Machine guarding

Your first line of defense

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Agenda

- North American Standards (OSHA/ANSI)
- Control Reliability
- Safety Distance
- Safety Systems and Software
- Stop Categories
- Circuit Structures (Safety)
- Safe Guarding Methods (pros and cons of each method)
- Risk Assessment
- European Safety Standards/Requirements (SIL, PL, Categories) including migration from EN 954-1 to ISO 13849-1
- Safety Light Curtains

Machine Safeguarding learning objectives

- Understand where most of the safety requirements originate
- Understand why risk is the key word in safety
- Understand that there are differences between US and European requirements
- Learn about the ease and power of Safety Controllers

Goals of machine safe guarding

- Reduce Injuries
- Reduce Cost
- Comply to Standards
- You have to ask are you striving for compliance, safety or a combination of the two.
- Compliance is adhering strictly to published standards and can be viewed as a reactive or defensive approach to safety (evade prosecution)
- Safety is a proactive approach to achieve a condition with as little risk as possible (or practical)

Machine Safeguarding

- Standards - OSHA & ANSI

Machine Safeguarding

- **Occupational Safety and Health Administration**
- OSHA was created by the Occupational Safety and Health Act of 1970
- www.osha.gov

- **American National Standards Institute**
  - ANSI is a private, non-profit organization that administers and coordinates the U.S. voluntary standardization system.
  - originally founded in 1918
  - www.ansi.org

Machine Safeguarding

So What's the Difference (OHSA and ANSI)

- OSHA is the LAW in the U.S.
- ANSI is a private group of representatives of users, manufacturers, etc.
- ANSI issues standards that are suggestions, recommendations and guidelines BUT!

Machine Safeguarding

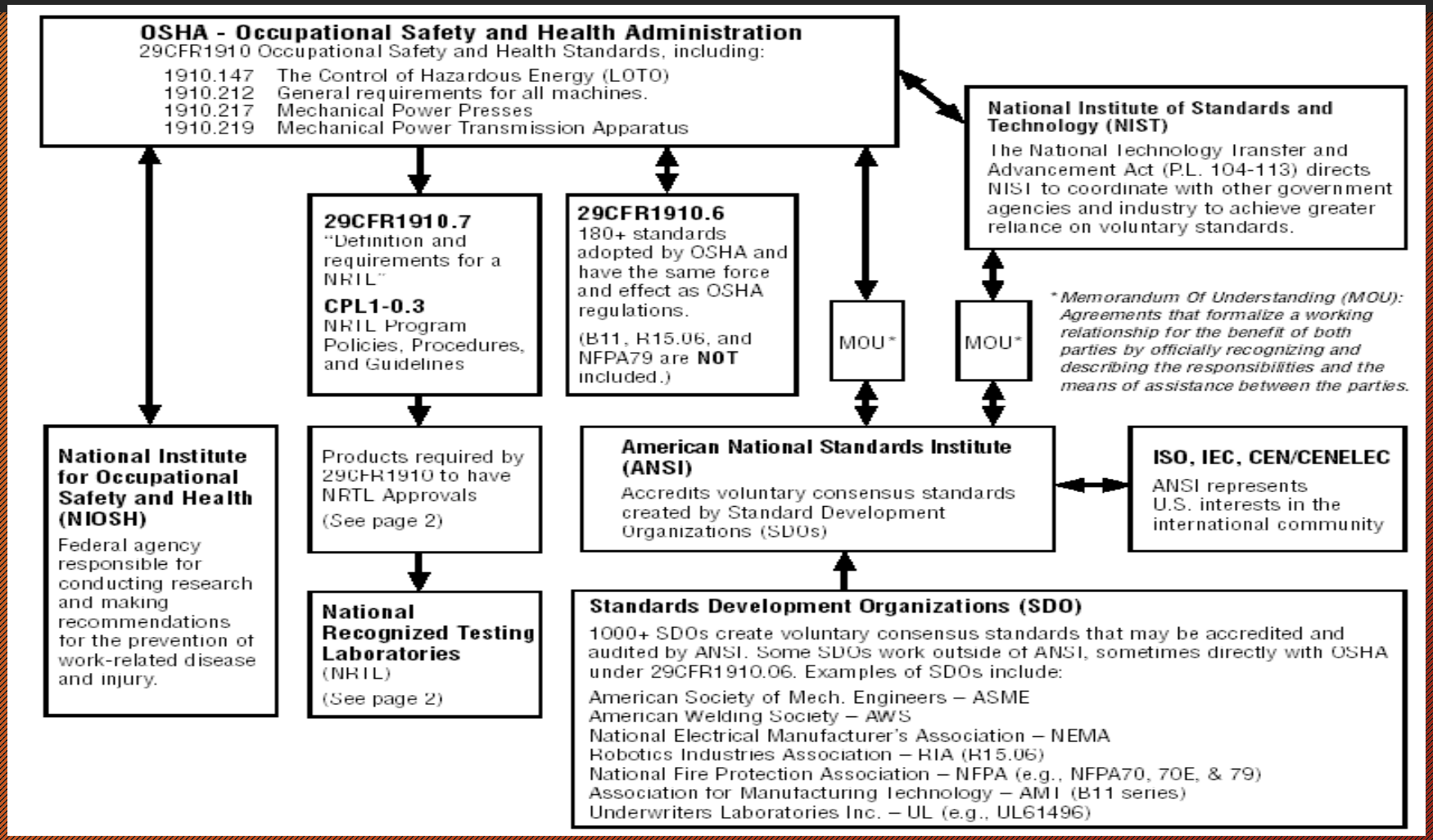
- **National Technology Transfer and Advancement Act of 1995**

- Section 12(d)(1) "… all Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies …"
- OSHA has **increasingly referred** to ANSI standards in 5(a)(1) citations since the passage of the National Technology Transfer Act

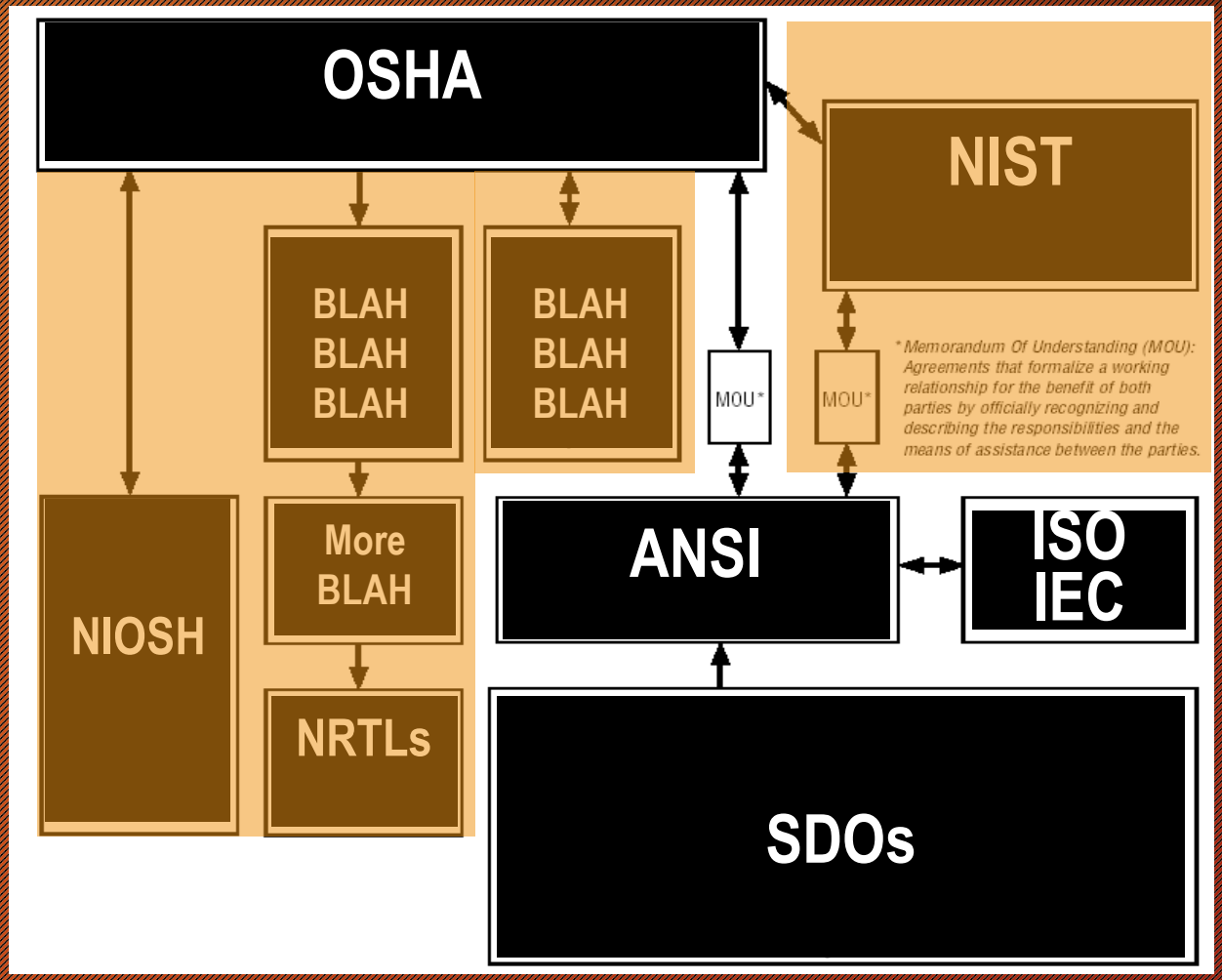
Machine Safeguarding

- **How does OSHA determine what is adequate 1910.212?**
- Consensus Standards: OSHA recognizes the valuable contributions of national consensus standards, and in many respects, offer useful guidance for employers
- OSHA's Enforcement Policy
  - If an employer complies with a consensus standard rather than the OSHA standard in effect at the time of inspection; AND
  - If the employer's action clearly provides equal or greater employee protection that violation may be de minims (to minor to merit consideration)

Machine Safeguarding



Machine Safeguarding



Machine Safeguarding

- **OSHA - General Duty Clause**

5. Duties

(a) Each employer -

(1) shall furnish to each of his employees employment and a place of employment which are **free from recognized hazards** that are causing or are likely to cause death or serious physical harm to his employees;

It is every employer's legal responsibility to recognize workplace hazards and provide safe and healthful working conditions for their employees.

Machine Safeguarding

- **OSHA – Federal Regulations**

1910.212 - General requirements for all machines.

  - "The point of operation of machines whose operation exposes an employee to injury **shall be guarded**."
  - "The guarding device shall be in conformity with **any** appropriate standards …"
  - 90% of Machine Guarding is addressed by this section (General Machine Guarding)

Machine Safeguarding

- Control Reliability

Machine Safeguarding

(1975)OSHA 1910.217 Paragraph b(13) Control Reliability: When required by paragraph (c)(5) of this section, the control system shall be constructed so that a failure within the system does not prevent normal stopping action from being applied to the press when required, but does prevent initiation of a successive stroke until the failure has been corrected. The failure shall be detectable by a simple test, or indicated by the control system. This requirement does not apply to those elements of the control system which have no effect on the protection against point of operation injuries.

Paragraph (c)(5) additional requirements for safeguarding. Where the operator feeds or removes parts…

Machine Safeguarding

- **OSHA**
- Control Reliability Part 1 OSHA 1910.217"... The control system shall be constructed so that a failure within the system does not prevent the normal stopping action from being applied when required."
- Requirement #1: Redundancy / Dual Channel Control
  Redundancy or dual channel control is required so that if any single failure were to occur in the control system a redundant or second channel could apply stopping action when required.

Machine Safeguarding

- Control Reliability Part 2 OSHA 1910.217 "...But does prevent initiation of a successive stroke until the failure is corrected."

- Requirement #2: Self-Checking – Required so that if any single failure were to occur in the safety system, the failure would be detected and all further machine cycles are prevented until the failure is corrected.

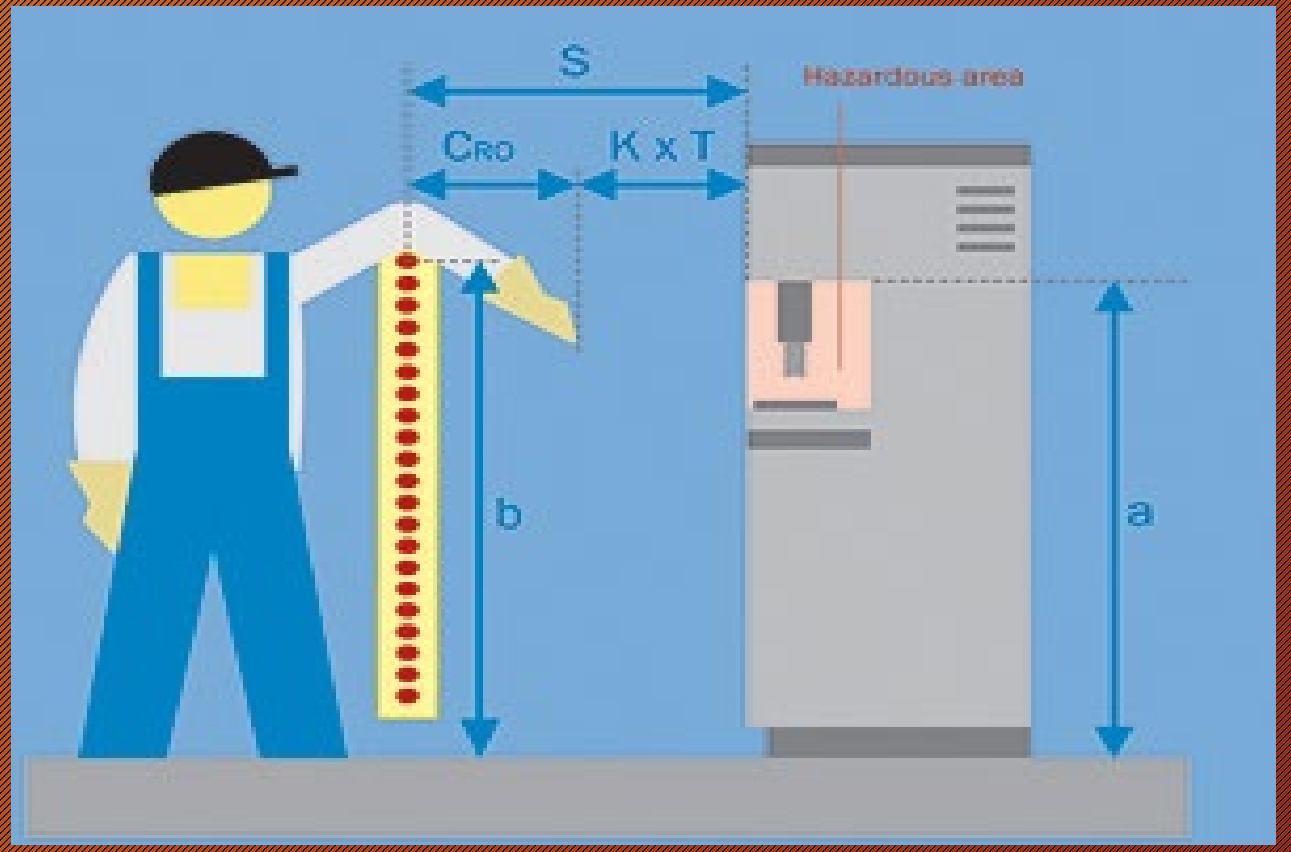
Machine Safeguarding

Machine Safeguarding

- **OSHA**
- Control Reliability Part 3 OSHA 1910.217 "The failure shall be detectable by means of a simple test, or indicated by the control system. This requirement does not apply to those elements which have no effect on the protection against point of operation injuries."
- Requirement # 3: Testable – System design requires that before the safety system is activated, all safety related control elements be tested. (For hand fed operations this test must be every machine cycle.)

Machine Safeguarding

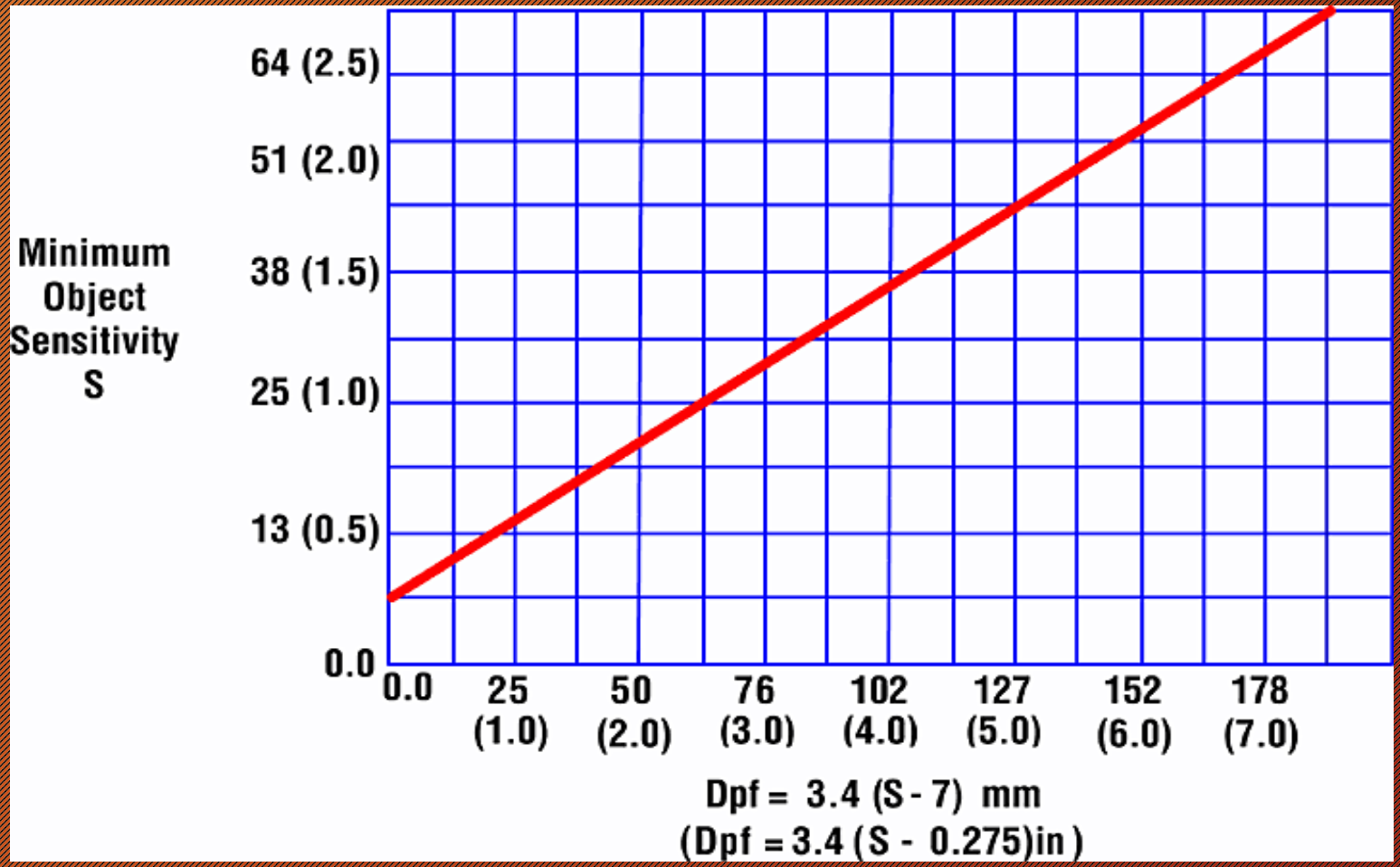
- Safety Distance



Machine Safeguarding

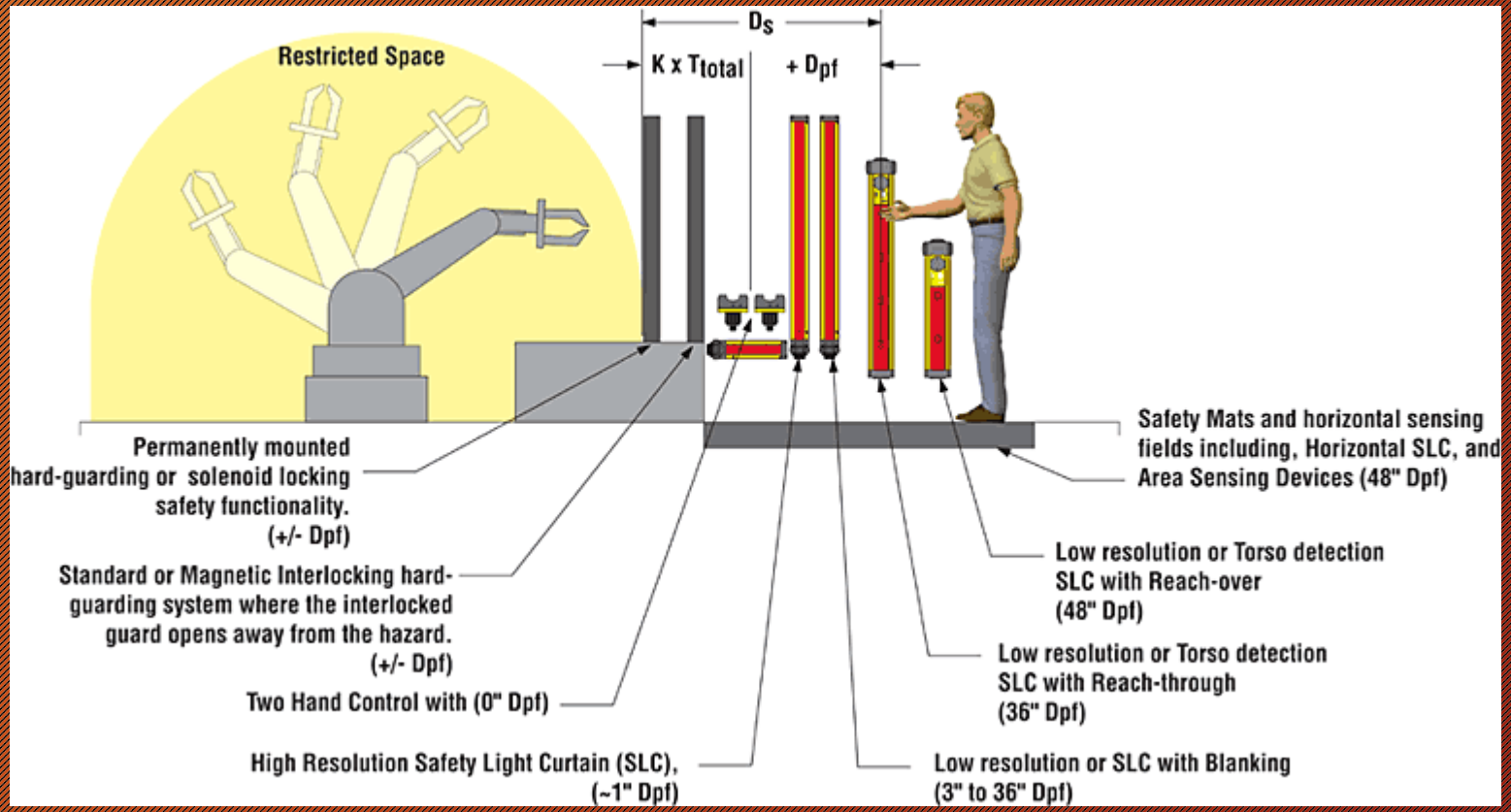
- **Safety Distance**
- **Ds = K * (Ts + Tr) + Dpf**
- Separation Distance (inches) = DS
- OSHA Hand-Speed Constant (in/sec) = K = 63 in/sec
- Machine Response (msec) = Ts
- Safety Device (msec) = Tr
- Depth Penetration Factor (inches) = Dpf

Machine Safeguarding



Machine Safeguarding

- **Safety Distance**



Machine Safeguarding

- Safety Systems and Software

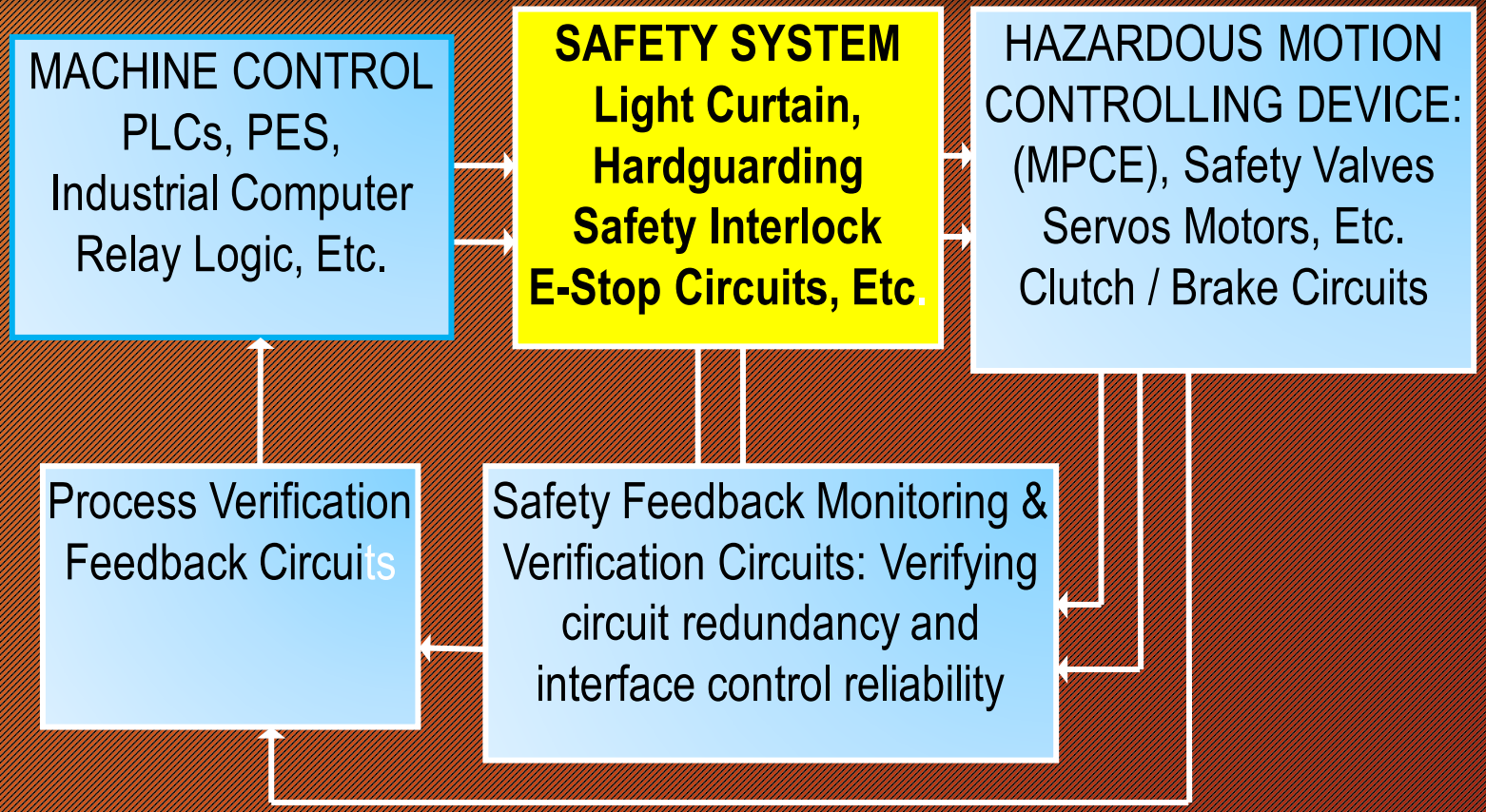
Safety Light Curtain

Machine Safeguarding

- The use of non safety rated programmable controllers in a safety system design is still a problem in the integration process.

- Several new and existing standards are addressing the specific requirements for software based safety systems. These standards include UL 1998, **IEC 61508, IEC 62061**, ISA S84 and DIN V VDE 0801

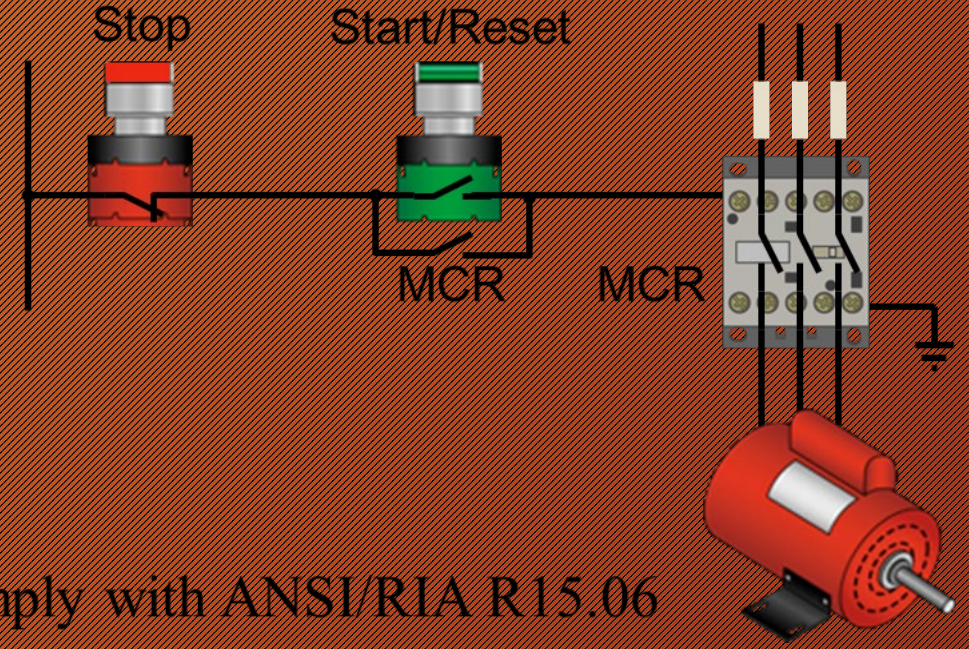
Machine Safeguarding



The safety system should be the last enabling set of contacts in the control circuit

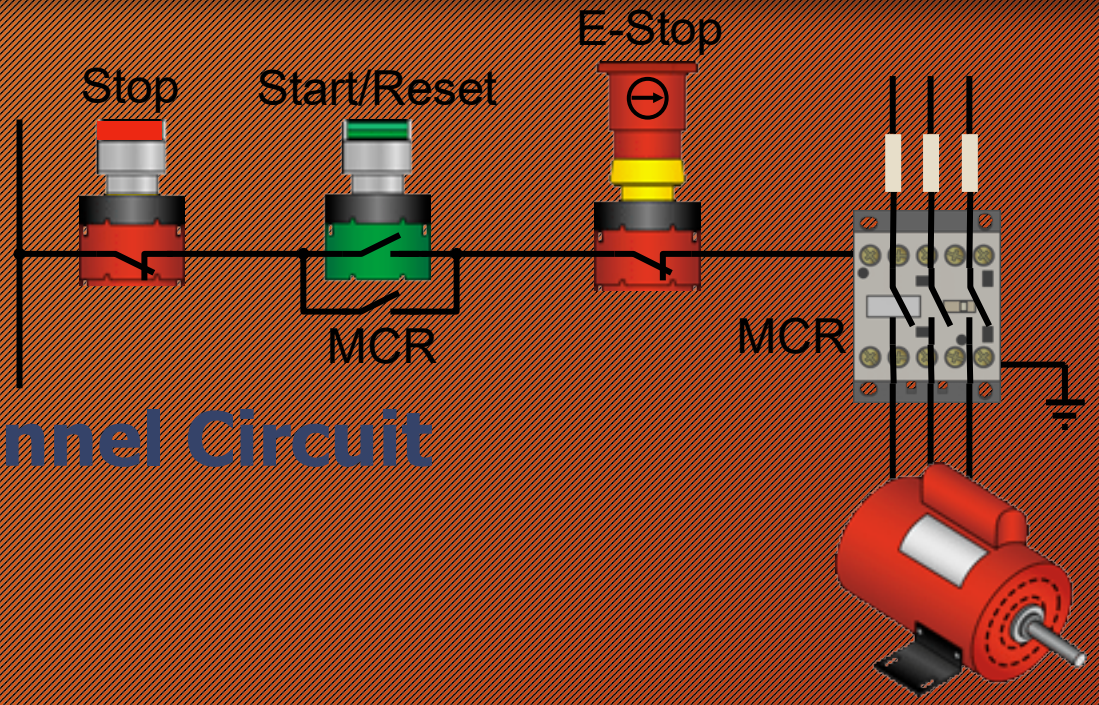
Machine Safeguarding

- **Basic Circuit**



A "**Basic Circuit**" can comply with ANSI/RIA R15.06 Simple Safety Circuit, or ISO13849-1 Category B or 1.

Machine Safeguarding

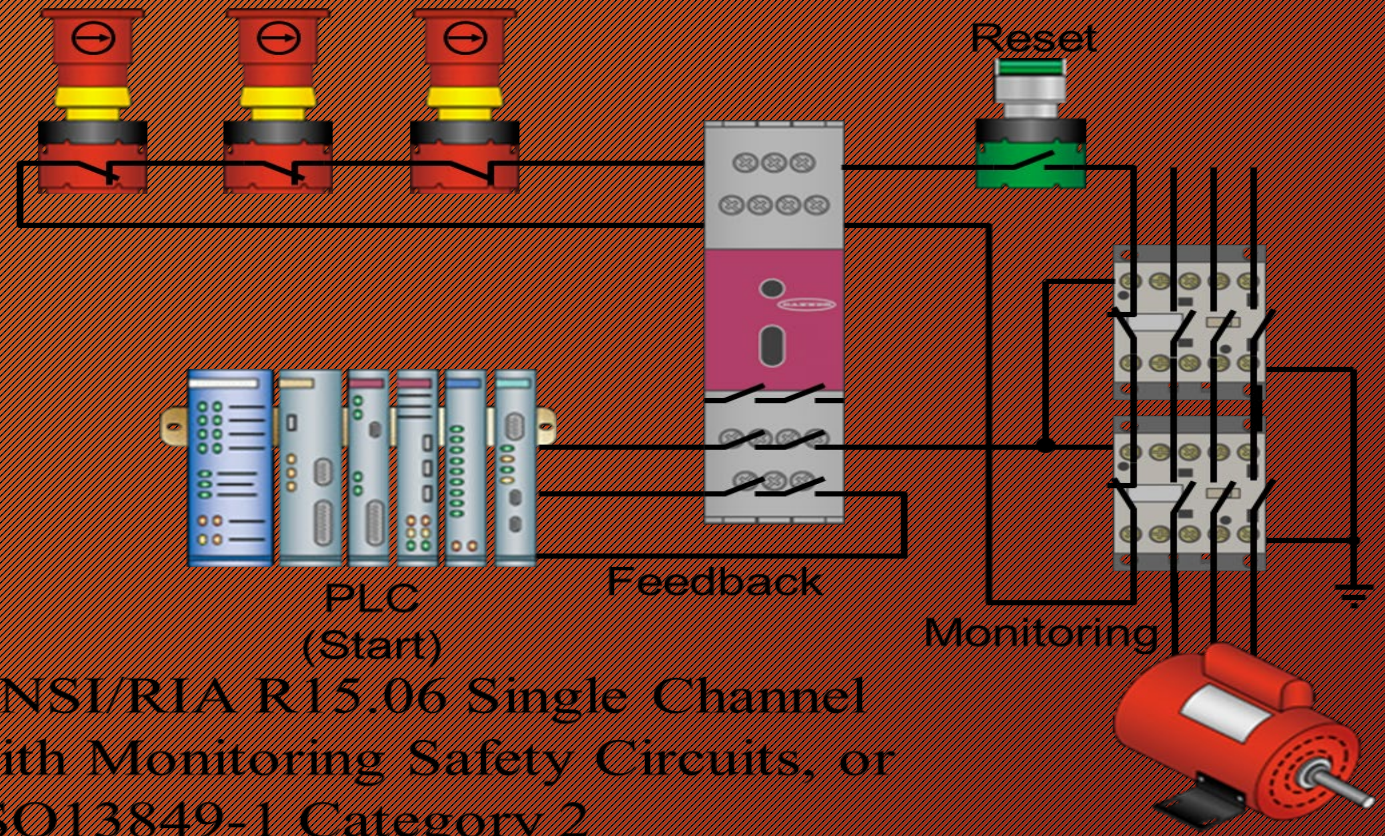


Single Channel Circuit

"**Single Channel Circuit**" can comply with ANSI/RIA R15.06 Single Channel Safety Circuits, or ISO13849-1 Category 1 or 2.

Machine Safeguarding

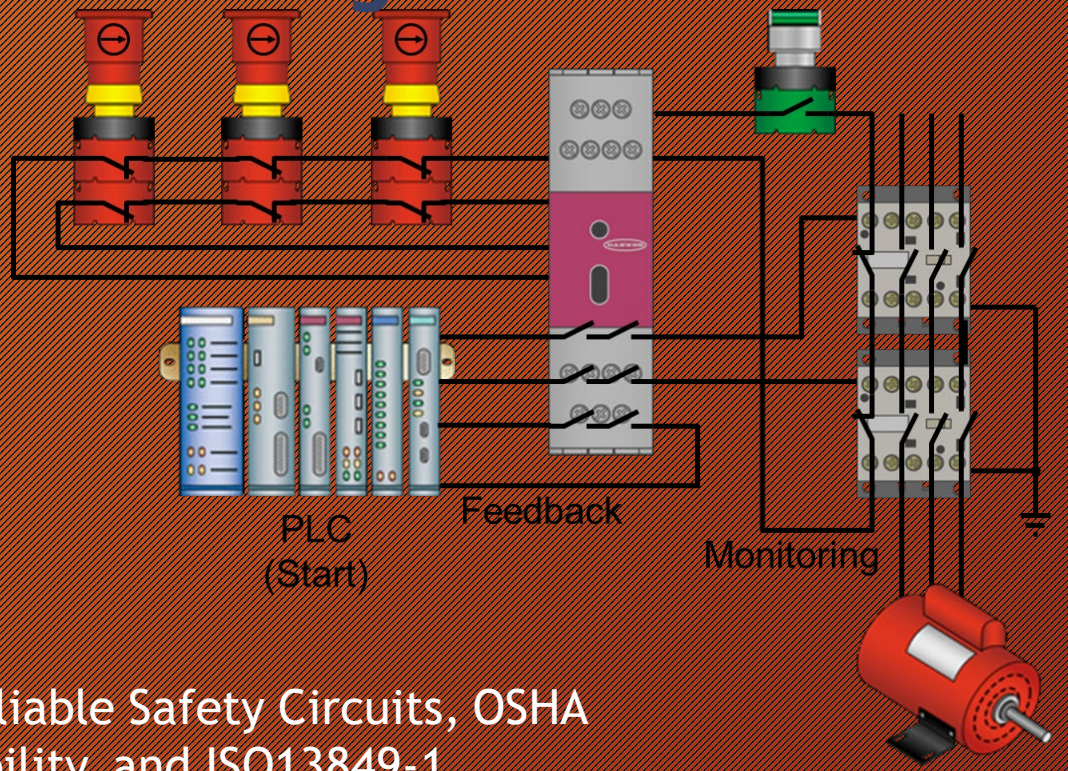
Single Channel with Monitoring Circuit



ANSI/RIA R15.06 Single Channel with Monitoring Safety Circuits, or ISO13849-1 Category 2

Machine Safeguarding

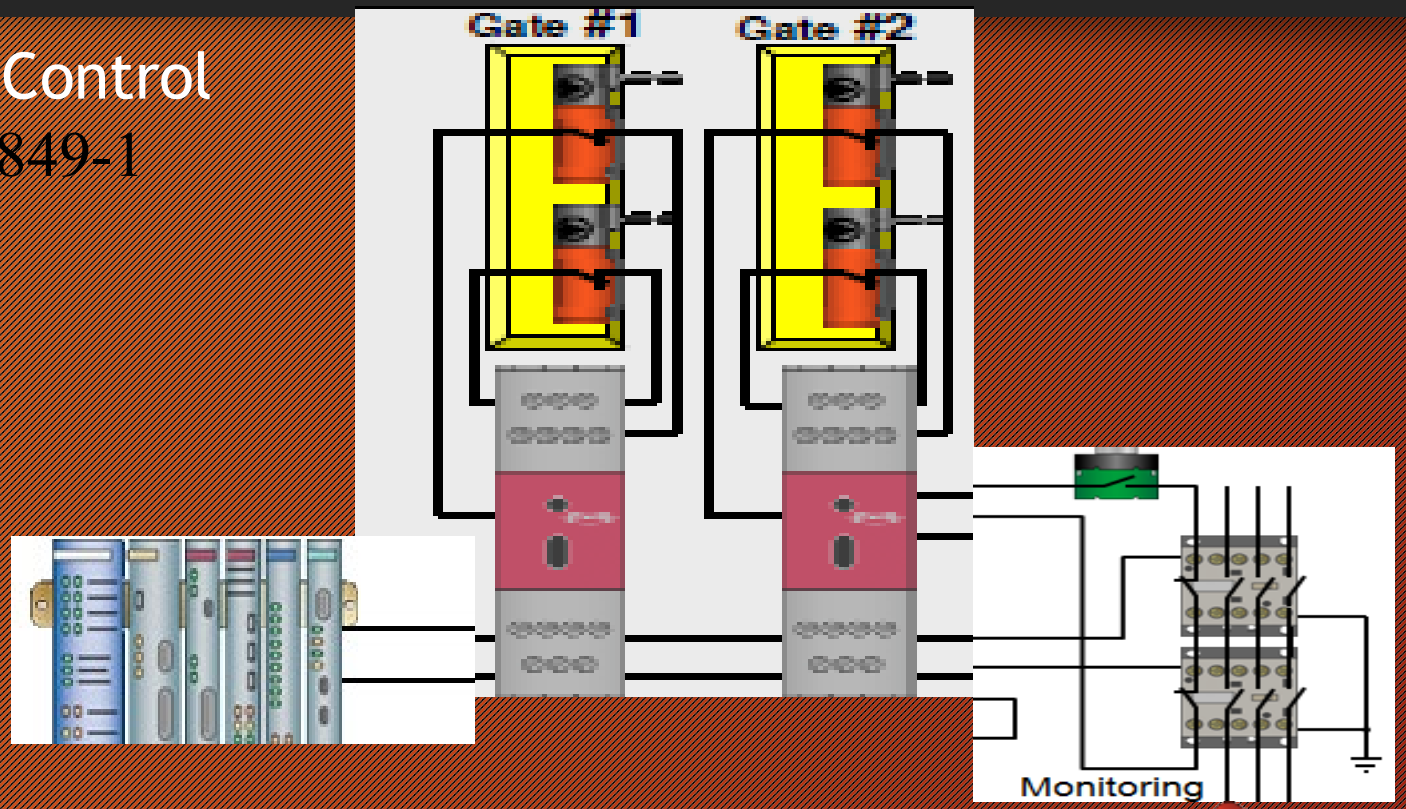
Dual Channel with Monitoring Circuit



ANSI/RIA R15.06 Control Reliable Safety Circuits, OSHA and ANSI B11 Control Reliability, and ISO13849-1 Category 3 or 4

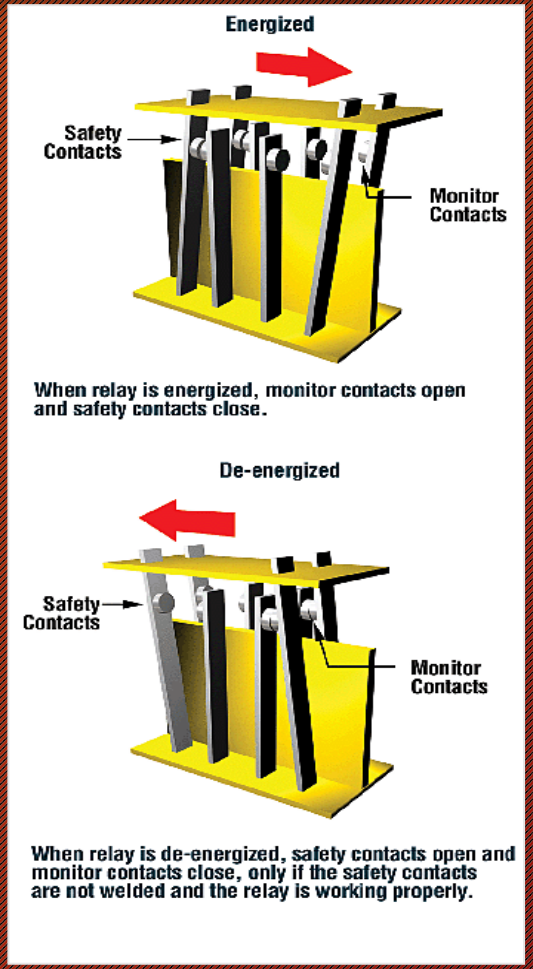
Machine Safeguarding

- OSHA and ANSI B11 Control Reliability, and ISO13849-1 Category 3 and 4



Machine Safeguarding

- What makes a relay
- SAFE?
- Force Guided Relays
- All contacts are mechanically tied together
- This allows the system to detect a welded contact



Machine Safeguarding

- **NFPA 79 Stops**
- There are many designations for stop commands
- Emergency, Safety, Top, End-of-travel, Overrun, Master, Cycle, etc...

Machine Safeguarding

- **NFPA 79 Category Stops**
- There are three categories of stops
- These are circuit performance criteria for a stop
- This criteria is valid for all types of machine stops (Safety, Cycle, Master, Top, Machine Protection, etc…)

Machine Safeguarding

- **NFPA 79 Category Stops**
- "**Category 0:** Stopping by Immediate Removal of Power to the Machine Actuators …"

  Application: Anything that can stop immediately without creating a hazard
- "**Category 1:** A controlled stop with power to the machine actuators available to achieve the stop and then removal of power when the stop is achieved."

  Application: Servo Applications, Calibrated Stops
- "**Category 2:** A controlled stop with power left available to the machine actuators."

  Application: Gantry systems, and where removal of power in a cycle will cause a hazard.

Machine Safeguarding

- NFPA 79 Emergency Stop
- Emergency Stops can only be category 0 or 1
- Emergency Stop is not the same as the Energy Isolating Device used in Lock Out/Tag Out (LOTO)
- LOTO has to isolate all forms of energy from the mechanical device

Machine Safeguarding

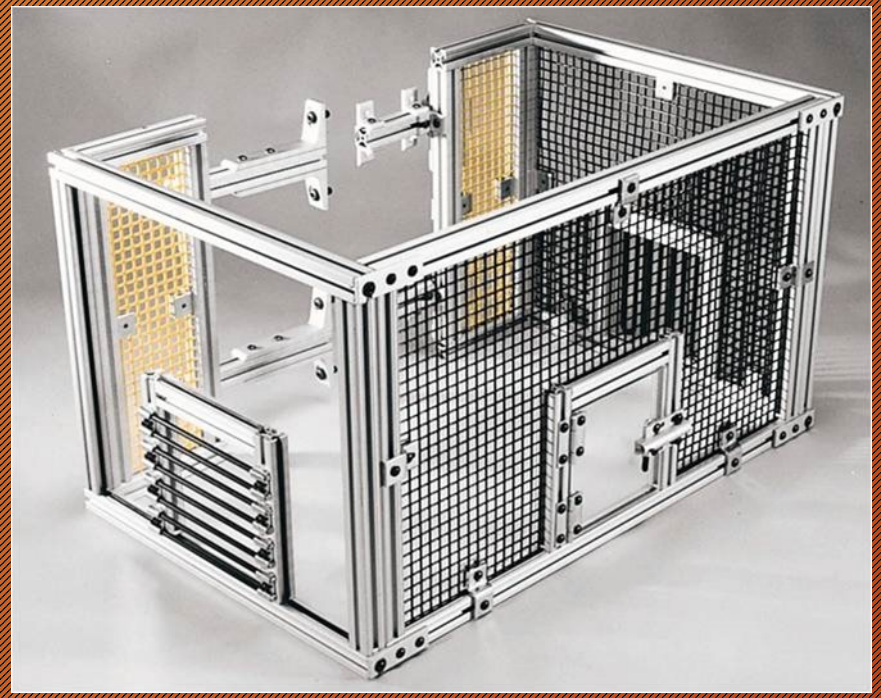
- NFPA 79, 2002 Edition
  Electrical Standard for Industrial Machinery
- **10.7.4 Emergency Stop Actuators:**
  - Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW.
  - The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications

Machine Safeguarding

Safe-Guarding Methods
Pros and Cons

Machine Safeguarding

Fixed Guards



Machine Safeguarding

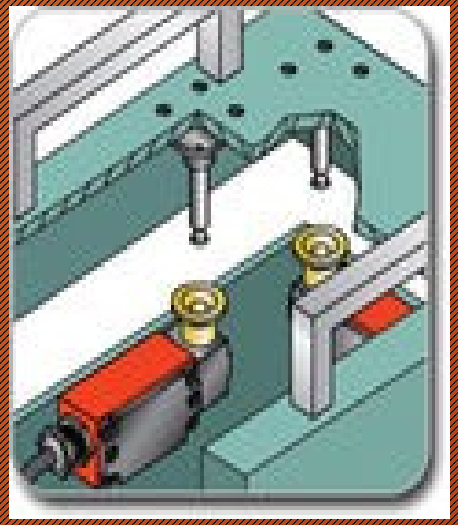
- Function
  - Physical barrier of sufficient strength to keep the hazard contained and the user out of it
    - Permanently installed (or at least requiring a tool to remove the guard)
  - Must prevent the user from reaching over, under, around or through the barrier
  - Most machines include some form of fixed guards

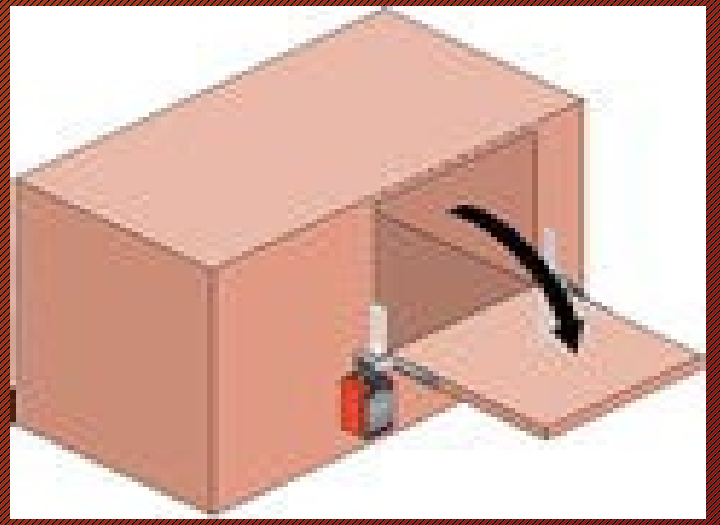
Machine Safeguarding

- Advantages
  - Protects all individuals
  - Low cost (small areas)
  - Low maintenance
  - Long Life
  - Contains ejected parts
- Disadvantages
  - Limits access and visibility
  - Maintenance activities may require removal
  - Can hinder production

Machine Safeguarding Doors

Interlocked Guards (Doors)





Machine Safeguarding Doors

- Function
  - Physical barrier of sufficient strength to keep the hazard contained and the user out
    - Barrier must be interlocked to send a stop signal if it is opened or removed
  - Must prevent the user from reaching over, under, around or through the barrier
  - Barrier and interlocking method must be difficult to defeat

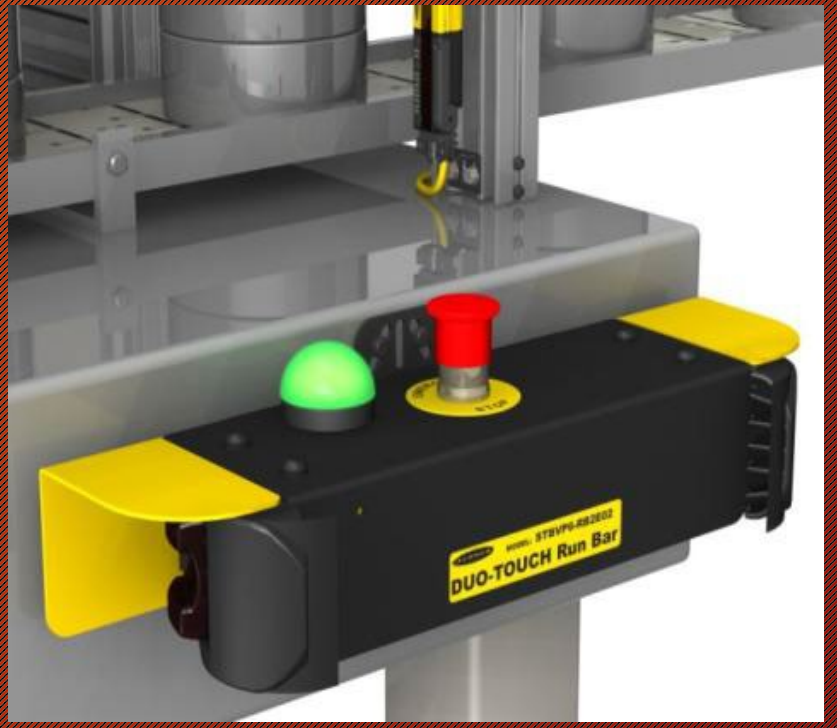
Machine Safeguarding Doors

- Advantages
  - Protects all individuals
  - Low cost (small areas)
  - Can keep people out until process is complete (locked)
  - Contains ejected parts
- Disadvantages
  - Limits access and visibility
  - Increased maintenance (alignment issues as machine ages)
  - Can hinder production
  - Potential ergonomic impact

Door Interlock Guards

Machine Safeguarding

Two Hand Control Systems



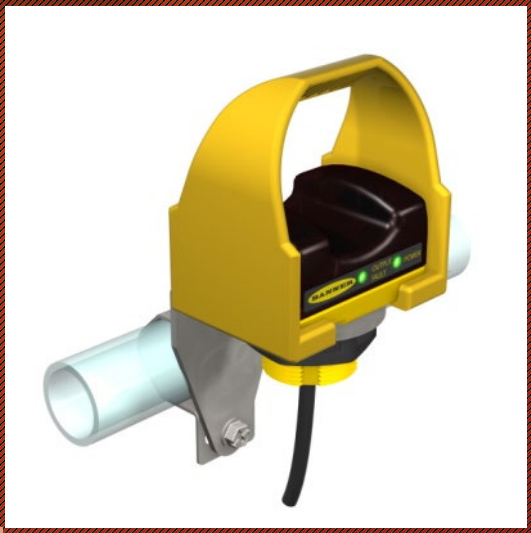
Two Hand Control Systems

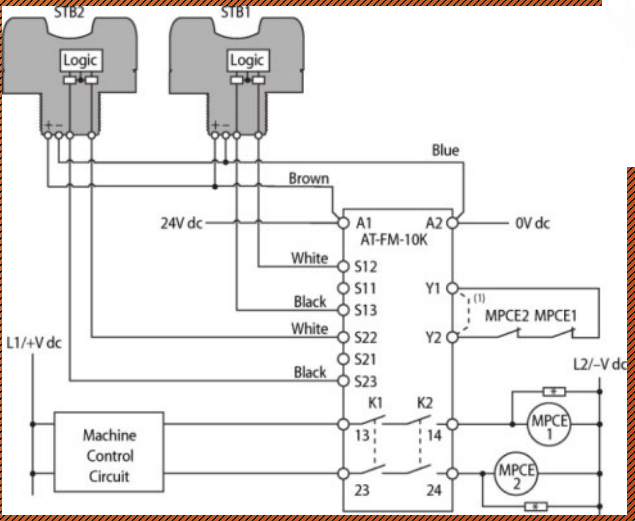
- Function (simplified)
  - Requires the operator to activate two buttons in less than 0.5 seconds and hold these buttons during the entire cycle
    - Removing either hand sends a stop signal
    - To start another cycle both buttons must be released
  - Buttons must be positioned such that a person can not activate them with a single hand (or hand and arm).

Two Hand Control Systems

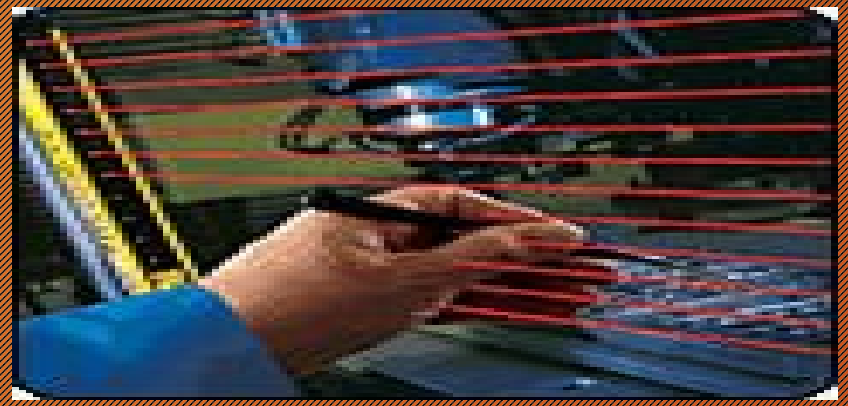
- Advantages
  - Operator's hands are away from the hazard
  - Low initial cost
  - Low maintenance
- Disadvantages
  - Potential ergonomic impact
  - No protection from ejected parts
  - Provides protection only for the operator
    - (Can position buttons so that the operator's body blocks the opening to help protect others)

Two Hand Controls



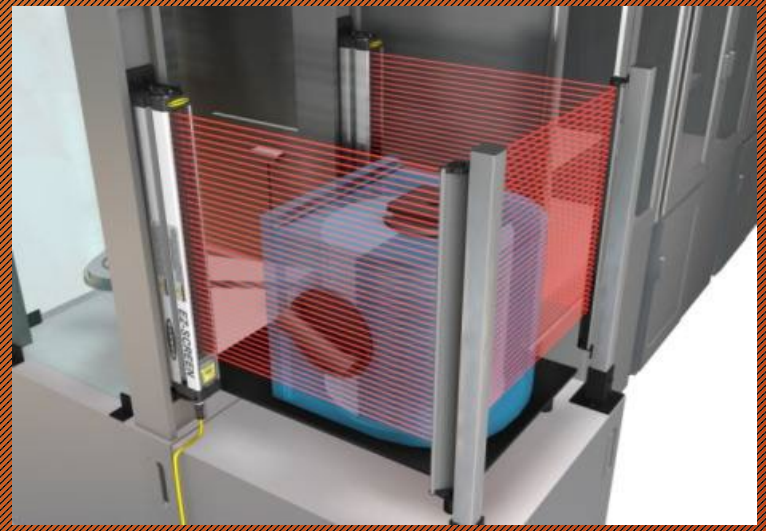


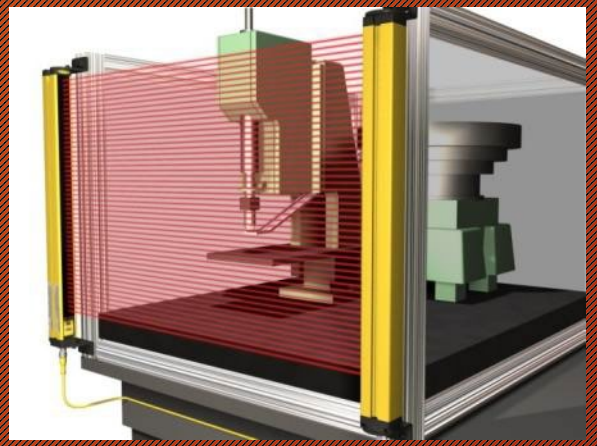
Machine Safeguarding Light curtains

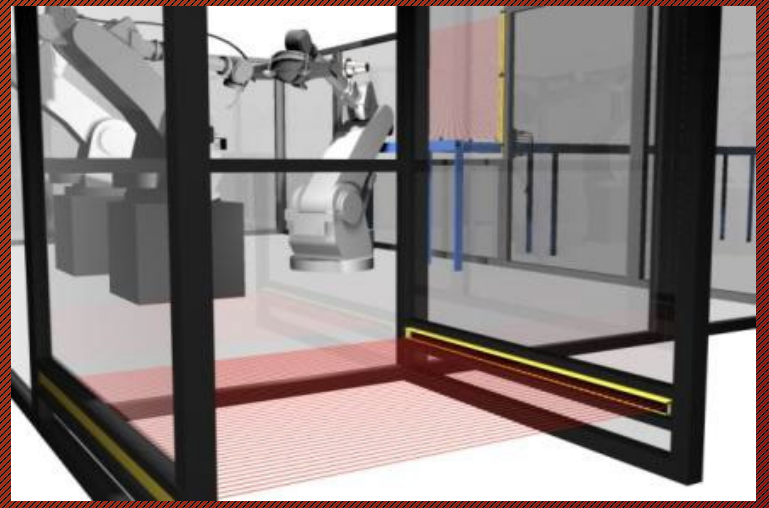


Light Curtains

(Optical Sensors)







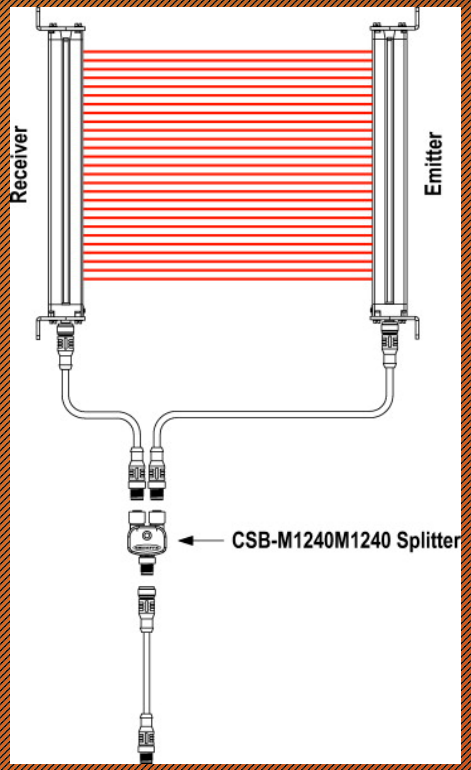
Light Curtains (Optical Sensors)

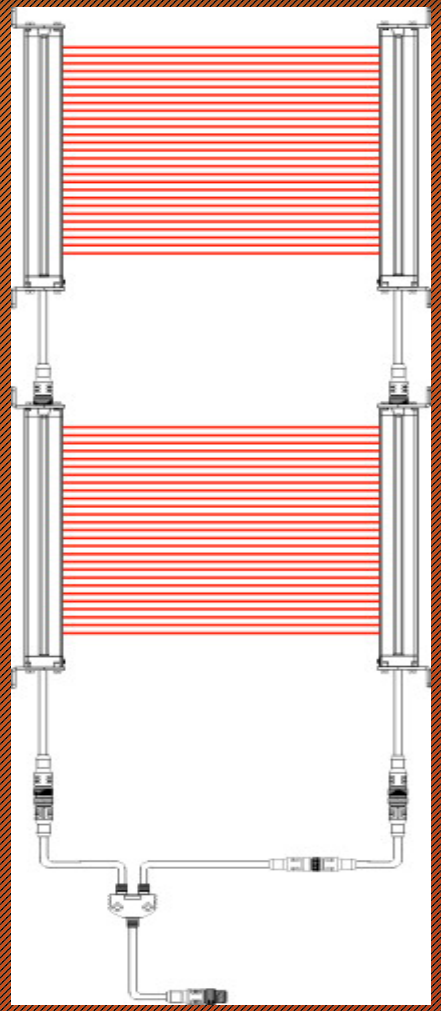
- Function
  - Create a sensing field that will detect items above a certain size that enters the field
    - If such an item enters the field a stop signal is sent
  - Various resolutions of light curtain are available for detecting items above a specified size (14mm, 25mm, 30mm, 40mm, etc)

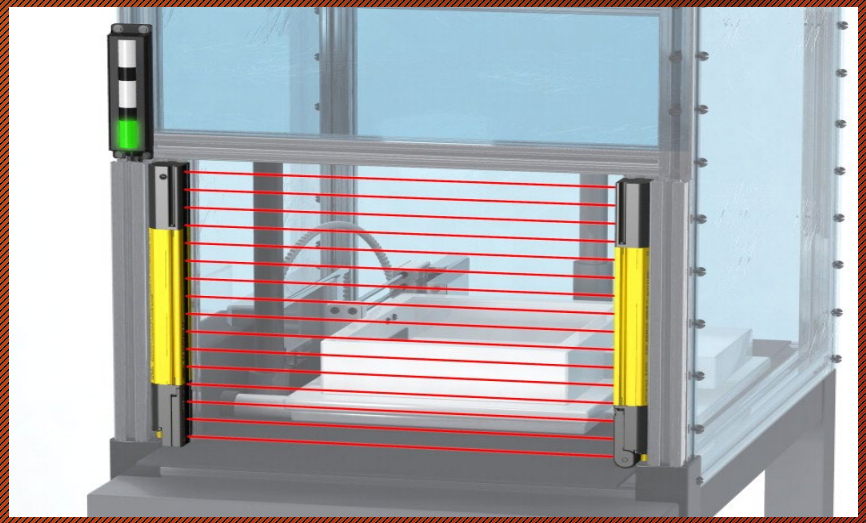
Light Curtains (Optical Sensors)

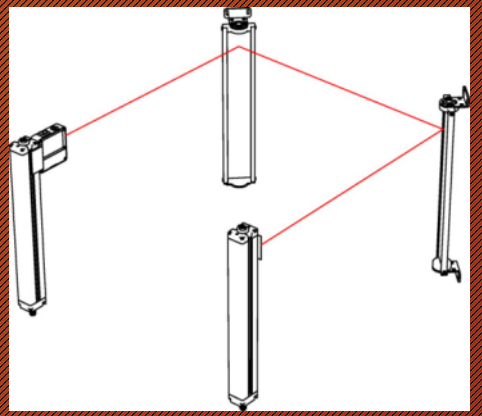
- Advantages
  - Protects all individuals
  - Excellent ergonomics
  - Allows easy access (minimal affect on production)
  - Allows for good visibility
- Disadvantages
  - No protection from ejected parts
  - Allows easy access (does not keep people out until process is complete)
  - Machine must stop 'quickly' and consistently

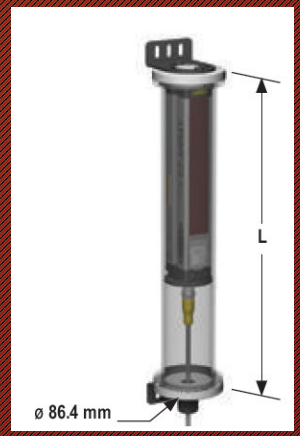
Light Curtains











Machine Safeguarding

E-Stops

&

Rope Pulls

E-Stops

- Function
  - E-Stops are NOT safety devices because they are not automatic (they are complementary devices)
  - Physical button that forces contacts open when the button is pressed
  - Button must require a twist or pull to return to run state

E-Stops

- Advantages
  - Immediate Response
  - Readily accessible to everyone in the area
  - Must always be active (can not mute or bypass) so can always stop a machine
- Disadvantages
  - Requires a conscious act of an operator
  - Does not prevent injury or machine damage but can limit the extent of injury or damage
  - Machines may need multiple buttons to insure quick and easy access

E-Stops

Machine Safeguarding

Safety Modules
and
Controllers
and
Safety PLCs

Safety Modules and Controllers

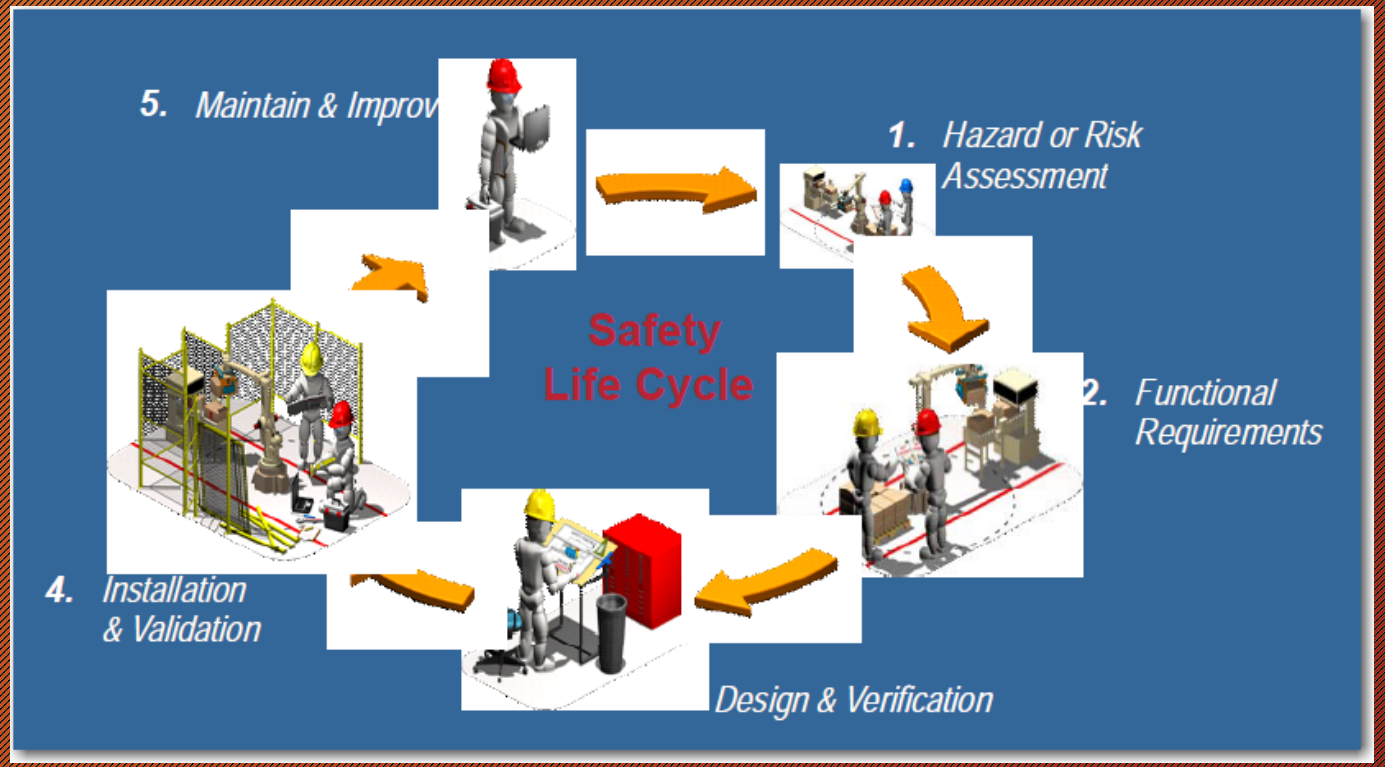
- Function
  - Safety system must perform a monitoring function to detect internal (and some external) faults
    - System needs some sort of smart device
  - Safety Modules and Controllers monitor the input circuit (dual channel) to insure that it is functioning correctly
  - Safety Modules and Controllers send the stop signal to the machine.

Safety Modules and Controllers

- Safety Controller
  - Are configurable/programmable units
  - Can perform most safety functions at the same time
  - Can reduce system wiring when multiple safety devices are needed
  - Circuit input structures are more flexible than Safety Modules
  - Provide more detailed status information than Safety Modules
  - Very cost effective for medium size machines

Machine Safeguarding

Safety Life Cycle



Risk Assessment

- **"Who" Needs To Do A Risk Assessment**

The "User" is not one individual, but the organization that uses the machine.

The intent is to form a "team" with:

- designers,
- maintenance,
- operators and helpers,
- installation personnel,
- supervisors,
- others,

Risk Assessment

When starting a risk assessment process

- Look at Your Machinery and Ask ….
  - "Are Employees Being Exposed to Controllable Hazards?"
  - "History of Accidents?"
  - "Do I Have Two Virtually Identical Machines with Two Obviously Different Levels of Safety?"
  - "Are Safety Systems Being Bypassed?
  - "Is There Safety Circuitry in my Panels?"
  - "Are THC's or Pull-Cords the Only Safety Devices?"

Risk Assessment

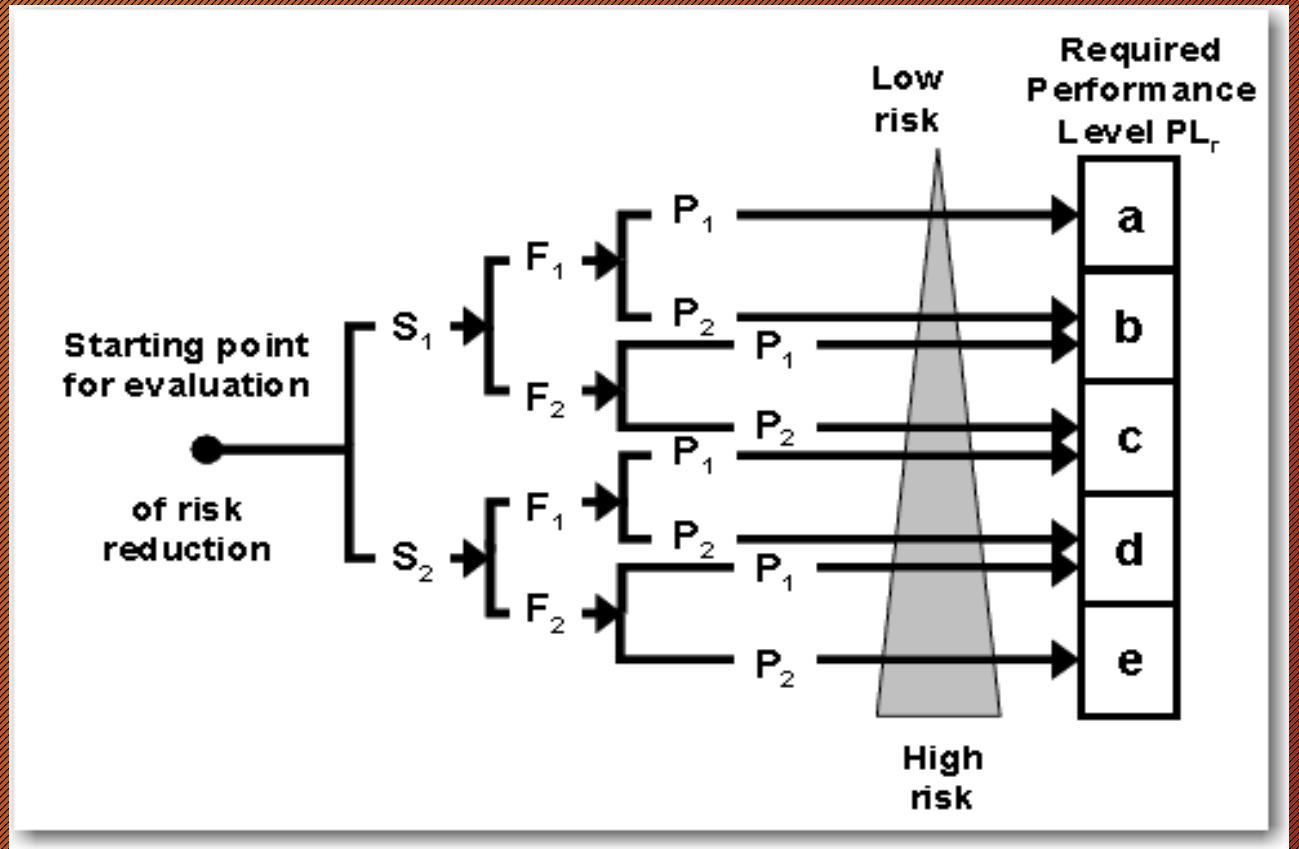
- Risk Assessment – Risk Estimation
  - For each task and hazard combination, determine the level of risk using
    - SEVERITY
    - EXPOSURE
    - AVOIDANCE

Risk Assessment

- Risk Assessment – Risk Estimation
  - SEVERITY
    - S2 = Serious Injury, normally irreversible, or fatality, or require more than first aid
    - S1 = Slight Injury, normally reversible, or requires only first aid

Risk Reduction Determination

ISO 13849-1 Converts the risk analysis into a required performance level



Machine Safeguarding Summery

ISO 13849-1	OSHA ANSI B11	ANSI/RIA R15.06	Circuit Requirements
B	NONE	Simple	Control as per basic specifications
1	NONE	Single Channel	Use of well-tried and tested components and principles
2	NONE	Single Channel w/Monitoring	Safety function shall be checked at suitable intervals (frequency to be determined according to application)
3	1910.217 b(13)	Control Reliable	A single fault must not cause the loss of the safety function. The fault should be detected whenever reasonable practicable. An accumulation of faults may cause the loss of the safety function.
4	Control Reliable		A single fault must not cause the loss of the safety function. The fault shall be detected at or before the next demand of the safety function. An accumulation of faults must not cause loss of the safety function.

Keep your people safe.