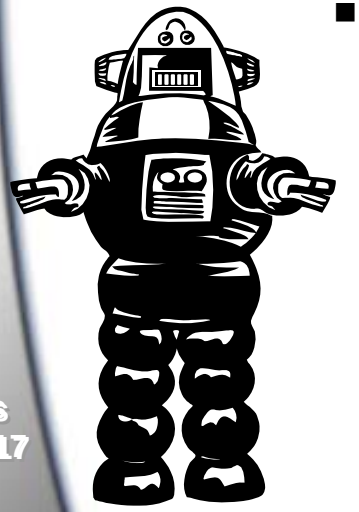
Power Source (The food)



- Electric
- Pneumatic
- Hydraulic

Increasing productivity while maintaining safety

- Safety = Productivity
  - Cost of an accident
    - Lost Time
    - Hospitalization
    - Loss of confidence
      - Company
      - Management
      - Machinery



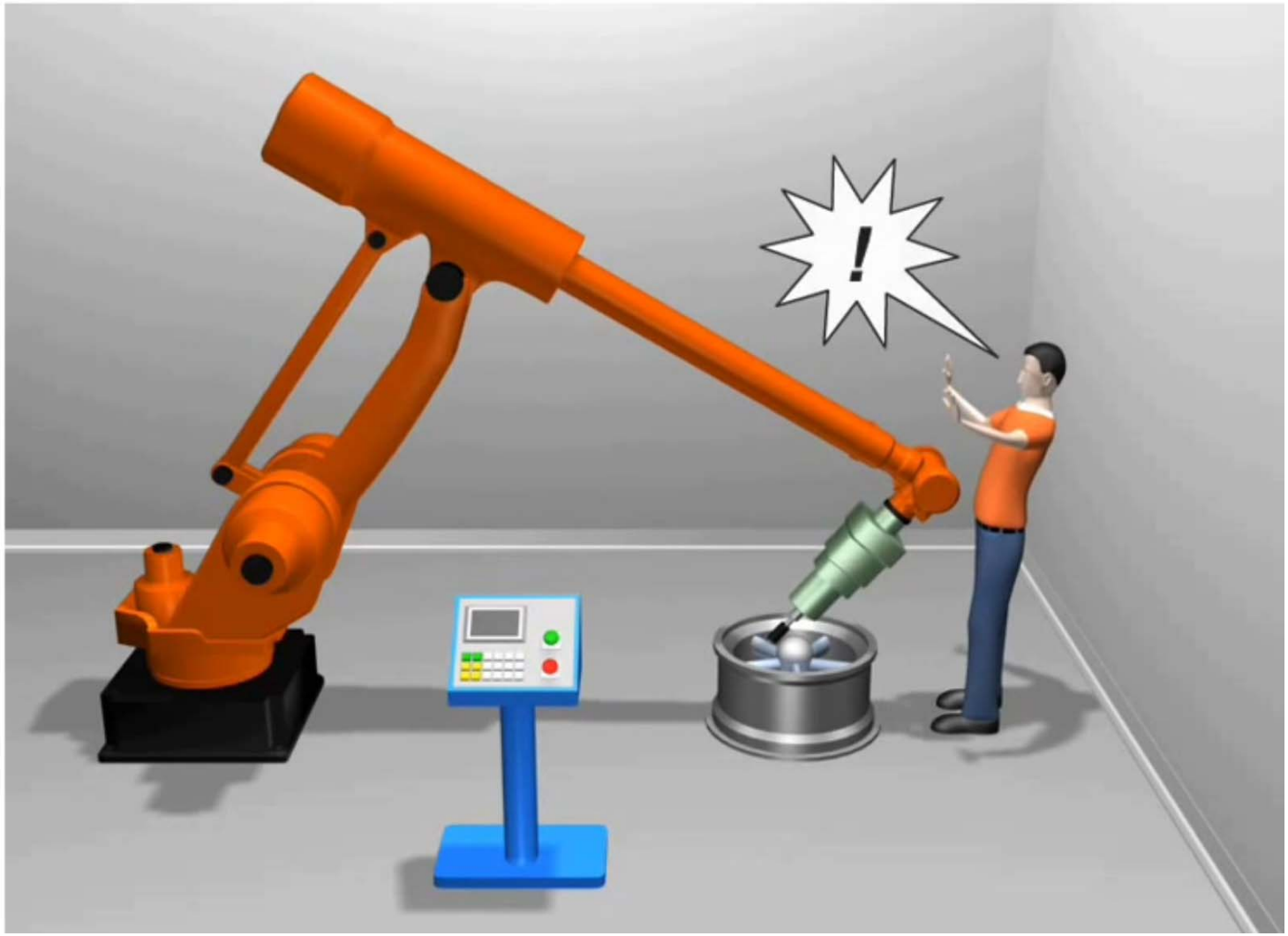
Consequences Of A Serious Injury	
Loss of Earnings	$1,755,000
Hospitalization	$ 96,000
Ongoing Therapy	$10,000
Outpatient Treatment	$90,000
Cost Of Retraining	$100,000
Home Help	$243,000
Compensation For Pain & Suffering	$80,000

Robot Safety

Environment/Proximity Control General Types

1. Physical Barriers
2. Interlock Gated Barriers
3. Vertical Light Curtains
4. Horizontal Light Curtains

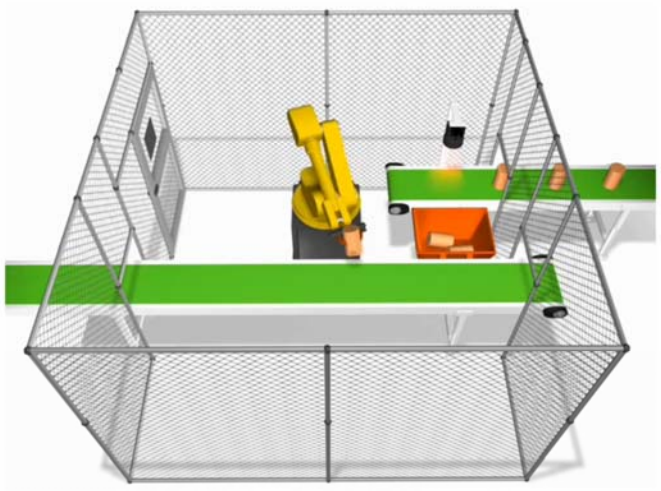
Robot Safety
(Room for you and the robot)

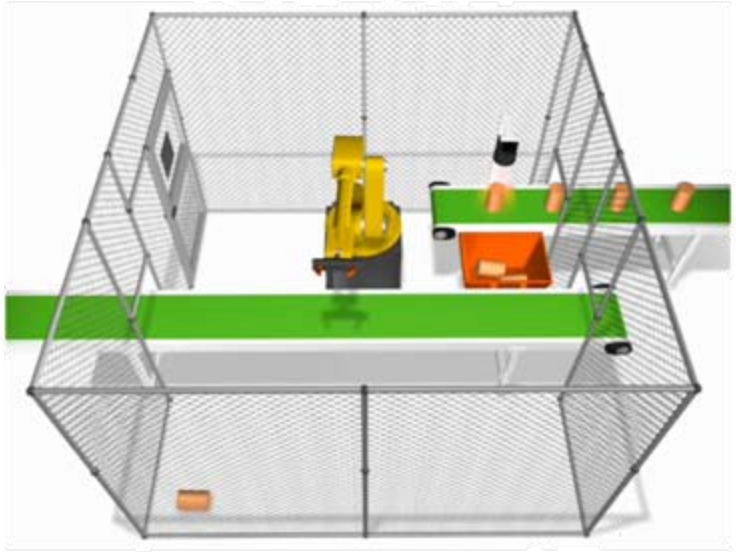


Going in to the safety area

- Going in to perform work but keeping others out
- Injuries often occur when more than one person is inside the safety distance

Part Hazard

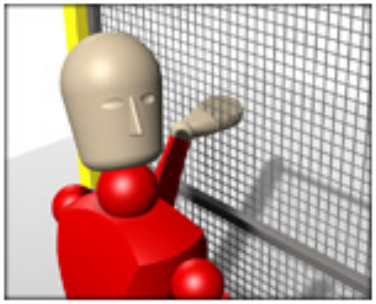




Part Hazard

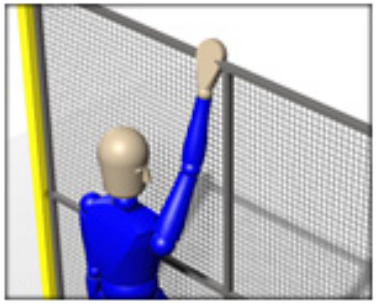
- Hazard due to the part being released
- This can also be an issue if when power is locked out that the part or material can be dropped or thrown.

Under, Over, Around & Through



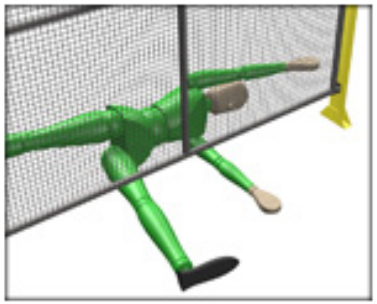
Mesh Aperture

Safe Zone has a mesh aperture of 22mm x 22mm which allows the fence to be located right up to 120mm from the hazard.



Height and Distances

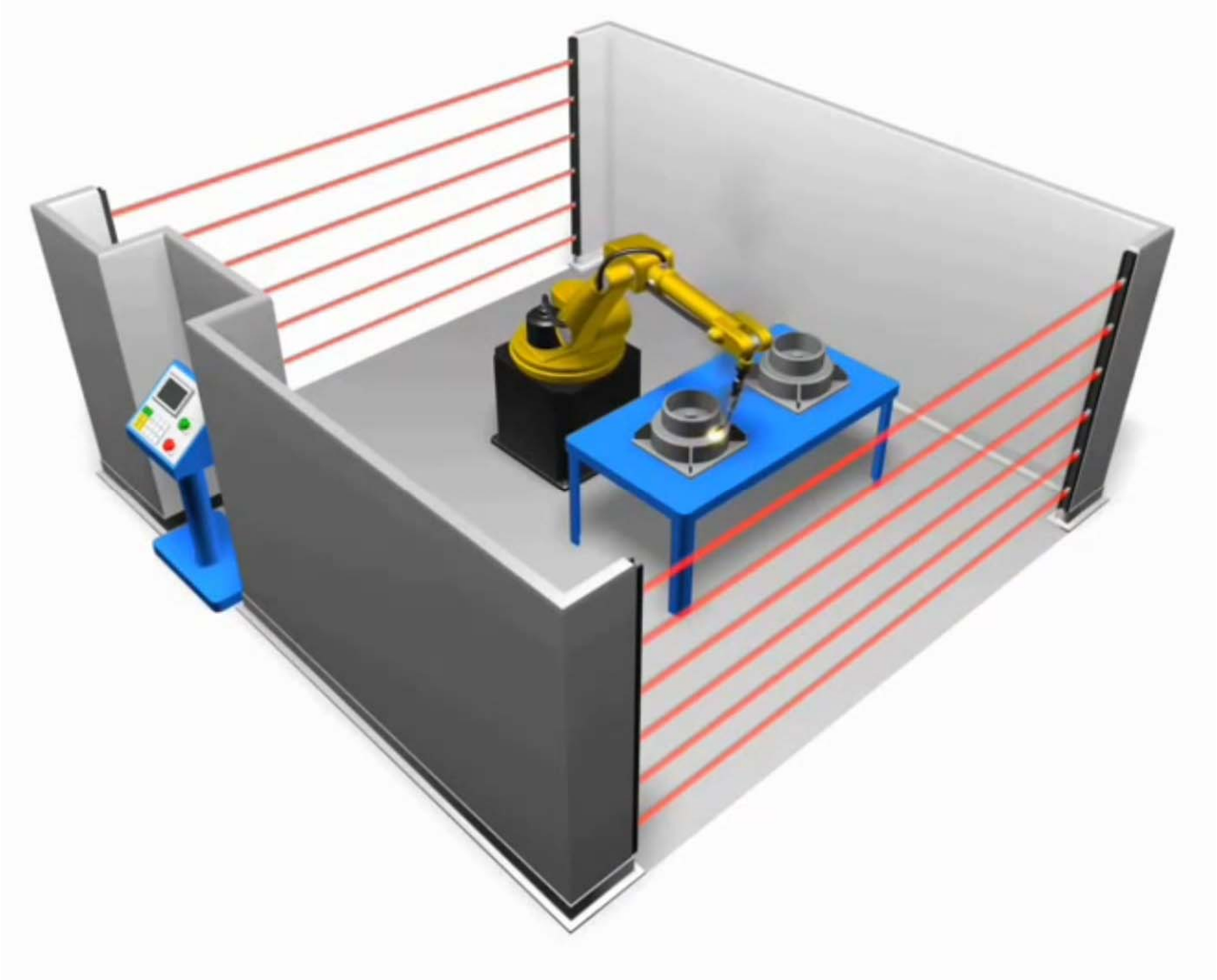
- Safe Zone has a panel height of 2000mm.
- Hazards between 2000mm and 2200mm above ground require a safety distance of 350mm.
- Hazards between 2200mm and 2400mm above ground require a safety distance of 100mm.



Clearances

Safe Zone provides a clearance of 200mm between the bottom of the panel and ground level for cleaning purposes. Where a hazard is located in the lower areas of the machine, the potential to reach under and around must be considered. Custom panels or the fence location can ensure correct safety distances.

Light Curtains / Perimeter Gd

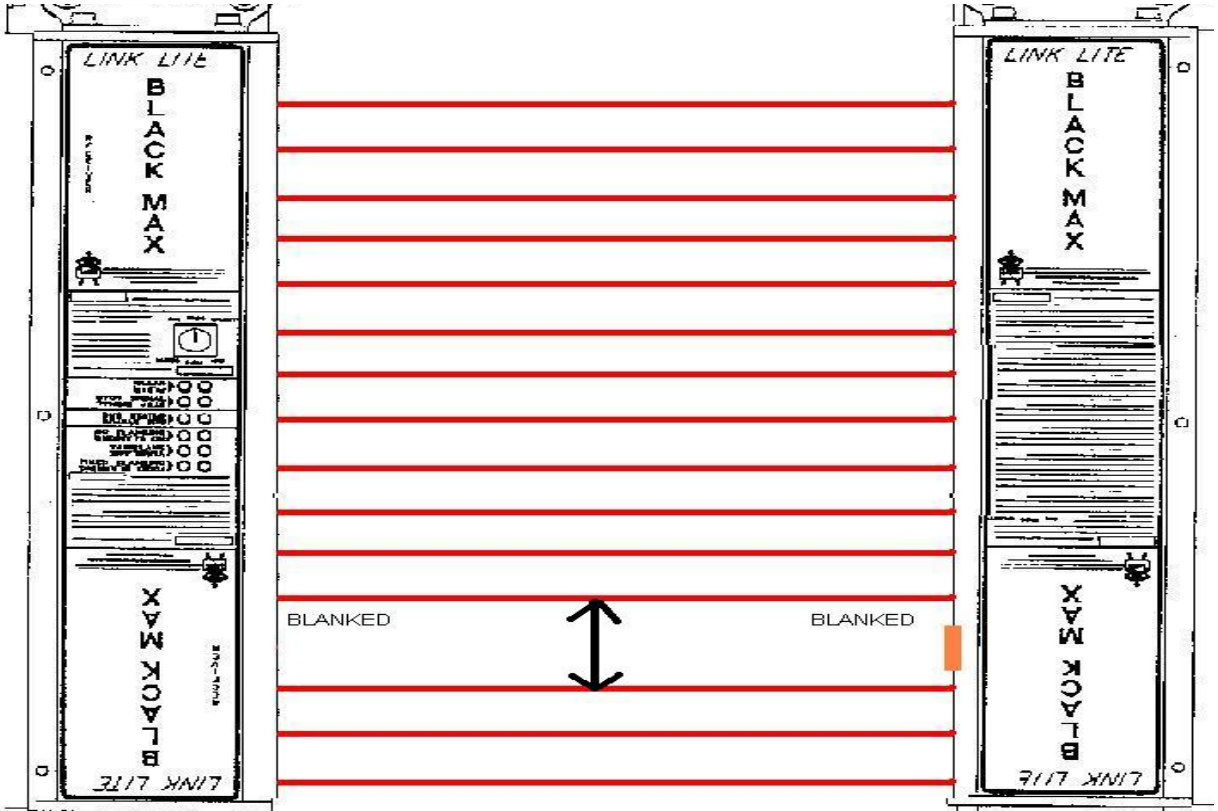


LIGHT CURTAIN
DEPTH OF PENETRATION

- Black Max Standard Light
  - Dpf = 3.4 x Obj Sensitivity – 0.275
  - No Blank Object Sensitivity = 0.95” (.75 Beam Spacing)
  - 1 Blank or Floating – Object Sensitivity = 1.7”

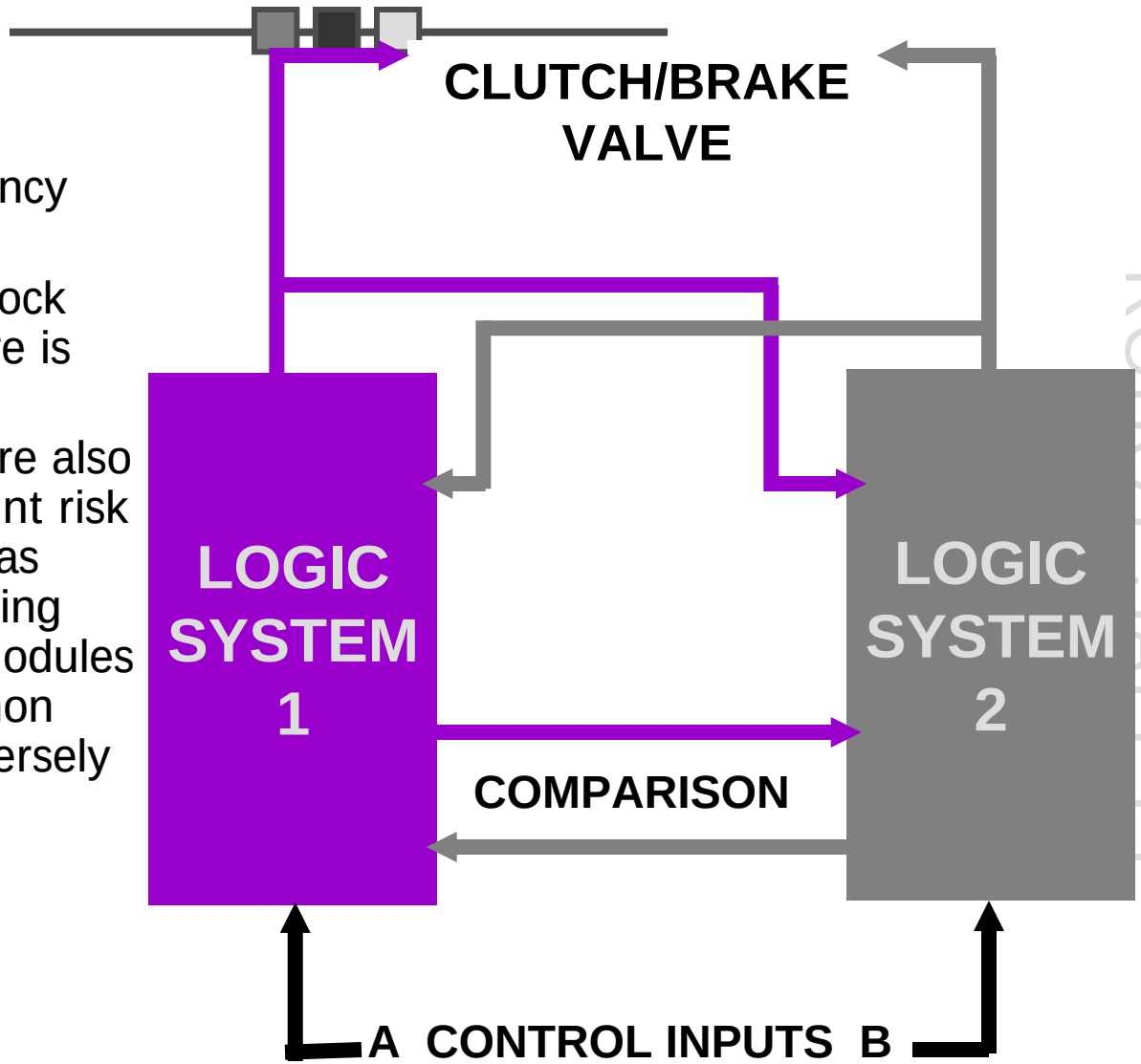
Do Not Use!

Instead Use

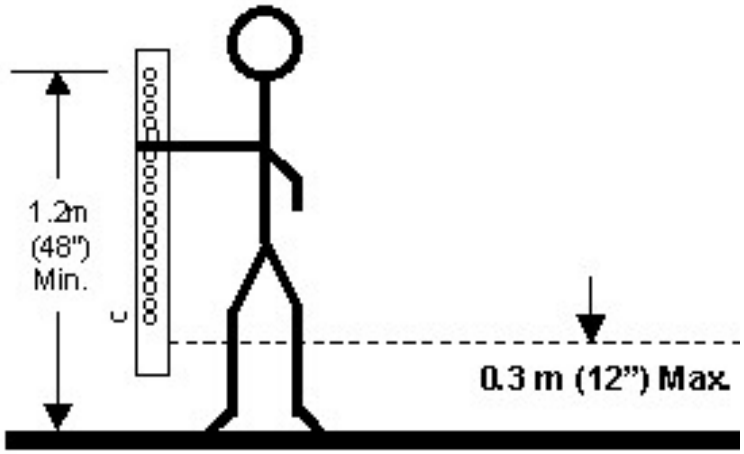


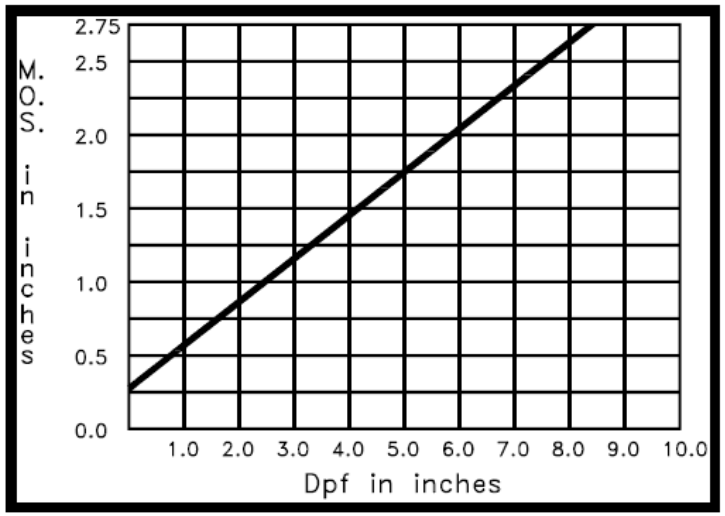
Control Reliability - PSD's are only as good as the control into which they are wired

- Control Reliability
  - Not just redundancy
  - Checking and Verification and lock out when a failure is detected.
  - New standards are also taking into account risk assessment and as such are addressing using different modules to prevent common failure rates. Diversely Redundant.



LIGHT CURTAIN
DEPTH OF PENETRATION

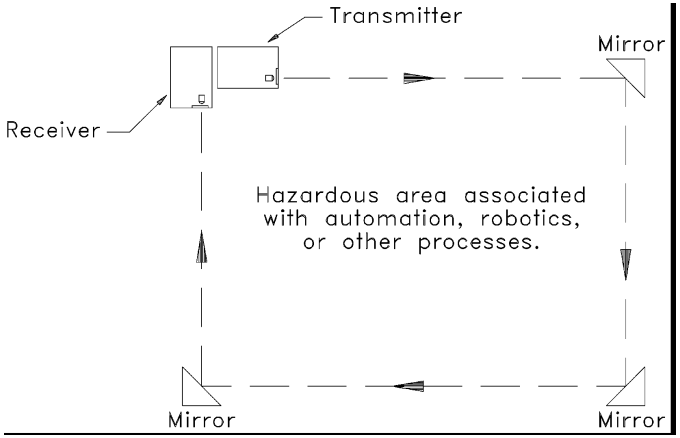


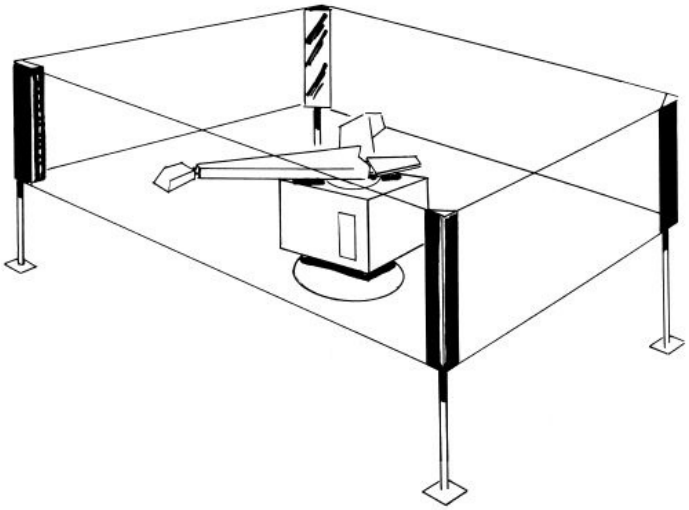


- Show the lights reaching over as well
  - Beam Blanking
    - "More Beams You Blank- The Further Back You Need To Be"

- PSD's Perimeter Guard

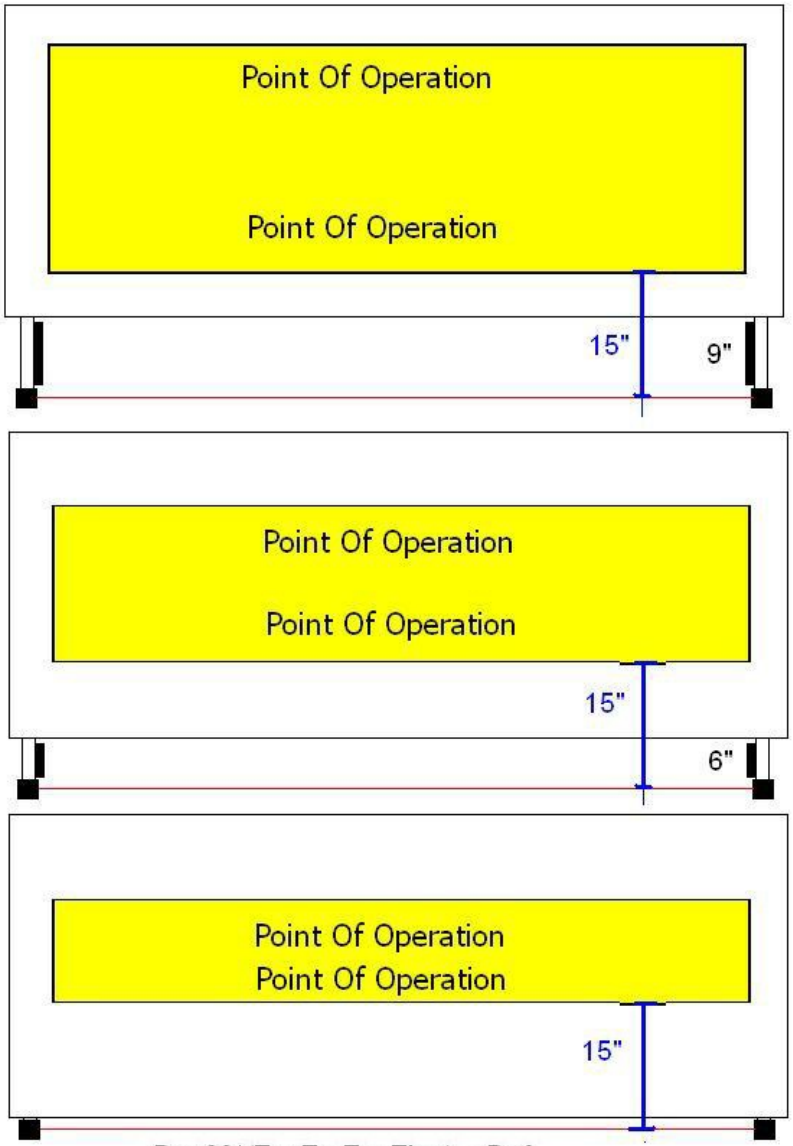
- Perimeter Light Curtain Guards
  - Perimeter Lights have a bigger beam spacicing since they are typically further away from the point of operation
  - They do not reset when you pass through the sensor, and therefore require you to reset the lights using a manual keyswitch.





POINT OF OPERATION

Remote Length Is Based On Dies Size & Point of Operation

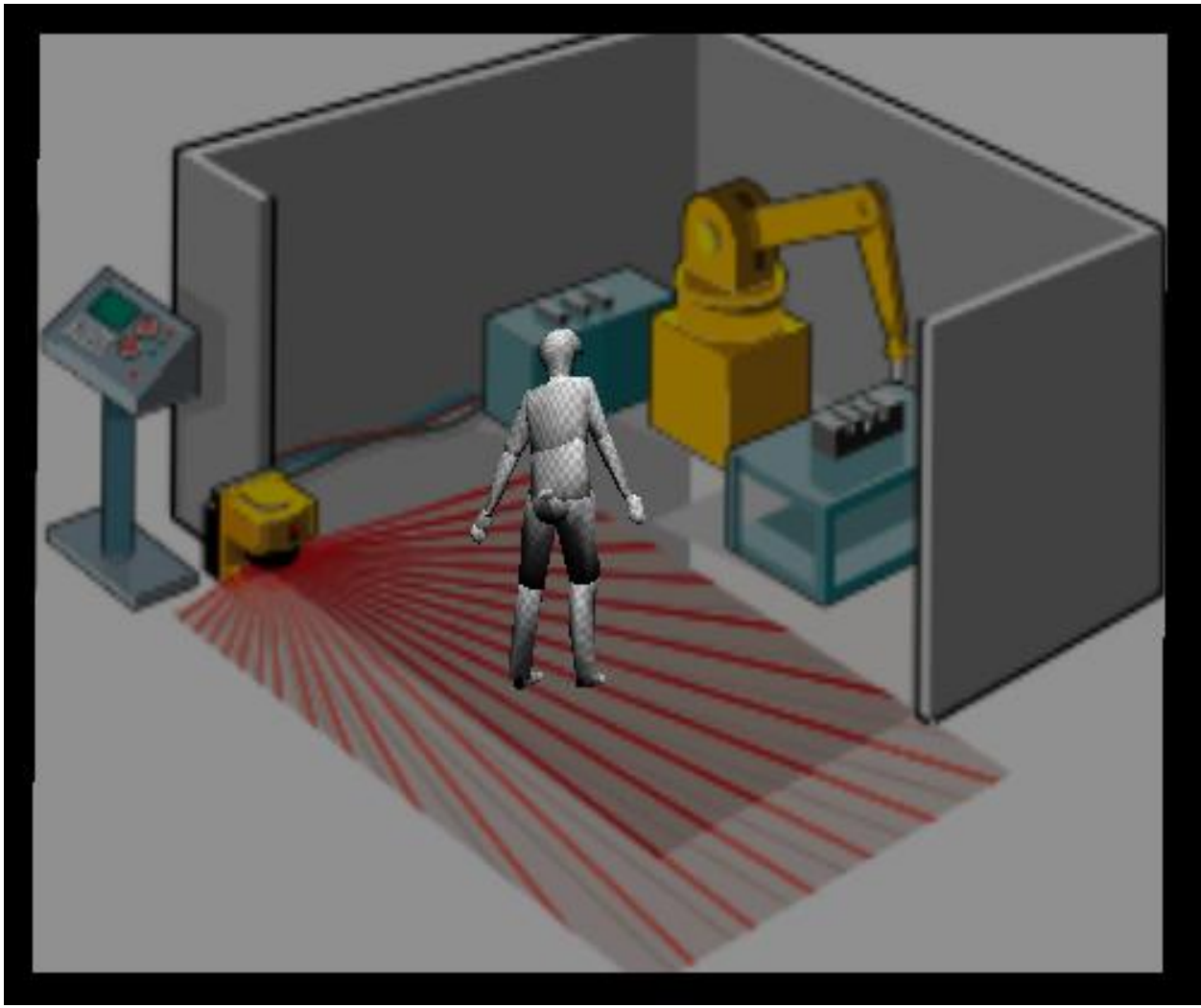


Ds=63*(Tc+Tr+Ts+Tbm) + Dpf

Ts - Stopping Time

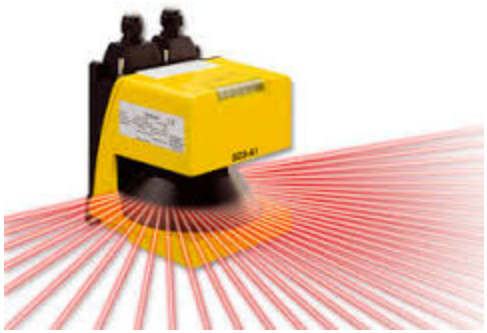
- Items That Impact Stopping Time
  - Velocity
    - Speed of each axis
  - Engagement (Inhibit off)
    - May or may not have motion
    - Motion available but no motion without signal (Not Safe)
  - Weight
    - Arm
    - Part or Tool
  - Inertia

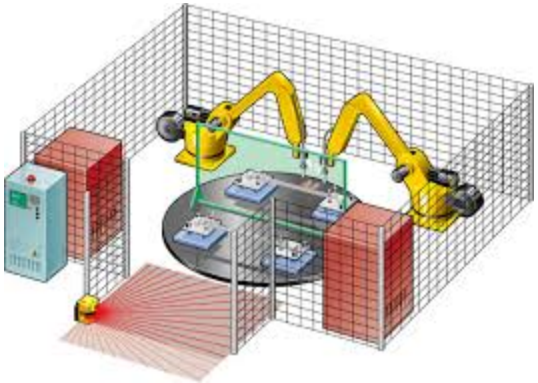
Risk Analysis



Are Laser scanners considered PSD's

- Lasers Scanners
  - Laser Scanners are not Presence sensing devices in the typical way.
  - Area Scanners used to scan are typically not categorized as the primary safety device which means you should be using another safety measure as the primary. These are typically used in a similar fashion as a safety mat. With the same limitation of reaching over
  - The same formulas don't apply for Light Curtains and Laser Scanners since you can reach over scanner





LOTO

- Integration with other equipment
  - Welding, Stamping, Insertion, Fabrication, etc
  - Often overlooked handshaking / communications
- Zone safety
  - Protecting areas, Lines of vision
- Primary and secondary safety
  - Guarding (with and without locking systems), Mats, Scanners, Light curtains
- What happens when it stops?
- What happens when it starts again?

Robots Performing The Work

- Types of robots- based on the work they do,
- Robots doing the work-
  - welding, inserting, etc
- Integration with other equipment
  - Welding, Stamping, Insertion, Fabrication, etc
  - Often overlooked handshaking / communications
- Zone safety
  - Protecting areas, Lines of vision
- Primary and secondary safety
  - Guarding (with and without locking systems), Mats, Scanners, Light curtains
- Fail-safes
  - What prevents unsafe action when pendent controlled- Speed limiting safety

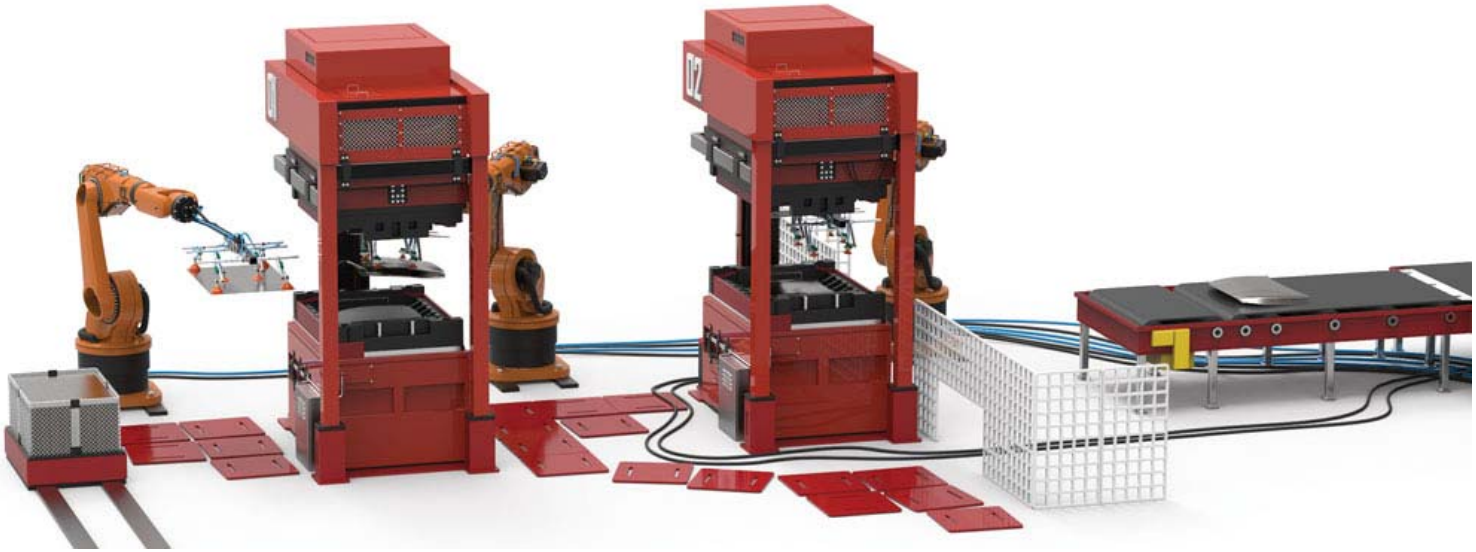
Integrating with other equipment

- Press Can run without the robot in the circuit
- Is robot still active, can it receive signals?
- Is it locked out?

- Who receives the stop signal first?
- If the robot is out of the circuit are the stops still active?

POINT OF OPERATION

Integration

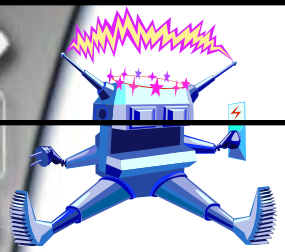


Robots Manipulating the part

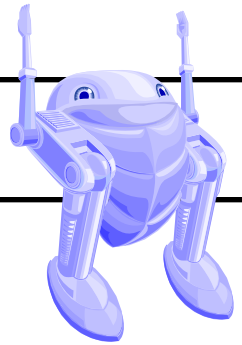
- Types of robots- based on the work they do,
- Robots manipulating the part-
  - Transferring, Inverting, pick and place, etc
- Integration with other equipment
  - Welder, Stamping Press, Insertion Mach, Fabrication, etc
  - Often overlooked handshaking / communications
- Zone safety
  - Protecting areas, Lines of vision
- Primary and secondary safety
  - Guarding (with and without locking systems), Mats, Scanners, Light curtains
- Fail-safes
  - What prevents unsafe action when pendent controlled- Speed limiting safety

General Robot Safety

- Safety/Operation
  - Essential personnel only
  - **Stay behind barriers**
  - Enter when authorized
  - Energize when approved
- Safety
  - Eye and foot protection at a minimum
  - **Assume you are at risk**
  - Scan for hazards
- Chemical Safety
  - Material Safety Data Sheets (MSDS)

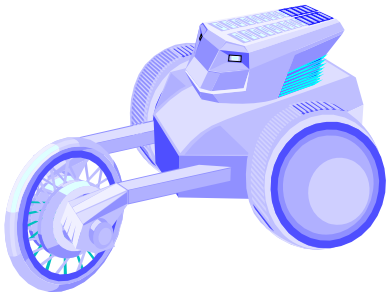


Prevention Overview



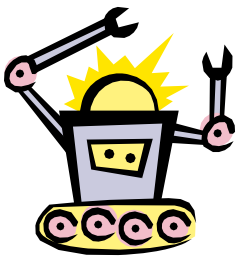
System components must be designed, installed, and secured so that the **hazards associated with stored energy are minimized.** Adequate room must be provided for a robot's movement as well as for workers. There must be a means for controlling the **release of stored energy in all the robotic** systems and for **shutting off power from outside the restricted envelope.**

A detailed risk assessment should be performed to ensure the safety of workers who operate, service and maintain the robotics system.



Control & Prevention

- **Eliminate EXPOSURE to the hazard if at all possible (Design / Engineer out)**
  - If there is NO EXPOSURE there is NO RISK of injury
- **Minimize the hazard if it can't be eliminated**
- **Restrict Access to necessary personnel**
- **Train/Educate those at risk**
  - Personnel who program, operate, maintain, or repair robots or robot systems should receive **adequate safety training** and be able to demonstrate competency in performing their jobs safely.
- **Protect against the damage or injury**
  - Personnel Protective Equipment (PPE)
  - Barriers and Safeguards



Hazards when Powered OFF

- When the tool is OFF is it Safe?
  - Not necessarily
    - Stored Energy
    - Potential Energy
    - Sharp points and edges
  - How do you know if it is Safe?
    - Only if you know all the tools' systems and hazards
    - Learn what components can store energy
    - Learn how energy can be released
  - **Integration with other equipment**
- Learn the hazards associated with each tool
- LEARN HOW TO OPERATE EACH TOOL BEFORE YOU USE IT

Training

- Safety training is necessary for new operators, **new or altered safeguards**, or new machines or operation
- Provide instruction or hands-on training in the following:
  - Describe and identify the hazards associated with each machine
  - The safeguards themselves, how they provide protection, and the hazards for which they are intended
  - How to use the safeguards and why
  - How and under what circumstances safeguards can be removed, and by whom (Remove an repair by qualified technician when safeguards are damaged, return to svc.)
  - What to do and what action to take if a safety incident occurs

Not Just PPE

- No Loose Clothing
  - Unnecessary risk around moving or rotating machinery (Can pull you into the machine)
  - Tripping Hazard
  - Can catch on nearby equipment

PPE Selection – Hazard Sources

- Motion
  - Machinery or processes where movement of tools, machine elements or particles could exist, or collision with stationary objects
- High Temperatures / Chemical Exposures
  - (Welded parts hot) (Chemical dip may remain)
- Harmful Dust
- Light Radiation
  - Welding, brazing, cutting, furnaces, heat treating, high intensity lights, etc.
- Falling objects or potential for dropping objects (Throw objects)
- Sharp objects
- Rolling or pinching objects which could crush the feet
- Layout of workplace and location of co-workers
- Electrical hazards
- Review injury/accident data to help identify problem areas

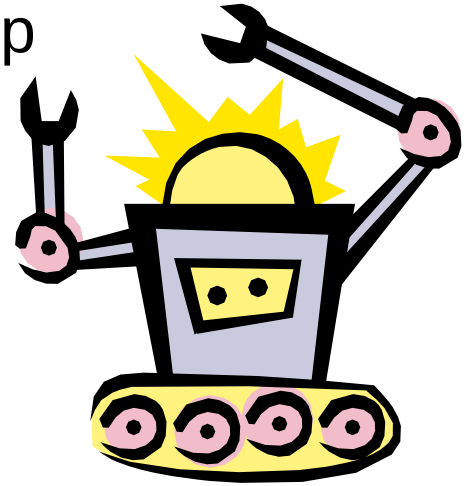
Anatomy of Robotic Accidents

Lower Incidence During:

- Demonstrated Autonomous Mode
- Operator Control with an Experienced Operator

Higher Incidence During:

- Operator Orientation, Training, and Experimentation
- Programming & Program Touchup
- New Operations
- Maintenance
- Adjustment
- Testing
- Repair
- Setup



Anyone who says change is good hasn't used a robot

Sources of Hazards

- **Human Errors**
  - New/One-time operations (e.g. crating/uncrating)
  - Prior to programming
  - **Interfacing activated peripheral equipment**
    - **Who's responsible / authorized**
  - Connecting live devices or sensors to the microprocessor or a peripheral
  - *The greatest problem, however, is overfamiliarity with the robot or tool* so that an individual places himself in a hazardous position.
- **Control Errors**
  - Faults within the control system of the robot
  - Errors in software
- **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.
    - Part is dropped, an operator enters the area

Sources of Hazards

- **Mechanical Failures**
  - Operating programs may not account for cumulative mechanical part failure, and faulty or unexpected operation may occur.
- **Power Systems**
  - Pneumatic or electrical power sources
  - Electrical shock and release of stored energy from accumulating devices **(Capacitors Servos)**

Types of Accidents

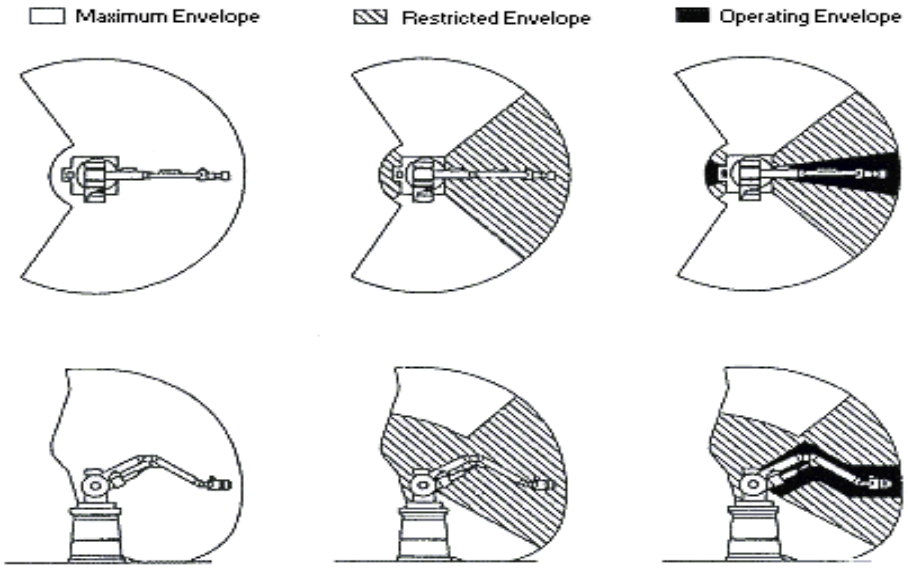
- **Contact**
  - Movement, component malfunction, or program changes
  - Crushing, Trapping, Piercing
- **Failure**
  - Components
  - Drive System
  - End Effectors
  - Peripheral Equipment
- **Trips, Slips, Falls**
- **Restricted Space**

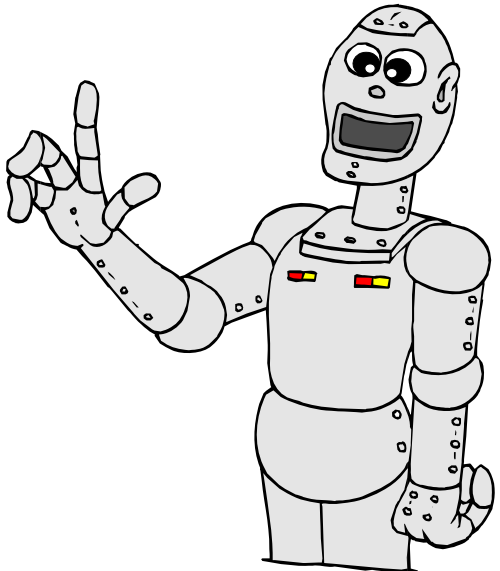
Risk of Injury or Damage

The WORKING ENVELOPE of the machine:

- More than just the robot – Any machine or tool
- Maximum, Restricted, Working
- Exists when there is energy to be released
- Changes DIMENSION when the robot MOVES
- Changing the program changes envelope (Home)

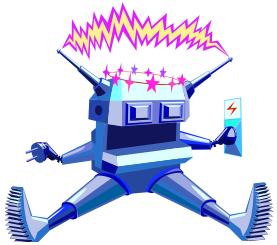
The risk exists to the edge the ENVELOPE + PART





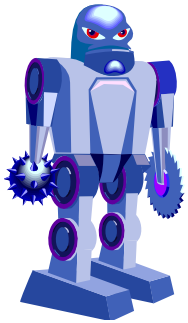
Energy Storage and Release (LOTO)

- **Mechanical Energy Storage**
  - Compressed Spring
  - Gear
  - Stalled Motor
  - Chain Tension
  - Momentum
- **Electrical Energy Storage**
  - Battery, Capacitor
- **Pneumatic Energy Storage**
  - Charged Air Cylinders
  - Compressed Air in Lines
- **Potential Energy Storage**
  - Extended Appendages
  - Bound Joints
  - Lifted Weights



Eliminate the Hazard

- Release stored energy before power-down
- Return it to its “home” position
- Power the equipment OFF



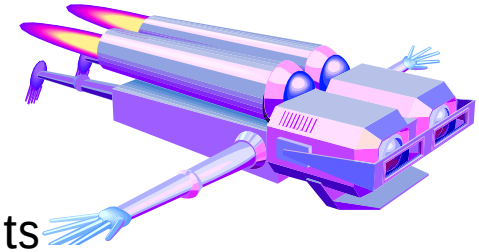
Safeguard Requirements

- Prevent Contact
  - The safeguard must prevent hands, arms, and any other part of a worker's body from making contact with moving parts.
- Secure
  - Workers should not be able to easily remove or tamper with the safeguard
- Protect from falling objects
  - The safeguard should ensure that no objects can fall into moving parts.
- Create no new hazards
  - A safeguard defeats its own purpose if it creates a hazard of its own.
- Create no interference
  - Any safeguard which impedes a worker from performing the job quickly and comfortably might soon be overridden or disregarded.
- Allow safe maintenance if possible.

Safeguards

- **RISK ASSESSMENT.** At each stage of development of the robot and robot system a risk assessment should be performed.

- **SAFEGUARDING DEVICES**. Personnel should be safeguarded from hazards associated with the restricted envelope (space) through the use of one or more safeguarding devices:
    - Mechanical limiting devices
    - Nonmechanical limiting devices
    - Presence-sensing safeguarding devices
    - Fixed barriers (which prevent contact with moving parts)
    - Interlocked barrier guards



- **AWARENESS DEVICES**
    - Chain or rope barriers
    - Supporting stanchions or flashing lights
    - Signs, whistles, and horns

Final

- During many of these operations, the Operator, Programmer or Maintenance Worker may temporarily be **<u>within the robot's working envelope</u>** where unintended operations could result in injuries.
- Mechanical hazards include workers :
  - Colliding with equipment (Robot's Arm or peripheral equipment)
  - Being crushed (trapped between the Robot's Arm or peripheral equipment)
  - Injured by falling objects (failure of gripper mechanisms with resultant release of parts)

Final

- Effective Safeguarding of Robotics
  - The proper selection of an effective robotic safeguarding system should be based upon a **hazard analysis** of the robot's system use, programming and maintenance operations.
  - Among the factors to be included are the tasks a robot will be programmed to perform.
    - Start up
    - Command or programming procedures
    - Environmental conditions
    - Location and installation requirements
    - Possible human error

    FULLY UNDERSTAND !

Thank You!!

Questions?

- Your Time Is Very Important, Thank You

- Thanks to all of you who made this training possible.
  - Free Manufacturing Podcast www.longevityindustries.com
  - Free 3 Day OSHA training www.linkelectric.com

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