Machine Risk Assessment and Guarding

Don Gardner, CSP
Loureiro Engineering Associates

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What Will Be Covered…

- Recognition of of machine/equipment hazards/risks
- Machine guarding requirements and standards
- Machine/equipment risk assessment
- Machine risk control options

What is a colloquium?

- "a usually academic meeting at which specialists deliver addresses on a topic or on related topics and then answer questions relating to them"

Merriam-webster.com

Everyone Loves…

- Mr. Adventure Guy

  No go! Go find some adventure, Mr. Adventure guy. Don't let my boring domestic life hit you in the butt on the way out."

Loureiro 4

What Is a Hazard?

An **act** or **condition** that:

- Exposes a person or the environment to physical forces or harmful chemicals, or
- Can cause adverse, acute, immediate, and recognizable impact on people or the environment, or
- Violates governmental laws

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What is a Risk?

- The combination of the likelihood of the hazard causing an injury and how severe the injury could be
  - Probability of occurrence/outcome (Frequency)
    - Length of Exposure
  - Significance of hazard (Severity)
- Poorly managed or unmanaged hazards

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Categorizing the Risk

Frequency of Occurrence	Severity			
	(1) Catastrophic	(2) Critical	(3) Marginal	(4) Negligible
(A) Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

Risk Categories:

High Serious Medium Low

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7

Prevention and Control Hierarchy

Level 1 **Prevention/Elimination**

Prevent a hazard from occurring in the first place, change the process or substitute non-hazardous materials or equipment to eliminate it.

Level 2 **Engineered Controls**

Barriers/Guards
Curbs/Walls
Ventilation
Enclosures

Containment

Pressure relief devices

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8

Prevention and Control Hierarchy

Level 3 **Management/Administrative Controls**

Rules/Procedures/Instructions
Protective Equipment Training

Personnel
Job Rotation

Level 4 **Awareness**

Communication/Training

Signs/Placards

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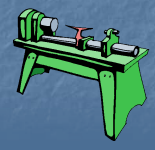
9

Mechanical Hazards

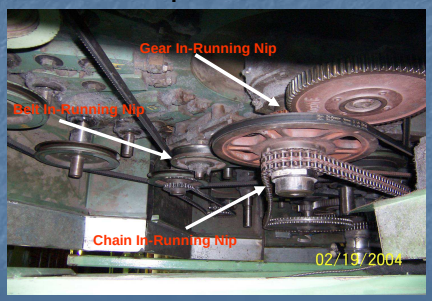
- Rotating
  - Revolving Shafts, Spindles, and Rolls
  - Screw Feeders
- In-running nip points
- Reciprocating/transverse running equipment
- Cutting
- Punching
- Shearing
- Forming



Physical Hazards

- Flying projectiles
- Heat
- Chemicals
- Compressed air
- Hydraulic fluids
- Radiation
  - (welding, x-ray & laser)

Nip Points



Nip Points

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13

Rotating Shafts

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14

Rotating Shafts

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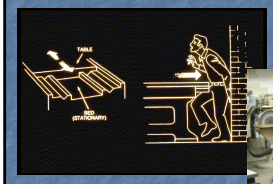
15

Transverse Movement



Pinch/Crush Point

Pinch/Crush Point

Pinch Points

19

Danger Point/Zone

Locations in or about the machine/equipment where an employee's body may come in contact with the movement of the machine/equipment.

20

Point of Operation

The point of actual contact of the machine and the material being processed

21

Point of Operation

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22

Multiple Points of Operation

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23

Regulatory Requirements and Standards

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Regulatory Requirements

Occupational Safety and Health Act of 1970

- General Duty Clause
  - Section 5 (a)(1) Each employer…

    "Shall furnish…a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees."

Machinery and Machine Guarding

- 1910-Subpart O
  - **.211-Definitions**
  - **.212 General Machine Requirements**
  - .213 Woodworking Machinery
  - .215 Abrasive Wheel Machinery

Regulatory Requirements

- OSHA 29 CFR-Subpart O
  - .216 Mill and Calendars – Rubber & Plastics
  - .217 Mechanical Power Presses
  - .218 Forging Machines
  - .219 Mechanical Power Transmission Apparatus

Other Regulatory Requirements

- 1910.147 Control of Hazardous Energy (LO/TO)

1910.212 General Requirements

- Machine guards must be provided to protect people from machine hazards.
- Points of operation that expose an employee to injury must be guarded.
- Special hand tools designed to place and remove material must keep hands out of danger zone. (*supplemental only)*

1910.212 General Requirements

•Revolving drums, barrels, and containers must be guarded by an enclosure.

•Fan blades must be guarded at less than 7' – ½''

•Machines designed for a fixed location must be secured in place.

1910.213 Woodworking Requirements

- Provide a disconnect switch that can be locked in the off position. (recommended)
- Prevent automatic re-start
- Provide combs (featherboards) or suitable jigs if standard guard can't be used.
- Power shut-off without leaving position
- All controls within easy reach

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190.213 Woodworking Requirements (selected)

- Table saws- must be equipped with hoods, spreaders and non-kickback fingers or dogs.
- Radial saws- must have blade guarding; return to home position; rotation marked
- Band Saws-blade guarding
- Belt sanders-guard nip point and unused run.
- Provide push sticks

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What are the Hazards…?

33

34

35

1910.215 Abrasive Wheel Machinery

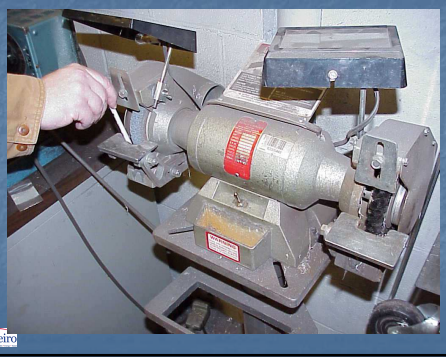
- Work rests must be used to support the work. Max. 1/8" from wheel
- Guard must cover spindle end and nut
- Safety guards for bench and floor stands and cylindrical grinders are subject to certain exposure adjustments. Max. 1/4" from tongue guard

36

1910.215 Abrasive Wheel Machinery

- Before mounting, all wheels must be closely inspected and sounded by the user. (29 CFR 1910.215(d)(1))
- All contact surfaces of wheels, blotters, and flanges must be flat and free of foreign manner. (29 CFR 1910.215(d)(3))

Pedestal Grinder

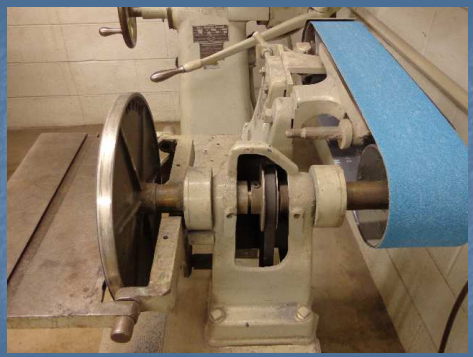


Mechanical Power Transmission Apparatus

- Belts
- Flywheels
- Shafts
  - Horizontal
  - Vertical and inclined
  - Ends
  - Keyways
- Pulleys
- Chains
- Gears

40

41



42

Other Standards/Requirements

- American National Standards Institute
  - ANSI B-11 TR 3 – Risk Assessment
  - ANSI B11.19 - Performance Criteria
  - ANSI B11.20 – Machine Tool Care/Use
- National Fire Protection Association
  - NFPA 79-Electrical Standard for Industrial Machinery
- European Machinery Directive (EN 1050)
- British Standards 6491

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43

What Requirements/Standards Apply ?

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44

Safeguarding Methods

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Types of Safeguarding

Access Control

- Location/distance
- Fixed barriers
- Interlocked barrier
- Movable/adjustable barriers
- Two-hand control systems (e.g., buttons/pull-backs)

Types of Safeguarding

Dangerous Motion Control

- Presence Sensing Safeguarding Devices (PSSD)
  - Safety Light Curtains
  - Safety Mat Systems
  - Area Scanning Systems
  - Single and multiple Safety Beams
- Brake monitors

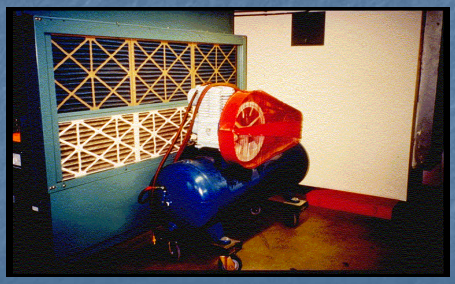
Important Points

- Guarding is not just for operators!
  - All people in the area must be protected
- Guards that do not support personal, social or supervisory requirements will not be effective.

Distance/Height

Fixed Barrier Guard

Fixed Barrier Guard



Enclosure/Fixed Guard

52

Adjustable Barrier Guard

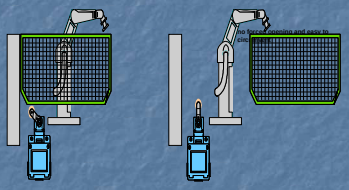
53

Interlocked Guards

54

Positive Mode Mounting for Interlock's

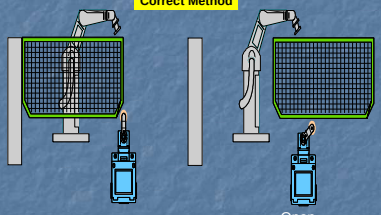
Incorrect Method



Closed Open

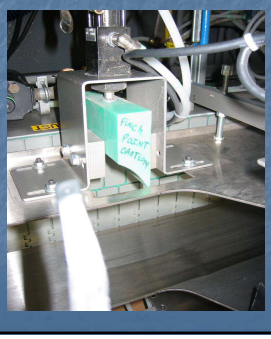
Positive Mode Mounting for Interlock's

Correct Method



Closed Open

Awareness "Guarding"



Two Hand Control Systems

Shall..

- Be designed to prevent accidental or unintentional operation
- Require that the individual operator's hand controls arranged such that both hands must be used, and both circuits must be activated within 500ms to initiate / cycle the machine
- Require individual hand controls for each operator when multiple operators exist

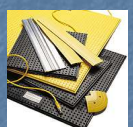
58

Presence Sensing Safety Devices - PSSD's

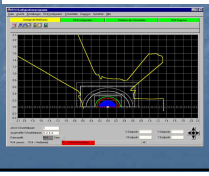
59

Types of PSSD's

Pressure Mats



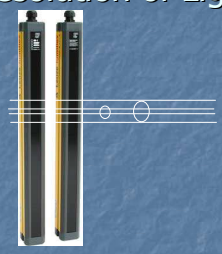
Laser Scanner



Infrared Light Curtain

60

Resolution of Light Curtains



Resolution is the size of the largest object that will always be detected this is determined by the beam spacing

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General Safety Distance Calculation

$$D_s = H_s \times (T_s + T_c + T_r + T_{bm}) + D_{pf}$$

H_s = Constant for speed of Body or parts of the body (63 in/s)

T_s = Machine stopping time

T_c = Response time of control relays

T_r = Light curtain response time

T_{bm} = Additional response time allowed for brake monitor to compensate for wear
Note: Any additional time delays must be accounted for in this calculation

D_{pf} = Depth of penetration factor
14mm Curtain 1 inch
30mm Curtain 3 inch

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Two Hand Control & Light Curtain

L'oureiro 63

Definitions for control reliability provided by ANSI and OSHA:

- **"Control reliability" means that, "the device, system or interface shall be designed , constructed and installed such that a single component failure within the device, interface or system shall not prevent normal stopping action from taking place but shall prevent a successive machine cycle."** (ANSI B11.19-1990, 5.5)
- **"The control system shall be constructed so that a failure within the system does not prevent the normal stopping action from being applied to the press when required but does prevent initiation of a successive stroke until the failure is corrected. The failure shall be detectable by a simple test, or indicated by a control system."** (OSHA 29 CFR 1910.217)

Types of Safety Switches

Limit

Keyed

Keyed Solenoid Locking

Hinge

Non-Contact Coded Magnet

Types of Safety Switches

Pressure Mats

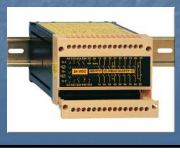
Edge & Bump Contact Strips

Rope Pull w/ E-Stop

Types of Safety Relays

Single or duel channel for
E-Stop and guard switches

Multi Channel with increased inputs and outputs enhance machine control and feedback



Specialty units for two hand anti tie down
Or stop motion detection

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67

What's new in Machine Guarding Hardware…

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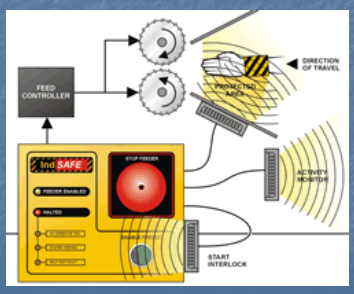
68

RFID & RADIO FEQUENCY TAG BASED SYSTEMS



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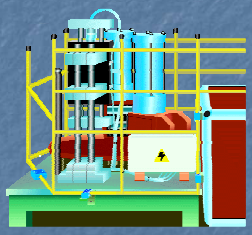
69

RF SENSING TECHNOLOGY



NFPA 79

Electrical Standard for Industrial Machinery

1.2 Purpose

- (a) The purpose of this…standard is to provide detailed information for the application of electrical/electronic equipment, apparatus, or systems supplied as parts of industrial machines that will promote safety...

NFPA 79 (9.2.2) Stop Categories

Category 0: stopping by immediate removal of power to the machine actuators(i.e., an uncontrolled stop)

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

Category 2: a controlled stop with power available to the machine actuators

NFPA 79 Stop Functions

- **Each machine shall be equipped with a category 0 stop.**
- Category 1 and/or Category 2 stops shall be provided where demanded by safety …
- Category 0 and Category 1 stops shall be operational regardless of operating mode and a category 0 stop shall take priority.
- Stop functions shall operate by de-energizing the relevant circuit and shall override related start functions.

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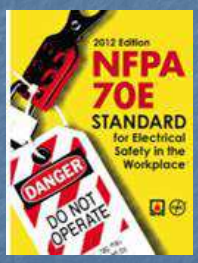
73

NFPA 70E

NFPA 70E: Electrical Safety in the Workplace covers the full range of electrical safety issues from work practices to maintenance, special equipment requirements, and installation.



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74

Machine Safety Risk Assessment

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Place Your Bets

Risk Assessment

- ANSI TR3 Risk Assessment and Reduction
  - A guideline to estimate, evaluate and reduce risks associated with machine tools
- RIA 15.06 American National Standard for Industrial Robots and Robot Systems
  - Safety Requirements
- EN 1050 European Standard Safety of Machinery
  - Principles for risk assessment
- Others

Definitions

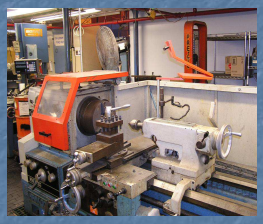
- ANSI TR-3
  - 3.4 HAZARD: A potential source of harm
  - 3.16 RISK: A combination of the probability of occurrence of harm and the severity of that harm.
  - 3.22 TOLERABLE RISK: Risk which is accepted for a given task and hazard combination (hazardous situation)

Tolerable Risk/Safe/Safe Enough…

(And/Or)

- In Compliance with Fed Regulations
- In Conformance with Internal Institutional Standards
- In Conformance with Consensus Standards
- Threshold Risk Ranking not exceeded for each task/hazard combination
  - Injury potential

Compliance Examples



Do these safeguards create an acceptable level of risk?

Analyze

Severity: The degree of injury or illness that could occur

- Catastrophic – death or permanently disabling injury or illness (unable to return to work)
- Serious – severe debilitating injury or illness (able to return to work at some point)
- Moderate – significant injury or illness requiring more than first aid (able to return to same job)
- Minor – no injury or slight injury requiring no more than first aid (little or no lost work time)

Analyze

Probability of Occurrence: the frequency, duration and extent of exposure, training and awareness, and the presentation of the hazard.

- Very likely-near certain to occur
- Likely-may occur
- Unlikely-not likely to occur
- Remote-so unlikely as to be near zero

Analyze

Probability of Occurrence

Consider:

- Workplace environment
- Extent of exposure (e.g., arm, whole body);
- Number of persons exposed;
- History;
- Effectiveness of existing controls
- Personnel who perform tasks
- Possibility to defeat protective measures
- Human factors

Risk Estimation Matrix

Example Risk Scoring System (from ANSI B11.TR3)

Probability of Occurrence of Harm	Severity of Harm			
	Catastrophic	Serious	Moderate	Minor
Very Likely	High	High	High	Medium
Likely	High	High	Medium	Low
Unlikely	Medium	Medium	Low	Negligible
Remote	Low	Low	Negligible	Negligible

Risk Assessment

- Gather the appropriate machine/task information
- Identify and document the hazards associated with the tasks
- Analyze the risk(s)
- Determine the resultant risk for each safeguarding method
- Evaluate each task/risk combination to determine whether or not it is tolerable

Identify/Evaluate Tasks

- Set up and try out
- Operation (all modes)
- All sizes/shapes of raw material
- All work products
- Tool change/modification
- Planned maintenance
- Unplanned maintenance
- Major repair

Identify/Evaluate Tasks

- Unsafe Acts/Conditions
- Work Culture
- Work priorities/drivers
- Value for conformance

Note:

- The human aspect is extremely important.
- The more holistic the assessment is…the more valuable it will be.

Lets Conduct A Mock Risk Assessment…

- Observe work conditions and acts of people
- Use guidance tools
- Identify tasks and associated hazards
- Determine risks associated with task/hazards
- Risk rank 1-2 task/hazard combination(s)
- Determine 2-3 for each solution that will result in a acceptable level of risk

Loureiro 88

Loureiro 89

Loureiro 90

Loureiro 91

Loureiro 92

Questions/Comments?

Thank you!

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