T77 - Improving Productivity Using Contemporary Safety Designs
Safety as a Core System Function

- Safety continues to emerge as core system function.
- Safety is a Key Differentiator:
  - Global Compliance
  - Common Designs
  - Reduced Costs
  - Increased Productivity –
    - Systematic MTTR Reduction
    - Improved Competitiveness
  - Reduced Floor Space and Direct Labor
  - Improved Ergonomics
Safety as a Core System Function…But How?

- New Tools:
  - Emergence of Global Standards – ISO, IEC
    - Machine Designs that are Globally Compliant
  - New Safety Technologies – Tools for Improved Machine Performance
  - New Design Approaches – Passive, Configurable and Lockable
    - “Design-In” Safety for user-friendly machines
- A Systematic Design Approach is Required.
- These systems don’t just happen!
  - The Rigor of The **Functional Safety Lifecycle** – Safety By Design

**Safety is a “Way of Life”**
Functional Safety Life Cycle
Risk Assessment – The Foundation

- Shows “Due Diligence” and Global Compliance (Ref. ISO 12100)
- Provides Safety Performance Level – Design Target
- Creates the Foundation of the Safety System Functional Requirements, System Design and Validation Protocol

Steps Include:

- Identification of Cross-Functional Team
- Determination of Machinery Limits and Functions
- Identification of Tasks and Associated Hazards
- Risk Estimation and Evaluation
- Risk Reduction and Mitigation
- Residual Risk Determination
- Documentation

Ref: ANSI/RIA TR R15-306-2016
For each safety function, the characteristics (see Clause 5) and the required performance level shall be specified and documented in the safety requirements specification. (13849-1 4.2.2)

- **Safety Function** - function of the machine whose failure can result in an immediate increase of the risk(s)

- Sub-systems include
  - Input
  - Logic
  - Output
OSHA “Minor Servicing” Exception

- Permitted by OSHA if:
  - Alternate Method provides equivalent Protection
  - Risk Assessment performed to determine Equivalency
  - System provides Exclusive Control

1910.147(a)(2)(ii)(B)
An employee is required to remove or bypass a guard or other safety device; or

Note: *Exception to paragraph (a)(2)(ii): Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection (See Subpart O of this Part).*
ANSI/ASSE Z244.1: Alternative Methods

- Compliments OSHA 1910.147 – “Minor Servicing”
- “Control of Hazardous Energy – Lockout/Tagout and Alternative Methods
- Provides additional guidance
- Requires Risk Assessment

5.4 Alternative Methods. When lockout/tagout is not used for tasks specified in 1.3 that are routine, repetitive, and integral to the production process (see 1.2), or traditional lockout/tagout prohibits the completion of those tasks, then an alternative method of control shall be used. Control options such as those specified in 5.4.3 through 5.4.6 shall be used following the hierarchy in 5.4.2 to ensure effective protection.
**Improved Productivity by Design:**

**MTTR Reduction**

**Typical Downtime Event**

1. Machine Stops
2. Maintenance Arrives
3. Fault Identified
4. LOTO
5. Repair Performed
6. Machine Unlocked
7. Repair Tested
8. Machine back in Auto
9. Production Resumes

**MTTR = 12 minutes (avg.)**
Safety Application: Operation Modes

Point of Entry Configurable Safety System

Gate Entry Box

Robots
- AUTO
- Outputs ON, Servos OFF
- Outputs ON, Servos ON

Tooling
- AUTO
- Tool Outputs ON, Transfer Motion OFF
- Tool Outputs ON, Transfer Motion ON

Easy, Intuitive, and Secure
Results:
- No need to bypass the safety system - designed to safely accommodate the maintenance and operating procedures
- Higher productivity - Safety system may be used in lieu of LOTO (Lockout/Tagout) for many routine maintenance and setup procedures
  - Improved MTTR, faster start-ups, highly standardized approach
- System is PASSIVE – The Easy Way is the Safe Way
- System is Lockable
- Reduction of injuries and associated costs
If the safety system design meets target safety level, and ANSI Z244-1 applies…

- The safety system may be used in lieu of LOTO, reducing MTTR by ~2 minutes.
- Manufacturer’s value of 1 minute of production = $10K
- Average downtime events per plant per year = 3000 (8/day)

Value of safety solution due to improved productivity (reduced MTTR)

$10K \times 2\text{min} \times 3000 = $60M/yr.

Safety = Productivity = Profitability

- What? - Safety System Optimization
  - Reduction of Safety Control System Latencies.
  - Simplification and Standardization of Safety Functions
- Why? - Provides Manufacturing Systems that:
  - Reduce Staffing Requirements, Reduction in Direct Labor via Improved Labor Efficiencies
  - Reduction of System Floorspace/Footprint
  - Reduction of Machine Cycle Times, Improved Productivity
  - Improved Ergonomics and Reduced Operator Strain
- Ok – sounds good but….HOW???

*Optimized Safety Systems can Reduce Costs!*
Safety System Optimization: Safe Distance

- Optimization of Tc
  - Safe Distance Calculation is \( D_s = K(T_r + T_s + T_c) + D_{pf} \)
  
- Systematic Reduction of safety control system latencies
  - Method 1 - Local processing – Safety "Chicken Brains"
  - Method 2 - Network scheduling RPI and safety task interval
  - Method 3 - Combination with Hardwired Systems

- Improves: Operator Utilization, Floor space utilization, Ergonomics

Goal is to Architect Faster System Response
<table>
<thead>
<tr>
<th>Safety System Optimization</th>
<th>Safe Distance</th>
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**Ds = [K x (Ts + Tc + Tr)] + Dpf**

where:

Ds = minimum safe distance between safeguarding device and the hazard

K = speed constant: 1.6 m/sec (63 inches/sec) minimum based on the movement being the hand/arm only and the body being stationary

**NOTE** – A greater value may be required in specific applications and when body motion must also be considered.

Ts = worst stopping time of the machine/equipment

Tc = worst stopping time of the control system

Tr = response time of the safeguarding device including its interface

**NOTE** – Tr for interlocked barrier may include a delay due to actuation. This delay may result in Tr being a deduct (negative value).

Dpf = maximum travel towards the hazard within the presence sensing safeguarding devices (PSSD) field that may occur before a stop is signaled. Depth penetration factors will change depending on the type of device and application. See figure B.2 for specific values.

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Table 6 from ANSI/RIA 15.06
Safety System Optimization - Example
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Diagram showing a safety system with a tool or fixture and an operator.
Safety System Optimization - Example

Operator

Tool or Fixture

M

480VAC

GLx

SIO

SIO

SIO
Safety System Optimization - Example

\[ Tc = ID + 4 \times IRPI \text{ (CRTL)} + ST \text{ Period} + ST \text{ Scan (Safety Watchdog)} + ORPI + OD \]

\[ = 16 + 4(24) + 50 + 25 + 50 + 6 \]

\[ = 243 \text{ ms} \] (~16")

Ref: \( Ds = K(Tr + Ts + Tc) + Dpf \)
Safety System Optimization - Example
Safety System Optimization - Example

Ref: $D_s = K(T_r + T_s + T_c) + D_{pf}$

$T_c = CR-30\ Scan = 45\text{ms}$
Safety System Optimization - Results

Results:
\[ T_c (reduced) = T_{c_{GLx}} - T_{c_{CR-30}} = 243 \text{ ms} - 45 \text{ ms} = 198\text{ms} \]
\[ D_s (reduced) = 0.198\text{s} \times 63" \]
Over 12” Ds Reduced.

Ref: \[ D_s = K(Tr + Ts + Tc) + Dpf \]
Cost Analysis

- **Reduced System Floor Space**
  - 12” reduction X 4’ load window width = 4 sq ft per load window reduced
  - 4 sq ft X 150 load windows/shop = 600 sq ft/shop reduced floor space
  - 600 sq ft X $100/sq ft/yr = $60K/yr savings

- **Improved Operator Utilization**
  - Typical Operator Cycle
    - Break LC and move to load point 1.5 sec
    - Load Parts 5.0 sec
    - Exit load window 1.5 sec
    - Palm/Initiate Cycle 1.0 sec
    - **Total** = 9.0 sec
  - Our 12” Ds savings may reduce this operator cycle by 0.5 sec overall; 0.5/9=5.6%
  - If designed in, this may reduce direct labor by 5 headcount (100 person shop reduced 5%)
  - 5 direct labor X $100K/head/yr (burdened) = $500K/yr reduced labor costs

- **Improved Ergonomics**

**Cost Savings can be Significant**
Safety System Optimization: Other Approaches

- How else could Tc be improved?
  - RPI’s configured to the application requirements
  - Hardwired approach

- How could Ds be improved?
  - Ref: \( Ds = K(Tr + Ts + Tc) + Dpf \)
  - Can we affect Tr or Ts?
  - What about Dpf?

\[
Ds = [K \times (Ts + Tc + Tr)] + Dpf
\]

where:
- \( Ds \) = minimum safe distance between safeguarding device and the hazard
- \( K \) = speed constant: 1.6 m/sec (63 inches/sec) minimum based on the movement being the hand/arm only and the body being stationary
- NOTE = A greater value may be required in specific applications and when body motion must also be considered.
- \( Ts \) = worst stopping time of the machine/equipment
- \( Tc \) = worst stopping time of the control system
- \( Tr \) = response time of the safeguarding device including its interface
  - NOTE = \( Tr \) for interlocked barrier may include a delay due to actuation. This delay may result in \( Tr \) being a deduct (negative value).
- \( Dpf \) = maximum travel towards the hazard within the presence sensing safeguarding devices (PSSD) field that may occur before a stop is signaled. Depth penetration factors will change depending on the type of device and application. See figure B.2 for specific values.

Safety System Optimization Requires a Systematic Approach
Safety System Optimization: New Thinking

- Safe Motor Control – Controlling the Hazard
  - Typically either “On” or “Off” today – STO, Contactors.
  - Safe Off, Safe Speed available today – Safe direction, position coming.
  - For Maintenance personnel, Operators
  - Changing the way hazards are managed
    - Modulating hazards based upon human proximity vs shutdown.

- Human Detection Methodology
  - Old Way – Simple “Go” or “No Go”
  - New Way – Multiple stage Detection with “Layers”

New Safety Technologies will Change the way Hazards are Managed
Safe Motor Control – Safe Speed
- Modulate hazard rather than shut down
  - What does this do for Safe Distance $D_s$?
    - $D_s = K(Tr + Ts + Tc) + Dpf$
  - Decreased cell size, Improved Uptime, reduced ergonomic load

- Safe “Standstill” for Operator Load
- Energy Conservation
Safety System Optimization:
Safe Motor Control – Applications

- Converting, print, and web applications
  - Press feed (safe speed)
  - Printing press cleaning (safe direction)
  - Web Handling (safe speed)

- Precious Cargo
  - People moving equipment (safe speed, safe position, safe torque)

- Robots and Gantries
  - Vertical Loads (Safe Position, Safe CAM, Safe Brake)
Competitive and Safe Machines

- Provides improved Machine Uptime and Ergonomics
  - Modulates Hazard rather than shutting down
  - Reduces Walk Distances
- Remove incentive to bypass the Safety System
  - System is operator and maintenance friendly
- New Safety Technologies enable advanced Safety Functions
- Improved Safety AND Improved Productivity
Thank You!

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