Part 1: Risk Assessment

Part 2: Updates to US Robot Standards

Matt Dodds
Product Marketing Manager - Safety
Agenda

• Part 1: Risk Assessment
  ◦ Definition
  ◦ Essential steps
  ◦ Sample documentation
  ◦ Recap

• Part 2: Updates to US Robot Standards
What is it?

- Part of a Safety Strategy
  - Risk Assessment – The process by which the intended use of the machine, the tasks and hazards, and the level of risk are determined.
  - Risk Reduction – The application of protective measures to reduce the risk to a tolerable level.
Why do it?

• To create a safer working environment for employees (as required by OSHA)
• To comply with national and international consensus standards, including:

  ANSI/RIA R15.06-1999 – For Industrial Robots and Robot Systems – Safety Requirements
  ANSI/NFPA 79-2002 – Electrical Standard for Industrial Machinery
  ANSI/ASSE Z244.1-2003 – Control of Hazardous Energy – Lockout/Tagout and Alternative Methods
  ANSI/PMMI B155.1-2005 (Draft) – Standard for Packaging Machinery and Packaging-Related Converting Machinery – Safety Requirements for Construction, Care, and Use
  CSA Z432-04 – Safeguarding of Machinery – Occupational Health and Safety
  CSA Z434-03 – Industrial Robots and Robot Systems – General Safety Requirements
  CSA Z460-05 (Draft) – Control of Hazardous Energy – Lockout and Other Methods
When does a Risk Assessment Need to be done?

a) at the design stage on new, refurbished, rebuilt, or redeployed equipment; and

b) whenever safety measures and/or configuration changes or modifications to existing work procedures, equipment, or materials would impact the safety of the user
How: The Essential Steps

- **Who?** – All Involved (involve the manufacturer)
- **How?** – Obverse in use
- **Limits of Machine**
- **Users** – training, experience, ability
- **Identify Tasks and Associated Hazards**
- **Risk Assessment**
  - Risk Estimation
  - Severity
  - Probability
- **Risk Reduction**
- **Implementation**
- **Documentation**
- **Sign-off**
1. Gather Proper Personnel

- EHS manager
- Operators
- Maintenance personnel
- Engineers
- Electricians
- Production managers
- Specialists
- Manufacturer*
- Any other relevant person

Use **THE A.TEAM** approach
2. Observe the machine in use
# Machine Safeguarding Checklist

**OMRON STI**  
Machine Services Division, 4545 East La Palma Avenue, Anaheim, CA 92807-1907 USA

The Machine Safeguarding Checklist MUST be performed by qualified personnel.

<table>
<thead>
<tr>
<th>Company Name:</th>
<th>Machine Type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
<td>Manufacturer:</td>
</tr>
<tr>
<td>Date:</td>
<td>Model #:</td>
</tr>
<tr>
<td>Inspector:</td>
<td>Serial #:</td>
</tr>
<tr>
<td>Department:</td>
<td>Asset / ID #:</td>
</tr>
</tbody>
</table>

1. **Point of operation guard(s) position and/or distance.**
   - Yes - Point of operation guards appear to be compliant at this time and the safe mounting distance has been calculated and recorded.
   - No - Point of operation guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed.
   - May not be compliant - The safe mounting distance and/or position needs to be checked.
   - N/A - Not applicable.

2. **Perimeter guards position and/or distance.**
   - Yes - Perimeter guards appear to be compliant at this time and the safe mounting distance has been calculated and recorded.
   - No - Perimeter guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed.
   - May not be compliant - The safety control system needs to be thoroughly reviewed for compliance with the required level of reliability.
   - N/A - Not applicable.

3. **Mechanical power transmission apparatus guard(s) position and/or distance.**
   - Yes - All mechanical power transmission apparatuses below 8 ft. have guards which appear to be compliant at this time.
   - No - Mechanical power transmission guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed.
   - May not be compliant - The safe mountain distance and/or position needs to be checked.
   - N/A - Not applicable.

4. **Safety control system meets performance requirements.**
   - Yes - The safety control system has been reviewed by a trained engineer and has been determined to be compliant at this time.
   - No - The existing control system does not use safety rated components, such as safety monitoring relays, force guided relays, or a safety rated PLC.
   - May not be compliant - The safety control system needs to be thoroughly reviewed for compliance with the required level of reliability.
   - N/A - Not applicable.

5. **Safeguarding (protective) devices are safety-rated and properly installed.**
   - Yes - All components of the safety system are rated for human safety and have been tested and listed for such use.
   - No - Safeguarding devices are missing, are not safety rated, or are misapplied. The effective protected area is not of adequate height, width, or depth to detect entry of an individual into the hazardous area.
   - May not be compliant - The safe mountain distance and/or position needs to be checked.
   - N/A - Not applicable.

6. **Emergency stop location and compliance with NFPA 79 (when required).**
   - Yes - The emergency stop devices appear to be compliant at this time.
   - No - The emergency stop devices:
     - are missing
     - are not self-closing
     - do not use positive guided contacts or do not use positive guided contacts or not positive
     - do not use positive guided contacts or are not designed for use in a safety-rated circuit
     - are guarded or not readily accessible
     - are not mushroom style (for pushbuttons)
     - do not have slack detection or are mounted without springs (for cable pulls)
   - May not be compliant - The contact blocks need to be checked.

Comments
3. Limits of the machine

- Understand the limits of the machine or process
  - Speed
  - Capacity
  - Pressure
  - Force
  - Material
  - ...
4. Users

- Awareness
- Functional Application
- Expert
- Specialist
5. Identify Hazardous Areas

- Packing and transporting
- Planned maintenance
- Unloading/unpacking
- Unplanned maintenance
- Systems installation
- Recovery from crash
- Start up/commissioning
- Set up and try out
- Housekeeping
- Operation (all modes)
- Decommissioning
- Tool change
- Disposal
- Major repair
- Troubleshooting
# 5. Task / Hazard Pairs

## Job Hazard Analysis Worksheet

<table>
<thead>
<tr>
<th>Sequence of Steps or Activities</th>
<th>Hazards or Potential for Mishaps</th>
<th>Preventive Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong>: Transferring Liquid Nitrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Analysis By</strong>:</td>
<td>Approved By: (Include signature or initials)</td>
<td></td>
</tr>
<tr>
<td><strong>Date</strong>:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sequence of Steps or Activities

1. **Check Oxygen monitor**
   - Oxygen deficiency due to malfunctioning monitor
   - Ensure oxygen monitor is operating properly prior to bringing LN2 cylinder into the lab.

2. **Inspect LN2 cylinder at dock**
   - Oxygen deficiency or frostbite
   - Check cylinder for damage, leaky valve, or faulty gauge.
   - Ensure cylinder is appropriate size.
   - Use proper cryogenic proof gloves and chemical splash goggles throughout process.

3. **Cart liquid nitrogen to the room. Place liquid nitrogen tank close enough to the NMR. Place cart outside of the room.**
   - Improper weight distribution may cause the loss of control of the cylinder cart and cause physical injury.
   - Injury (strain or sprain) due to improper material handling.
   - A good working cylinder cart and an able body to carry the large cylinder on the cart.
   - Use the freight elevator.

4. **Secure LN2 cylinder in lab.**
   - Blocked egress due to movement in an earthquake.
   - Position cylinder in a designated area.
   - Secure seismic restraints.

5. **Connect threaded end of the transfer tube to the “liq” valve of the cylinder.**
   - The transfer tube needs to be attached smoothly so it does not damage the valve.
   - Oxygen deficiency due to leaky fitting
   - Additional help should be requested to hold up the transfer tube while attaching to the cylinder.
   - Do a leak check
   - Do not over tighten. Use designated tools.
6. Risk Assessment

• Many popular ways
• Choose the method which is appropriate for the situation
• They all refer to:
  ◦ Severity of potential injury
  ◦ Frequency of exposure
  ◦ Probability of injury
## Table 1

<table>
<thead>
<tr>
<th>Factor</th>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Severity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>Serious Injury</td>
<td>Normally Irreversible; or fatality; or requires more than first-aid as defined in OSHA 1904.12</td>
</tr>
<tr>
<td>S1</td>
<td>Slight Injury</td>
<td>Normally reversible; or requires only first-aid as defined in OSHA 1904.12</td>
</tr>
<tr>
<td><strong>Exposure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>Frequent Exposure</td>
<td>Typically exposure to the hazard more than once per hour.</td>
</tr>
<tr>
<td>E1</td>
<td>Infrequent Exposure</td>
<td>Typically exposure to the hazard less than once per day or shift.</td>
</tr>
<tr>
<td><strong>Avoidance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Not Likely</td>
<td>Cannot move out of the way; or inadequate reaction time; or robot speed greater than 250mm/sec.</td>
</tr>
<tr>
<td>A1</td>
<td>Likely</td>
<td>Can move out of the way; or sufficient warning/reaction time; or robot speed less than 250mm/sec.</td>
</tr>
</tbody>
</table>
Table 2 - Risk reduction decision matrix prior to safeguard selection

<table>
<thead>
<tr>
<th>Severity of Exposure</th>
<th>Exposure</th>
<th>Avoidance</th>
<th>Risk Reduction Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S2</strong> Serious Injury</td>
<td>E2 Frequent Exposure</td>
<td>A2 Not Likely</td>
<td>R1</td>
</tr>
<tr>
<td>More than First-aid</td>
<td>E1 Infrequent Exposure</td>
<td>A2 Not Likely</td>
<td>R2B</td>
</tr>
<tr>
<td><strong>S1</strong> Slight Injury</td>
<td>E2 Frequent Exposure</td>
<td>A2 Not Likely</td>
<td>R2C</td>
</tr>
<tr>
<td>First-aid</td>
<td>E1 Infrequent Exposure</td>
<td>A2 Not Likely</td>
<td>R3B</td>
</tr>
</tbody>
</table>

Table 2 - Risk reduction decision matrix prior to safeguard selection
# Table 3

<table>
<thead>
<tr>
<th>Category</th>
<th>SafeGuard Performance</th>
<th>Circuit Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Hazard Elimination or hazard substitution (9.5.1)</td>
<td>Control Reliable (4.5.4)</td>
</tr>
<tr>
<td>R2A</td>
<td>Engineering controls preventing access to the hazard, or stopping the hazard (9.5.2),</td>
<td>Control Reliable (4.5.4)</td>
</tr>
<tr>
<td></td>
<td>e.g. interlocked barrier guards, light curtains, safety mats, or other presence sensing devices (10.4)</td>
<td></td>
</tr>
<tr>
<td>R2B</td>
<td></td>
<td>Single Channel with monitoring (4.5.3)</td>
</tr>
<tr>
<td>R2C</td>
<td></td>
<td>Single Channel (4.5.2)</td>
</tr>
<tr>
<td>R3A</td>
<td>Non interlocked barriers, clearance, procedures and equipment (9.5.3)</td>
<td>Single Channel (4.5.2)</td>
</tr>
<tr>
<td>R3B</td>
<td></td>
<td>Simple (4.5.1)</td>
</tr>
<tr>
<td>R4</td>
<td>Awareness means (9.5.4)</td>
<td>Simple (4.5.1)</td>
</tr>
</tbody>
</table>

Table 3 - Safeguard Selection Matrix
• R1 Risk reduction shall be accomplished by hazard elimination or hazard substitution which does not create an equal or greater hazard. When hazard elimination or substitution is not possible, all provisions of a category R2 risk reduction shall apply and provisions of categories R3 and R4 shall be provided for safeguarding residual risk.

• R2 Safeguarding shall be by means that prevent access to the hazard, or cause the hazard to cease. Provisions of categories R3 and R4 may be used for safeguarding residual risk.

• R3 Safeguarding, at a minimum, shall be by means of non-interlocked barriers, clearance from the hazard, written procedures, and personal protective equipment if applicable. Provisions of Category R4 may also be used for safeguarding residual risk.

• R4 Safeguarding, at a minimum, shall be by administrative means, awareness means including audio/visual warnings and training.
How to Determine Required Performance Level ($PL_r$) in accordance with ISO 13849-1

**S: Severity of Injury**
- $S1$: Slight injury
- $S2$: Serious injury (amputation, death, etc.)

**F: Frequency and/or Exposure to Hazard**
- $F1$: Occurs infrequently or lasts for a short time
- $F2$: Occurs frequently or lasts for a long time

**P: Possibility of Avoiding Hazard or Limiting Harm**
- $P1$: Possible under specific conditions
- $P2$: impossible

Diagram:
- $S1$ leads to $F1$ and $F2$
- $F1$ leads to $P1$ and $P2$
- $F2$ leads to $P1$ and $P2$
- The combination of $S1$, $F1$, and $P1$ results in Low Risk
- The combination of $S2$, $F2$, and $P2$ results in High Risk

$PL_r$:
- $a$
- $b$
- $c$
- $d$
- $e$
OSTI - Risk Estimation: Step 1 - Severity

1. THE SEVERITY OF POTENTIAL INJURY.

For this consideration we are presuming that the accident or incident has happened. Careful study of the hazard will reveal the most severe injury that can be reasonably conceived.

The severity of injury should be assessed as:

FATAL

MAJOR - (Normally irreversible)
Permanent disability, loss of sight, limb amputation, respiratory damage etc.

SERIOUS - (Normally reversible) Loss of consciousness, burns, breakages etc.

MINOR - Bruising, cuts, light abrasions etc.
2. FREQUENCY OF EXPOSURE

The frequency of exposure to hazard can be classed as:

- **FREQUENT** - Several times per day.
- **OCCASIONAL** - Daily.
- **SELDOM** - Weekly or less.
OSTI - Risk Estimation: Step 2 - Probability

3. PROBABILITY OF INJURY

You should assume that the operator is exposed to the hazardous motion or process. By considering the manner in which the operator is involved with the machine and other factors such as speed of start-up etc., the probability of injury can be classed as:

- CERTAIN
- PROBABLE
- POSSIBLE
- UNLIKELY
Additional Factors

Fig. 1.6 The results of any additional factors are then added to the previous total as shown.

<table>
<thead>
<tr>
<th>Additional Factor</th>
<th>Suggested Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than one person exposed to the hazard.</td>
<td>Multiply the severity factor by the number of people.</td>
</tr>
<tr>
<td>Protracted time in the danger zone without complete power isolation.</td>
<td>If time spent per access is more than 15 minutes, add 1 point to the frequency factor.</td>
</tr>
<tr>
<td>Operator is unskilled or untrained.</td>
<td>Add 2 points to the total</td>
</tr>
</tbody>
</table>
## 9. Risk Reduction: Hierarchy of Controls

<table>
<thead>
<tr>
<th>PROTECTIVE MEASURE</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Most Effective</strong></td>
<td></td>
</tr>
</tbody>
</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) | ➢ Mechanical hard stops  
➢ Barriers  
➢ Interlocks  
➢ Presence sensing devices (light curtains, safety mats, area scanners, etc.)  
➢ Two hand control and two hand trip devices |
| Awareness Means | ➢ Lights, beacons, and strobes  
➢ Computer warnings  
➢ Signs  
➢ Restricted space painted on floor  
➢ Beepers  
➢ Horns  
➢ Labels |
| Training and Procedures  
(Administrative Controls) | ➢ Safe work procedures  
➢ Safety equipment inspections  
➢ Training  
➢ Lockout / Tagout / Tryout |
| Personal Protective Equipment  
(PPE) | ➢ Safety glasses and face shields  
➢ Ear plugs  
➢ Gloves  
➢ Protective footwear  
➢ Respirators |

**Least Effective**
10. Implement Safety Measures

- Review with stakeholders
- Systems not useable will be bypassed
- It is important that the entire system be considered
  - Devices (interlock switches, light curtains, etc.)
  - Hardware (gates, posts, etc.)
  - Control system (safety monitoring relays, safety PLC, positive guided relays)
  - Wiring
Proper Installation

- Key to reliability
- Tried and true methods
  - Applicable national, regional, and local regulations
  - Consensus standards
  - Customer specifications
  - Device and machine manufacturer’s recommendations
- Use devices rated for human safety (safety-rated)
Set Back Distance of Barrier Guards

Gotcha Stick

Set Back Distance Comparison

- Liberty Mutual
- OSHA 1910.217
- ANSI 01.1
Figure B2 – Dimensions a, b and c Used in Table B1 and Table B2

- a is the height of the danger zone;
- b is the height of the protective structure;
- c is the horizontal distance to the danger zone.
### 11. Documentation

#### Company - MAYKIT WRIGHT LTD
#### Facility - Tool room - East Factory.
#### Date - 29/8/95
#### Operator profile - Apprentice / Fully skilled.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloggs turret head milling m/c Serial no 17304294 Manuf 1995 Installed May 95</td>
<td>M/c Dir. EMC Dir</td>
<td>RA416</td>
<td>None</td>
<td>Movement of bed (towards wall)</td>
<td>Crushing</td>
<td>Move machine to give enough clearance</td>
<td>13/4/95 J Kershaw Report no 10064</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cutting fluid</td>
<td>Toxic</td>
<td>Change to non toxic type</td>
<td>30/11/94 J Kershaw Report no 9714</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Swarf cleaning</td>
<td>Cutting</td>
<td>Supply gloves</td>
<td>30/11/94 J Kershaw Report no 9715</td>
<td></td>
</tr>
</tbody>
</table>
# Summary Spreadsheet for ABC Company - Somewhere, CA

<table>
<thead>
<tr>
<th>Pg #</th>
<th>Asset Number</th>
<th>Manufacturer</th>
<th>Machine Type</th>
<th>Model Number</th>
<th>Serial Number</th>
<th>Location / Dept.</th>
<th>Highest Risk Score Before Guarding*</th>
<th>Highest PL**</th>
<th>Appears Compliant</th>
<th>Risk Level After Guarding***</th>
<th>Highest Prioritization Score to Establish Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>EEE / FFF / GGG / HHH</td>
<td>Balance Tech. Inc. / XY Tool &amp; Die</td>
<td>Widget Assembly Line (Balancer) / EEE / FFF / GGG / HHH</td>
<td>EEE / FFF / GGG / HHH</td>
<td>Assembly</td>
<td>42 d No</td>
<td>A 27.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>CCC / DDD</td>
<td>Fanuc / Federal / Kingsbury</td>
<td>Robot Cell (Press, Robots, Assembly)</td>
<td>CCC / DDD</td>
<td>Assembly</td>
<td>25 d No</td>
<td>A 23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>BBB</td>
<td>Bliss</td>
<td>Punch Press</td>
<td>BBB</td>
<td>Forming</td>
<td>14 e No</td>
<td>A 13.72</td>
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<tr>
<td>62</td>
<td>AAA</td>
<td>HEM Inc.</td>
<td>Horizontal Band Saw</td>
<td>AAA</td>
<td>Machining</td>
<td>12 d No</td>
<td>A 3.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>JJJ</td>
<td>Weld Wire</td>
<td>Welding Position Table</td>
<td>JJJ</td>
<td>Welding</td>
<td>9 b Yes</td>
<td>A 0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Executive Summary

Assessment Results
In summary, Omron STI reviewed 5 machines to determine if they meet the minimum requirements for machine safeguarding. Of these 5 machines, 1 appears to be adequately guarded in accordance with our interpretation of the applicable equipment safeguarding requirements, but may require additional engineering review.

*Highest Classification by Initial Risk Levels
(4) HIGH risk machines (score of 12 or higher)
(1) MEDIUM risk machines (score of 7-11)
(0) LOW risk machines (score of 6 or lower)

**Highest Classification by Required Performance Levels
(1) PL e
(3) PL d
(0) PL c
(1) PL b
(0) PL a

***Classification by Potential Residual Risk Levels
(9) Level A – Reduced Risk and Compliance Achieved
   The residual risk level will be Low/Negligible and compliance with the appropriate standards will be achieved if the recommended risk reduction measures listed below are correctly implemented in accordance with the applicable requirements. The customer is responsible for ensuring that adequate training, supervision, and administrative controls are implemented and executed as necessary. This is based on Omron STI’s experience and interpretation of the relevant safety standards.

(9) Level B – Reduced Risk but not Fully Compliant
   The residual risk level will be Low/Negligible if the recommended risk reduction measures listed below are correctly implemented in accordance with the applicable requirements. However, the equipment will not meet full compliance with the appropriate standards due to the unique nature and special use of the equipment. The customer is responsible for ensuring that adequate training, supervision, and administrative controls are implemented and executed as necessary. This is based on Omron STI’s experience and interpretation of the relevant safety standards.

(9) Level C – Lower Risk and Compliance Achieved
   The residual risk cannot achieve a Low/Negligible level due to the unique nature and special use of the equipment, but it can be significantly reduced and compliance with the appropriate standards will be achieved if the recommended risk reduction measures listed below are correctly implemented in accordance with the applicable requirements. The customer is responsible for ensuring that adequate training, supervision, and administrative controls are implemented and executed as necessary. This is based on Omron STI’s experience and interpretation of the relevant safety standards.

(9) Level D – Lower Risk but not Fully Compliant
   The equipment will not meet full compliance with the appropriate standards and the residual risk cannot achieve a Low/Negligible level due to the unique nature and special use of the equipment, but the residual risk can be significantly reduced if the recommended risk reduction measures listed below are correctly implemented in accordance with the applicable requirements. The customer must determine if the residual risk(s) still present is tolerable for the identified hazard(s) associated with the task(s) required by the customer to operate the equipment. The customer is responsible for ensuring that adequate training, supervision, and administrative controls are implemented and executed as necessary. This is based on Omron STI’s experience and interpretation of the relevant safety standards.

Optional Stop Time Measurement
Of the 5 machines assessed, 3 require a stop time measurement to determine the adequate safe mounting distance of presence sensing devices. This proposal includes Omron STI performing this service at our standard labor rate. However, a Stop Time Measurement device can be purchased to allow your facility to conduct the periodic measurements required for compliance with appropriate regulations. Please contact John Peabody at 714-809-0197 to obtain a quotation for this device.
Plant Name:
ABC Company

Location:
Somewhere, CA

Machine Manufacturer:
Balance Tech, Inc. / XY Tool & Die /

Machine Type:
Widget Assembly Line (Balancer / Rivet

Machine Model:
EEE / FFF / GGG / HHH

Machine Serial Number::
EEE / FFF / GGG / HHH

Machine Asset Number: 
EEE / FFF / GGG / HHH

Machine Location/Dept.:
Assembly

Applicable Vertical (Machine Specific) Standards [See page 6 for additional information]:
ANSI B11.20  ANSI/ASME B20.1

Emergency Stop Recommendations
Category (per NFPA 79): 1 - Controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved
Circuit Performance: Single Channel with Monitoring

Estimated Residual Risk Level
Level A – Reduced Risk and Compliance Achieved
The residual risk level will be Low/Negligible and compliance with the appropriate standards will be achieved if the recommended risk reduction measures listed below are correctly implemented in accordance with the applicable requirements. The customer is responsible for ensuring that adequate training, supervision, and administrative controls are implemented and executed as necessary. This is based on Omron STI’s experience and interpretation of the relevant safety standards.
Assessment Report

Safety Function / Zone(s): Cell Interior

Risk Evaluation

Description of Task(s) Evaluated:
- Restoring the machine after stopping / interruption
- Mounting or changing tools, tool-setting
- Housekeeping

Hazards:
- Mechanical - Crushing
- Mechanical - Cutting or severing
- Mechanical - Stabbing or puncturing
- Mechanical - Entanglement

Description of Hazard(s):
- There are crushing, shearing, cutting, entanglement, and abrasion hazards at various points of operation within the assembly line.

Prioritization Score to Establish Corrective Actions

The Prioritization Score for this machine is 27.30 and is provided to present further information to help determine a corrective action plan. This value is based upon the following common safeguarding categories evaluated for compliance at the time of our assessment.

Basic Safeguarding Categories Evaluated for Compliance

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>COMPLIANCE ACHIEVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of Operation / Perimeter Guards:</td>
<td>No</td>
</tr>
<tr>
<td>Mechanical Power Transmission Guards:</td>
<td>Yes</td>
</tr>
<tr>
<td>Safety Control System:</td>
<td>No</td>
</tr>
<tr>
<td>Safety-Rated Devices:</td>
<td>Yes</td>
</tr>
<tr>
<td>Emergency Stop Devices:</td>
<td>No</td>
</tr>
<tr>
<td>Electrical Drop-Out Protection:</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Required Performance Level (PL) per EN ISO 13849-1:2006: PLe

Review Figure 2 for further explanation of PL and comparison to combinations of Categories and selection of components.
Risk Reduction (Safeguarding) Recommendations

Install yellow legend plates on the existing emergency stop push button devices for compliance. Replace the existing light curtains at the load/unload stations with safety-rated devices and install covers on the existing optical two-hand control devices to prevent unintentional actuation. The perimeter barrier guards will be augmented to prevent contact with the hazardous moving equipment by reaching around, under, through, or over the guards. A hinged interlocked guard will be installed at the conveyor and a fixed tunnel guard will be installed at the out feed conveyor to prevent access to the part transfer equipment. The existing pushbutton station at the out feed conveyor will be rotated to prevent intentional bypassing by personnel. All safety-rated devices will be integrated to a safety interface control.

See plan view drawing for location of guards and controls.
11. Train
12. Complete sign-off
Reference

www.sti.com/catalogdownload
Parting thought: Tolerable Risk

• It is important to conduct a documented risk assessment both before and after safeguarding the machine / process

• If the residual risk is not tolerable after applying safeguards, conduct the process again
What is ‘Tolerable Risk’?

- Example: A moving chain in close proximity to hands
- Chain speed is 5,000 ft/min
  - 57 mph
  - 83 ft/sec

- Is this tolerable?

If this risk is not tolerable, no chainsaw could ever be used.
Questions
Part 2: Updates to US Robot Standards

Original presentation by
Tina Hull
Product Engineer - Safety
Applicable Standards for Robot Safety

- International Organization for Standardization
  - ISO 12100: Safety of Machinery – General Principles for Design
  - ISO 11161: Safety of Machinery – Integrated Manufacturing Systems

- Robotic Industries Association
  - ANSI/RIA R15.06-2012
  - Safety standards for robots and robotic systems

- National Fire Protection Association
  - NFPA 79: Electrical Standards for Industrial Machinery
  - Safeguards from fire and electrical hazards
Harmonization

- ISO 12100 and ISO 11161
What is an Industrial Robot?

- Automatically controlled
- Reprogrammable
- Multipurpose manipulator
- 3 or more axes

Includes: controller, teach pendant & communication interfaces
**ABC Standard Types**

- **Guards**
  - ISO 14120
  - Fixed Guards
  - Movable Guards
  - Interlocking devices: ISO 14119

- **Safety distance**
  - ISO 13857
  - Minimum gap
  - Positioning
  - ISO 13854
  - ISO 13855

- **Protective Equipment**
  - PSE
  - ESPE
  - IEC TS 62046

- **Limiting Devices**
  - Fixed Devices
  - Portable Devices
  - Two Hand Controls: ISO 13851
  - Enabling Devices: ISO 10218-1

- **Safety control systems**
  - ISO 13849-1/2

- **Industrial Robot Systems**
  - ISO 10218-2

- **Positioning**
  - ISO 13855

- **Light curtains**
  - IEC 61496-2

- **Laser scanners**
  - IEC 61496-3

- **Safety cameras**
  - IEC 61496-4

- **Protective measures**
  - ISO 12100-2

- **General design**
  - ISO 12100-1

- **Risk Assessment**
  - ISO 14121-1
What’s New for Robot Standards

• Added Requirements
  ◦ Collaborative Robots
  ◦ Hand Guided Robots
  ◦ Safety Rated Soft Axis
  ◦ Limiting Motion
  ◦ Cableless Teach Pendants

• Updated Terminology
  ◦ High Speeds
  ◦ Stops
  ◦ Operators

• Robotic Systems
  ◦ Restart
  ◦ Remote Restart
  ◦ Safe Distance
  ◦ Clearance
Collaborative Workspace

• New Requirements:
  ◦ Only for predetermined tasks
  ◦ Protective measures active
  ◦ Features designed for use

ISO/TS 15066: Collaborative Operation Concepts

Rethink Robotic’s Baxter™
Other Collaborative Robots

- FANUC Robotics
- KUKA
- ABB
- YASKAWA MOTOMAN ROBOTICS
- OMRON
Collaborative Robot in Action
Types of Collaboration

- Hand over window
- Collaborative workspace
- Interface Window
- Inspection
Hand Guiding Now Defined

• Requirements are:
  ◦ Close to end effector
  ◦ Safety rated monitoring speed
  ◦ Set distance from operator
  ◦ Singularity
**New - Safety Rated Soft Axis**

- Able to stop the robot at full rated load and speed
- Can’t be automatically configured
- Reinitialize the safety related sub-system to change
- Always activated at power-up

**Only on new robots!**

Current way
New Standards for Limiting Motion

- Safety-rated soft axis
- Hard stops
- External limiting devices

Dynamic limiting – Automatically controlled change of the robot system’s restricted space during cycle
  - Cam-operated limit switches
  - Light curtains
  - Control activated retractable hard stops
Cableless Teach Pendant Standards

• Requirements:
  ◦ Visual indication to show it is active
  ◦ Loss of communication results in protective stop
  ◦ No confusion between active/inactive e-stops
  ◦ Enable switches on both sides

• Now allowed in:
  ◦ ANSI/RIA15.06-2012
  ◦ NFPA 79 2012
  ◦ Coming soon: IEC 60204-1
How many people can be in the safeguarded space for each available teach pendant?

A. 0
B. 1
C. 3
Frequently Asked Question

How do I safeguard when multiple people are in the workspace?

Answer: Everyone needs an enabling device!
Terminology Changes: Operational Modes

- **High Speed APV → High Speed Manual**
  - Previously called APV (Attended Program Verification) or T2
  - Greater than 250 mm/sec
  - Deliberate action
  - Defined in section 5.7.4 Manual High Speed

- **Teach Mode → Manual Reduced Speed**
  - Used to be called T1 or Teach
  - Defined in section 5.7.3 Manual reduce speed
Which one is not a protective stop?

A. Safety mats

B. Enabling switches

C. Emergency stop
Terminology Change: Stops

Emergency Stop

Safety Stop → Protective Stop
Terminology Change: Operator

Production Employee → All personnel
Multiple Robot Environment Defined

**Simultaneous Motion requirements:**

- All under control of one teach pendant
- All same operating mode
- Visual indication when in collaboration
Part 2

Industrial Robot Systems and Integration
What is a Robot System?

- Robot
- End effector
- Machinery supporting robot task
Risk Assessment

• Ways to reduce risks:
  ◦ Eliminate hazard thru design
  ◦ Prevent operators from coming into contact with the hazard
  ◦ Control the hazard
  ◦ Reduce risk thru intervention (teaching)

“This machine is perfectly safe … As long as you never press this button.”
99.9% Compliance Means…

- One hour of unsafe drinking water per month
- Two unsafe landings at O’Hare airport each day
- 16,000 lost pieces of mail per hour
- 20,000 incorrect drug prescriptions per year
- 500 incorrect surgical operations each day
- 22,000 checks deducted from the wrong account each day
- 15 newborn babies dropped at birth each day

As quoted from Jeff Dewer of Dewer international and Mike Rubell of the National Compliance Institute in the United States
Safety Related Control Systems

• Single fault does not lead to loss of safety function

• Single fault detected before or at next demand of the safety function

• When fault occurs, safety function is still performed

• Safe state is maintained until fault is corrected

• All reasonable foreseeable faults shall be detected
• Requirements:
  ◦ Restart interlock to prevent restart of hazardous operation
  ◦ Not possible to activate from inside the cell
  ◦ Provided through a safety-related control system
  ◦ Achieved if all safety functions are operative
  ◦ Not initiate motion or hazardous situation by itself
Remote Access for Manual Intervention

- Can’t change safety-rated safe axis and space limiting parameters
- Manual mode, reduced speed
- Person has enabling device
- One source of control
- All in a safe state
- Indication
Safe Distance

- ISO 13855 Requires:
  - Robot max speed 1600 mm/sec
  - Guard 55 inches from adjacent walking surface
  - Wireless pendant can increase calculation times
  - Supplementary measures for hidden spaces
  - Only required if doing task
  - 20” (Use to be 18”)
Think About Your Operators…
Are they all the same size?
Clearance

- 1999 RIA - 60”
- 2012 RIA/ISO - 55”
- CSA - 72”

- 1999 RIA - 12”
- 2012 RIA/ISO - 7”
- CSA - 6”
Clearance with ESPE

• All 48"

• All 12"
Know the New Standards

• ANSI/RIA R15.06-2012
  • American National Standard for Industrial Robots and Robot Systems – Safety Requirements
    ◦ Purchase from www.robotics.org
    ◦ Price: $275 for RIA members, $325 for non-members

• NFPA 79
  • Electrical Standard for Industrial Machinery
    ◦ Read or buy at www.nfpa.org
Questions