Machinery Safety

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OMRON STI provide total safety solution!

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- Hold various safety seminar

Control technique & Product line-up
- Safety solution center
- Safety components series catalog

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Know-how
- OHSAS18001/JACO Management system Factory tour

Machine safety
Achievement
- Technical conference
- Global support Europe/ America/ Asia/ China

Safety Solution
Abstract Summary

There is a lack of common understanding in the industries of applying proper Safety technologies for machines dangerous to hands. Improper use of Programmable Controllers or switches to bypass safeguards is often applied even though this is prohibited by consensus standards universally.

Abstract Summary

A Standard Code of Practices harmonized with International Safety Standard will serve as a good guideline to the Industries in designing or retrofitting safety control measures for machines thereby, achieving an optimal balance between safety & productivity.
International Safety Standard

Structure of international standards regarding safety of machinery

ISO/IEC Guide 51

- Basic concepts, general principles for design
- Principles of risk assessment (IEC 61508)

Machine safety
- Safety of machinery - General principles for design (ISO 12100)
- Safety of machinery - Safety-related parts of control systems (ISO 13849)
- Safety of machinery - Safety distances (ISO 13850)
- Safety of machinery - Presence of dangerous start-up (ISO 13855)
- Safety of machinery - Control systems (ISO 13856)
- Safety of machinery - Protection by emergency stop devices (ISO 13857)
- Safety of machinery - Permanent absence of access to hazardous stops in machinery (ISO 13858)

Type A standards
- Safety of machinery - Direct safety measures of machines (ISO 12100)
- Safety of machinery - Electromechanical interlock devices (ISO 12100)
- Safety of machinery - Functional safety barriers (ISO 12100)
- Safety of machinery - Interlock and stop of control parameters (ISO 12100)
- Safety of machinery - Safety voltage levels (ISO 12100)
- Electrical equipment for safety function group B (IEC 61508)

Type B standards
- B1 standards (safety aspects)
- B2 standards (safety devices)

Type C standards
- Individual product standards

Three Step Method for Safety Measures

There are four safety measures shown in ISO 12100.

1. Reducing risks caused by design
   - Safeguarding by isolation
   - Safeguarding by shutdown

2. Constructing safe machinery
   - Isolating a hazard and a person by space
   - Isolating a hazard and a person by time
   - Adding preventive measures for allowable risks

3. Additional preventive measures
   - Emergency stop device
   - Securing of energy zero state

4. Information in use
   - Displaying hazardous states
   - Annex

The residual risks should be noticeable to the user.
Reducing Risk Caused by Design

I: Risk reduction by inherently safe design

Design in which an operator and a hazard do not exist in the same area or time.

Safe Guarding

II: Risk reduction by safeguarding measures

Fixed guard: Principle of isolation
### Fixed Guard Installation Notes

#### Safety distance of upper limbs

<table>
<thead>
<tr>
<th>Body part</th>
<th>Graphic display</th>
<th>Opening</th>
<th>Safety distance or</th>
<th>Unit: mm</th>
<th>Rectangular</th>
<th>Square</th>
<th>Circle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fingertip</td>
<td></td>
<td>e &lt;= 4</td>
<td>&gt;= 2</td>
<td></td>
<td>&gt;= 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 &lt;= e &lt;= 8</td>
<td>&gt;= 10</td>
<td></td>
<td>&gt;= 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger up to finger joint or hand</td>
<td></td>
<td>6 &lt;= e &lt;= 8</td>
<td>&gt;= 20</td>
<td></td>
<td>&gt;= 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 &lt;= e &lt;= 10</td>
<td>&gt;= 80</td>
<td></td>
<td>&gt;= 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 &lt;= e &lt;= 12</td>
<td>&gt;= 100</td>
<td></td>
<td>&gt;= 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 &lt;= e &lt;= 20</td>
<td>&gt;= 120</td>
<td></td>
<td>&gt;= 120</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 &lt;= e &lt;= 30</td>
<td>&gt;= 120</td>
<td></td>
<td>&gt;= 120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm up to the base point of the shoulder</td>
<td></td>
<td>30 &lt;= e &lt;= 40</td>
<td>&gt;= 850</td>
<td></td>
<td>&gt;= 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 &lt;= e &lt;= 120</td>
<td>&gt;= 850</td>
<td></td>
<td>&gt;= 850</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Since the thumb functions as a stopper if the length of the rectangular opening is 65mm or less, safety distance can be reduced up to 200mm.

### Safe Guarding

II: Risk reduction by safeguarding measures

Movable guard: Principle of stop
(Interlock Guarding)

--> Machine stops when the guard opens
Safe Guarding

II: Risk reduction by safeguarding measures
Movable guard: Principle of stop

--> The guard does not open until the machine stops.

Additional Preventive Measure

III: Risk reduction by additional preventive measures

Emergency stop devices
- Emergency switch
  - A16SE (f16)
  - A22E (f22)
- Enabling switch
  - Used for emergency stop at teaching in a hazardous area.
  - Enabling switch A4E
  - Both horizontal and vertical mounting available.

Lockout/tagout
- At normal status
- In the event of emergency
Safeguarding based on engineering controls is the most effective method.

<table>
<thead>
<tr>
<th>Protective Measure</th>
<th>Example</th>
</tr>
</thead>
</table>
| Elimination or Substitution | - Eliminate human interaction in the process  
- Eliminate pinch points (increase clearance)  
- Automated material handling (robots, conveyors, etc) |
| Engineering Controls (Safeguarding Technology/ Protective Devices) | - Barriers  
- Interlocks  
- Presence sensing devices (light curtains, safety mats, area scanners, etc)  
- Two hand control |
| Awareness Means | - Lights, beacons, and strobes  
- Computer warnings  
- Sign & labels  
- Beepers, horns and sirens |
| Training & Procedures (Administrative Controls) | - Safe Work procedures  
- Safety equipment inspections  
- Training  
- Lockout/tagout |
| Personal Protective Equipment (PPE) | - Safety glasses  
- Ear plugs  
- Gloves  
- Protective footwear  
- Respirators |

Warning (lamp, sound)

Warning label

<table>
<thead>
<tr>
<th>Hazard Identification</th>
<th>Mandatory Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric shock</td>
<td>Wear eye protector</td>
</tr>
<tr>
<td>IEC 61310, ISO 3864</td>
<td>IEC 61310</td>
</tr>
<tr>
<td>Risk of caught-in</td>
<td>No smoking</td>
</tr>
<tr>
<td>IEC 61310</td>
<td>ANSI Z535.3</td>
</tr>
</tbody>
</table>
Machines dangerous to Hand

Major Injury – Amputation / Finger Crushing

(Source TA-Machinery Dangerous to Hands Draft)

(Source http://www.osha.gov/SLTC/etools/machineguarding)

Machinery Safeguarding: How Risk is measured?

Determine Risk level through Safety Categories

- **Start**
  - Determination of the limits of machinery
  - Hazard Identification
  - Risk Estimation
  - Risk evaluation

- **Risk Reduction**

- **Low Risk**
  - **Risk Assessment**
    - Requirement for safety measures (performance evaluation of functions for safety measures)
      1. *Functions of safety-related parts of control systems must be fulfilled.*
      2. *Carefully examined high-reliability components must be used and safety must be ensured based on safety principles.*
      3. *Requirements of category B must be satisfied.*
      4. *Safety must be ensured based on safety principles.*
      5. *Requirements of category C must be satisfied.*
      6. *Safety must be ensured based on safety principles.*
      7. *Design requirement: safety function should not fail by a single failure.*
      8. *A single failure should be detected as much as possible.*
      9. *Requirements of category D must be satisfied.*

- **High Risk**
  - **Risk Assessment**
    - Requirement for safety measures (performance evaluation of functions for safety measures)
      1. *Functions of safety-related parts of control systems must be fulfilled.*
      2. *Carefully examined high-reliability components must be used and safety must be ensured based on safety principles.*
      3. *Requirements of category B must be satisfied.*
      4. *Safety must be ensured based on safety principles.*
      5. *Requirements of category C must be satisfied.*
      6. *Safety must be ensured based on safety principles.*
      7. *Design requirement: safety function should not fail by a single failure.*
      8. *A single failure should be detected as much as possible.*
      9. *Requirements of category D must be satisfied.*

- **Is the machine Safe?**

- **End**

ISO13849-1 Safety of Machinery
Safety Measures Criteria

• Safety must be ensured base on Safety Principles

Examples of Safety Principles:-
• Compliance of components with relevant standard
• Components are well-tried, reliable, suitable for safety-related applications and have their reliability validated.
• Decreasing the probability of failure occurrence.
• Early detection of failures.
• Defining the failure mode, such as opening the circuit and turning OFF the supply when failure occurs.
• If no failure is detected, operation is possible.

Safety Components Comply to Safety Principles

Safety Interlock Switch

It disapproves by the implements such as screwdrivers and coins and so on.

It approves by the dedicated actuators.

Forcibly making “OFF” when contacts remain welded. Keeping “OFF” when spring fails.

Ex.) If the general micro-switch is used for the detection of the door-opening, it is easily to be made Anti-tamper by the finger during door opening.
### Applications of Safety Interlock Switches

#### Emergency Stop Switch (The demand)

**Application**: It is used for the emergency stop of the machine.

**The demand**: The demand is based on the standard ISO13850.

- **Requirements for the actuator**
  - Shape: mushroom-type push-buttons
  - Color: red

- **Contact-block**
  - Must have the direct opening mechanism.
  - (About the direct opening mechanism, reference Safety Switch.)

- **As far as a background exists behind the actuator and as far as is possible, it shall be colored yellow.**

*Ex. Type A22E*
Rope-Pull Emergency Stop Switch

Applications
Material Handling & Conveyor Line

If there is a long conveyor line, it needs many emergency stop. In the situation, the rope switch is used. The rope switch is installed around the power of danger. And if the workers feel danger, they pull the rope and the machines are made “OFF”.

Two Hand Control

Applications: To ensure both hands of the operator in safe position.

- Two start button must be operated at the same time (within 0.5s) to run machine.
- Must be monitored by a safety controller
- Machine should not go from one cycle to another without the releasing and pressing of both buttons. Prevents the possibility of both buttons being blocked, leaving the machine to run continuously.
- Releasing of either button must cause the machine to stop.
### Safety Light Curtain

**Application**
The detection of the intrusion of fingers, arms, or human bodies into hazardous areas.

- **Finger Protection**
- **Arm Protection**
- **Hand Protection**

**Description**
Safety Light Curtain unlike area sensor is safety rated and comply to relevant safety standard. These devices emit a “curtain” of harmless infrared light beams in front of the hazard area. When beams are blocked, the light curtain control circuit sends a stop signal to the guard machine.

**Examples**
- Guarding a Food Mixing Machine
- Applied in LCD Panel Assembly Process

### Safety Mat

**Application**
Operator Presence Detection in work areas.

- **Operator Presence Detection**
- **Turret Punch Machine Guarding**
- **Welding Machine Guarding**

**Description**
Safety Mats guard machine operators against some of the potential hazards and dangers of a modern manufacturing environment. Compared with other guarding methods, such as mechanical barriers, sliding gates, safety mats offer operators freedom movement flexibility that not only enhanced safety, but may also reduce the occurrence of cumulative trauma disorder.
**Safety Laser Scanner**

| Application | Operator Presence Detection in work areas with complex shape |

Safety Laser Scanner uses a harmless laser light to sense an intrusion into a guarded area. It can be configured for multiple irregularly shaped hazardous areas, making it an excellent choice for safeguarding work cells, transfer lines, robot stations, and automated guided vehicles.

**Guarding a Tumbler Machine**

**Human Presence Detection**

**Applications of Safe Guarding**

**Applications #1: Mechanical Clutch Power Press**

- Complimentary safe guarding technologies are also applicable i.e. stop time monitoring, dual spool port valve & brake monitoring systems.
- Safe Guarding systems have 2 functions:
  1. To properly safeguard operators from machines
  2. To monitor faults within the safety system to prevent loss of safety functions in the event of requesting.
- If some part of the beams of Safety Light Curtains are blocked, it will send a stop signal to the air clutch without stopping the power.
Applying Safety Light Curtain in Power Press

Check List:
- Apply Correct Safety Distance
- No reach-over, reach under or reach behind
- No large gaps left open
- Must always active
- Not suitable to use in Full-revolution Press.
- No space to stand undetected between light curtain and machine

Additional Safety Feature of Safety Light Curtain
- Fixed Blanking feature

Applications of Safe Guarding

Applications #2: Press Brake Machine

- Safe Guarding press brake machine through adoption of Single laser beam safety sensor, Lazer Safe.
- Allow operator to work closely at high speed.
- Continuously monitor the speed and stopping distance of the movable ram of the machine.
- Reduction in productivity cycle.
Applications of Safe Guarding

Applications #3: CNC Machining Centre

1) Spindle at High Speed when operating.
2) Spindle will not stop immediately due to high inertia.
3) Movable Slide

Maintaining Safe Work access with door lock

Detect position of door

Safety Interlock Door Switch

Stopping Equipment in an emergency

Applications #4: Wood Cutting Machine

- Cut wood to specified length for assembly of furniture

- Structure of the machine
  This work cell consists of a conveying system to transport the wood to the cutter. The cutter is a saw blade mounted to a Motor, the motor is mounted onto a linear slide

- Process of application
  - The lumber enters through an aperture from an adjacent work cell, the conveyor carries the wood to the saw blade, when the wood has passed the saw blade by a predetermined length the servo moves the induction motor (spinning saw blade) and cuts the wood.
  - The operator only needs to enter the cell for maintenance or clearing a jam at which time the servo goes to a home position. Before the operator is allowed to enter the work cell, they must press a “Request to Enter” button located near the door.
Application #4

Crush hands to Moving Servo
Cut hands by Spinning Saw blade
Cut hands by Sharp blade
Applications of Safe Guarding

Applications #4: Wood Cutting Machine (Safety Measure)

Be Safe and yet not affecting productivity

Conclusions

1. Machinery Safeguarding is a form of engineering control and most effective.

2. As long Safety is concern, Safety rated components should be reasonably applied.

3. Safety Components are well tried, field proven, fault tolerant and comply to relevant safety standards.

4. Due diligence of machine manufacturers and user in the process of safeguarding that Safety solutions can be applied practicably and reasonably.