Two very common misconceptions about Machine Safeguarding

1) Older machines must be "grandfathered-in" as being OK as is (safety-wise) because they were probably manufactured before the Safety Standards and Regulations existed.

2) Newer machines must be "good to go" (safety-wise) because their manufacturers must have built them to meet "up-to-date" Safety Standards and Regulations.

Risk Assessments are the primary objective in these flow charts:

ANSI B11.0-2015 Table 1
Risk Assessment Scoring System

<table>
<thead>
<tr>
<th>Probability of Occurrence of Harm</th>
<th>Catastrophic</th>
<th>Serious</th>
<th>Moderate</th>
<th>Minor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Likely</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Likely</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Negligible</td>
</tr>
<tr>
<td>Remote</td>
<td>Low</td>
<td>Low</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

OSHA 5 (a) (1) General Duty Clause

OSHA 5 (a) (1) General Duty Clause

EMPLOYERS to furnish a place of employment free from recognized hazards likely to cause death or serious physical harm to employees

5 (b) EMPLOYEES shall comply with OSHA standards, rules, regulations, and orders applicable to his own actions and conduct

Public Law 91-596
91st Congress, S. 2193
Williams-Steiger Act of 12/29/70

OSHA 1910.212 General requirements (a) (1)

- point of operation
- ingoing nip points
- rotating parts
- flying chips & sparks

Examples of safeguarding methods: barrier guards, two-hand actuators, electronic safety devices, etc.
5 concerns on any machine

Point of Operation
Safeguarding - guard, device, method
Controls - control reliability
Disconnect and other LOTO devices
Starter - magnetic (drop-out protection)
Covers - rotating components covered to (7 feet - OSHA) from floor/working platform (8 feet - ANSI) (10 feet – European Stds.)

Guards (Point-of-operation and Perimeter)
Used as barriers to PREVENT ACCESS to the Point of Operation so that people can’t reach Over - Under - Through - Around. Used on mechanical power presses for OSHA 1910.217 and other machines for 1910.212

Shields
Used on cutting/turning machines to LIMIT ACCESS to the Point of Operation. Often applied to either control chips/coolant or as a chuck shield for OSHA 1910.212.

Covers
Used on many categories of machines to PREVENT CONTACT with rotating components like flywheels, gears, sprockets, chains, etc. for OSHA 1910.219 Mechanical Power Transmission Apparatus. Must protect up to at least 7” from floor / working platform.

Foot controls shall be protected to prevent operation from falling or moving objects or from unintended operation by accidental stepping onto foot control. This meets NFPA 79 Electrical Standard for Industrial Machinery.

• Red Button
• Yellow Background
• Manual Latch

E-Stops are not considered Safeguarding

Disconnects don’t comply: Lockable either ON or OFF

Don’t meet OSHA 1910.217 (b)(8)(i) and NFPA 79-2015
Article 119.7 Electrical Safety Program

(A) General.
The employer shall implement and document an overall electrical safety program that directs activity appropriate for the voltage, energy level, and circuit conditions.

Source: Littlefuse

Magnetic-type Motor Starter
This is 480 volts and must be transformed down to 120vac to meet NFPA-79

Protected Start Button
Spring-loaded push button indicates a MAGNETIC motor starter

Power Interruption Device provides Dropout Protection (anti-restart) on small machines

No “dropout protection” with these old ones
TIMED CONCURRENT
“anti-tie-down” on first cycle

ANTI-REPEAT
“anti-tie-down” on all single cycles

BOTH ARE REQUIRED

Point of Operation Guard Requirements
OSHA 1910.217(c)(2) and ANSI B11.1-2009(8)(5)

• can’t reach over, under, through, around (OUTA)
• meets Table 0-10 for openings and distances
• no pinch points between guard & moving parts
• good visibility into the point of operation
• fasteners not readily removable (tool required)
• materials strong enough to protect people
• no sharp edges that could injure people
Expanded Metal Guarding with Black Mesh for visibility

Spring Operated Interlock Switches can be easily defeated (cheated)

Newer Guard Interlock Switches
KEY geometry makes it difficult to defeat
KEY forces a make/break of electrical contacts

These types of fasteners are an easy way to cheat the interlock

Interlocked Guard with a latching motion sensor

- Minor Risk – Cat. 1
- Serious Risk – Cat. 2
- Major Risk – Cat. 3
- Fatal Risk – Cat. 3

Point of Operation Guard on a Tube Processing Machine

These hinged Lexan Guards are electrically interlocked
2 Reasons to “Function-test” Guard Interlocks:
1) to make sure the interlock WORKS
2) to make sure it has NOT been CHEATED

American National Standard
ANSI B11.3-2012
Power Press Brakes

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery
Point of Operation Safeguarding: Guards; (fixed, adjustable, interlocked), Movable Barriers Type-A gates, Type-B gates, Presence-sensing devices (Light Curtains & Close Proximity AOPD (Lasers), Pullbacks, Restraints, Two-hand control, Single control (hand or foot), Safe Distance, Safe Speed

Laser Safeguarding Devices for Hydraulic Press-Brakes

• “AKAS III” - Fieslser Electronik - (Bystronic PB’s)
• “BendGuard” - (Trumpf Tru-Bend PB’s)
• “Laser Sentry” - Metal Tech Controls
• “V-4000” - SICK Automation
• “Lazer Safe” - Scientific Technology Inc.
• “Laser Beam” - Zakron DSF

Light Curtains on Mechanical Press Brakes
Down-acting Hydraulic Press Brake

Laser Device for parts with tall side-legs

Up-Acting Hydraulic Press Brake

“LazerSafe Sentinel” Active Optical Protective Device along with a vertical Light Curtain on a down-acting Hydraulic Press Brake

Backs of two Press Brakes
Both with Awareness Barriers
OK
Not OK

1910.219 Guard
1910.212 Guards

Back of the Mechanical Press Brake Lunch Room

American National Standard
ANSI B11.4-2003
Shears

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Guards; (fixed, adjustable, interlocked), Presence-sensing devices, Pullbacks, Two-hand control, Single control (hand or foot), Awareness devices, barriers, signals, signs, gap (throat) guard

3 Point of Operation Hazards on Shears:
1. Shear Blade
2. Hold Downs
3. Hand Slot

Pinch-point
American National Standard
ANSI B11.6-2001
Lathes

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery
Point of Operation Safeguarding: Chuck Shields, Chip/coolant Shields, Awareness Barriers (back), kick-bar coast-down brakes, Spring-loaded chuck wrenches, boot trays, Barriers, Signals, Danger/Warning Signs, Safe Work Practices

GUARDS prevent intentional entry into hazardous areas
SHIELDS prevent inadvertent entry into hazardous areas

Storing wrench in the Chuck leads to #1 Accident on Manual Engine Lathes

Spring Loaded Chuck-Wrench
Hinged Chuck Shields

Hinged Steel Chuck Shields

Hinged Chuck Shield in open position

Chip/Coolant Shield with built-in Interlock

Chip/Coolant Shield 8.2.3

Chuck Shield Movable Guards 8.2.3

BOOT TRAY on headstock to store setup components

Telescopic stainless-steel sleeves cover horizontal rotating components

www.centryco.com
www.buww.com
American National Standard
ANSI B11.8-2001 (R07)
Drilling Milling Boring
Manual machines with or without Automatic Control

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Guards; (fixed, movable, interlocked), Presence-sensing devices, Two-hand control, Awareness barriers and devices, Chip/coolant shields

Chip/Coolant Hazards
ANSI B11.8 - 8.5.2 Chips/coolant shall be controlled from being thrown or splashed onto operator, aisle, or assigned work area using a SHIELD or other means

- Spring-loaded Chuck Keys
- Interlocked Chip Shield
- Releasing and Lifting Telescopic Chuck Shield
- Belt Cover Closed
  For pre-1957 J-head Bridgeport Vertical Milling Machines
- Belt Cover Open
1910.219 (c)(4)(i) Projecting Shaft Ends
Projecting shaft ends shall present a smooth edge and end and shall not project more than one-half the diameter of the shaft unless guarded by non-rotating caps or safety sleeves.

American National Standard
ANSI B11.9-2010
Grinding Machines
ANSI B7.1-2000 Abrasive Wheels
OSHA 1910.215 Abrasive Wheels (MACHINE SPECIFIC REG)
OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2012 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Wheel Guards; (exposure angles vary), Self-closing guards, Band-type guards, Tongue guards (spark arrestors), Work rests and allowed openings, Swarf shields, Ring testing, Vibration testing

1/8” maximum opening for Work Rest

Grinder Safety
If rotating wheel breaks, fragments can hit Operator
“Ring Test” Wheels before mounting and carefully follow mounting procedures

OSHA 1910.215 (9)(d)(i) requires “Ring-Testing”
ANSI B7.1-2000 6.1.1.2 has same procedures

Never adjust work-rest with wheel in motion

ANSI B7.1-2000 Abrasive Wheels
1/4” maximum opening
Both ANSI Standards
Covered spindle end/nut
OSHA 1910.215 (a)(2)(i)
Direction Arrow
Both ANSI Standards
1/8” maximum opening for Work Rest
#1 OSHA Machine Safeguarding violation-every state in the U.S.A.
OSHA 1910.215 (a)(4)
American National Standard
ANSI B11.10-2003
Metal Sawing Machines

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Blade guards, Shields, Awareness barriers, Devices, Safe holding of piecepart
(Safeguarding by Distance)

Horizontal Band Saws

Blade Guards

Unused portion of the Saw Blade is exposed

User-fabricated Blade Guard replaces original

Rotating shaft hazard
“Scotchbrite” soft Wheels

4 NOT mentioned
OSHA 1910.215
• Polishing Wheels
• Soft Grinding Wheels
• Scratch (Wire) Brushes
• Sanders

Rubber cap over end nut

ANSI B11.9 - 2010
9.1.1 User’s Responsibilities

... abrasive products shall be stored, handled, inspected, and mounted ... in accordance with ANSI B7.1 - 2000
(Abrasive Wheels)

OEM Blade Guards

Unused portion of the Saw Blade is exposed

User-fabricated Blade Guard replaces original
Blade-guard extension was added per OSHA

Both need a Blade Guard underneath the table

Blade must also be guarded UNDER the table

American National Standard
ANSI B11.12-2005
Rollformers and Rollbenders

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Guards; (fixed, adjustable, interlocked), Presence sensing devices, Two-hand control, Operator location, Awareness barriers and signals, Safe work procedures, Area Laser Scanners, mats.

Rollformer with custom interlocked P.O.O. Guard that meets O.U.T.A.
American National Standard
ANSI B11.15-2001 (R07)
Pipe Tube and Shape Benders

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Guards; (fixed, adjustable, interlocked), Presence sensing devices, Two-hand control, Operator location, Awareness barriers and signals, Safe work procedures, E-stop Body-contact plate on swing-arm

Horizontal Tube Bender
• Pressure Mats
• Light Curtains
• Area Laser Scanner
• Rear-end Guard

Note
Floor Line

Area Laser Scanner

Awareness Barrier Railings surround horizontal Tube Bender

5 Safeguarding Methods in ANSI B11.19

Guards: Prevent access to Point of Operation

Devices: Control access to Point of Operation

Distance: Large piecepart size/shape prevents (Safe Holding) Operator from reaching the P.O.O.

Location: Operator not required to be in the (Safe Position of Controls) in Point of Operation hazard area

Safe Opening: ¼” or less opening at P.O.O.

Light Curtain
Presence Sensing Devices
can only be used on machines that can stop consistently and immediately anywhere in their stroke or cycle
without damaging: machine - tooling – work or creating another hazard
**Light Curtain**
Presence Sensing Devices

**Point of Operation L.C.**
Prevents or stops cycle when a person’s hand/arm REACHES through sensing field

**Perimeter L.C.**
Prevents or stops cycle when a person WALKS through sensing field

Multiple Light Curtains and Two-hand Controls

2-sided Perimeter Light Curtain

Light Curtain Blankers allow for conveyor

STM FLAG NOT interrupting Light Curtain

STM FLAG interrupting Light Curtain
Function Testing Light Curtains

Function Test Checklist steps on this plastic-laminated quick-reference guide are generic. Refer to make model specific function test procedures from the manufacturer of your light curtain.

Safeguarding of Personnel & Equipment

- Welding robot cells
- Automatic assembly
- Packaging machines
- Tire Manufacturing
- Forklifts, Lift Trucks
- Tube-bending machines
- Press/bolster guarding
- Automatic Storage & Retrieval Systems (ASRS)
- Complex material handling processes
- Shrink-wrap machines
- Palletizing robots
- Carton-making machines
- Automatically Guided Vehicles (AGV’s)
- General safety mat replacement
Mat Function Indicators
ANSI B11.19-2010 8.5.1.2
Capable of being supervised
ANSI B11.19-2010 6.6.5
Pressure-sensitive Mats

- Large enough
- No sneak between
- Anchored to floor

Riveters with Drop-Probes

 ANSI B11.19 - 2010 8.7.1.2
The probe detection device shall not, in or of itself, create a hazard

Straight wire fabricated into probe

Riveters with Drop-Probes

Heavy-duty Drop-probe Device

Long-stroke “Detect-a-Finger”
Drop Probe Device on Spot Welder

“Safe Holding”?

Part is fixtures with Two-Hand Control

Awareness Barriers  ANSI B11.19 - 2010  9.1
provide a visual boundary to hazards . . . person must make a . . . conscious effort and contact with the barrier . . .

A/B makes people aware of hazard area by surrounding it with an obstacle (railing, chain, cable) requiring an intentional act to get beyond

Awareness Barriers

Stack Lights

Light Curtain
and Two-hand Control

Visual or Audible Awareness Signals
ANSI B11.19 - 2010  9.2.1

NFPA-79 2015
Machine Indicator Lights
- Red – Danger
- Blue – Action
- Green – Safe
- Yellow – Warning

A/B makes people aware of hazard area by surrounding it with an obstacle (railing, chain, cable) requiring an intentional act to get beyond

A/B makes people aware of hazard area by surrounding it with an obstacle (railing, chain, cable) requiring an intentional act to get beyond
Safe Opening
ANSI B11.19-2010 10.3

P.O.O. opening, with no workpiece in place is small enough to prevent reaching into (e.g. machines with less than 1/4" stroke such as when blanking thin flat sheets)
P.O.O. opening, with workpiece in place is small enough to prevent reaching into (may need part in place sensor in P.O.O.)

Emergency Stop Cables

- Red and clearly visible
- E-stop command if cable breaks
- Entire length visible from reset location
- Easy reach without opening gates or guards
- E-stop command activated from any part of cable
- Cables required on each accessible side of equipment
- Cables must be maintained (and any damage repaired)
- Deflection: amount required and amount possible
- Minimum clearance between cable and nearest object
- Force required to activate switch at end of cable

General Motors “Design for Health and Safety” - 2001 9.4.5.2.2

American National Standard
ANSI B11.21-2006

Machine Tools using Lasers

Point of Operation Safeguarding:
Local protection, Peripheral protection, Presence sensing devices, Interlocked Guards

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Employer to ensure that employees know the meaning of signs tags color codes be aware of language differences, illiteracy, & color blindness (ADA)
Use International Symbols and Pictograms whenever possible

Laser Classifications

Class I no biological harm “Exempt”
Class IM no biological harm unless viewed through optical magnification device
Class IIa no biological harm unless viewed for more than 1000 seconds (visible lasers only) “Low Risk”
Class II no biological injury within aversion response time (0.25 seconds) blink or natural eye and body movement “Low Risk”
Class 2M no biological injury within aversion response time (0.25 seconds) unless viewed through optical instrument “Low Risk”
Class IIIa depending on Irradiance, possible eye hazard for longer viewing or viewing with collecting optics “Moderate Risk”
Class 3R avoid beam exposure or direct eye exposure (similar to IIa)
“Relaxed Requirements”
Class IIIb severe eye hazard and minimal skin hazard for direct or specularly reflected radiation “Moderate Risk” (requires LSO)
Class IV severe eye and skin hazard for exposure to either the direct beam or scattered radiation also a fire hazard “High Risk” (requires LSO)
Machine Tools using Lasers
ANSI B11.21 - 2006 Protection during operation Laser Radiation Safeguarding
One or more guards (or safeguarding like floor mats or light curtains) shall prevent human exposure during operation to levels of laser radiation higher than the MPE “Maximum Permissible Exposure” as determined by Laser Safety Officer
A hazard analysis shall be performed to determine which type of safeguarding shall be used; Local protection vs. Peripheral protection

Common Causes of Laser Related Injuries
• Eye protection not used or pushed down on nose
• Eyewear not correct for type and class of laser
• Eye exposure during the alignment procedure
• Unprotected viewing laser generated plasmas
• Optics misaligned - beams directed upwards
• Operators not trained on laser equipment
• Unanticipated exposure to eyes or skin
• Photochemical injuries to eyes or skin
• Inhaling laser generated fumes, gases
• Fire hazards with Class IIIIB and IV lasers
• Failure to follow Safety Operating Procedures
• Improper equipment restoration after service
• Lack of protection for secondary hazards
• Intentional exposure of unprotected personnel
• High voltage hazards – Lockout/Tagout issues

ANSI B11.22-2002 (R07)
Automatic Numerically Controlled Turning Machines and Centers
OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery
Point of Operation Safeguarding: Guards; (fixed, interlocked, movable), Presence sensing devices, Two-hand controls, Stopping performance monitor, Awareness barriers and devices, Chip or coolant shields, Safe work procedures

Regularly check “jaw gripping ability”
CNC Lathe with sliding interlocked door
Always stand off to SIDE running high RPM

American National Standard
ANSI B11.23-2002 (R07)
Machining Centers and Automatic Numerically Controlled Milling, Drilling Boring Machines
OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery
Point of Operation Safeguarding: Guards; (fixed, interlocked, movable), Presence sensing devices, Two-hand controls, Stopping performance monitor, Awareness barriers and devices, Chip or coolant shields, Safe work procedures
Door Interlock “ON” the key is removed while machine is running a part. Door closed and interlock is turned “ON” when parts are being turned - key should be removed and supervised.

Fasteners Removed

Interlock Cheated

American National Standard
ANSI/RIA R15.06-2012
Industrial Robot Systems

OSHA 1910.212 General Requirements for All Machines
OSHA 1910.219 Mechanical Power Transmission Apparatus
NFPA 79 2015 Electrical Standard for Industrial Machinery

Point of Operation Safeguarding: Guards; (fixed, interlocked), Two-hand control, Presence sensing safeguarding devices; (Light curtains, Safety beams, Safety mats, Area scanning laser devices, Radio frequency), Perimeter guarding, Latch-out reset controls, Trapped-key interlocks, Enabling devices

Maximum
Restricted
Operating

portion of maximum space restricted by limiting devices

maximum designed movement of all robot parts including end effector

portion of restricted space that the robot actually uses during programmed motions (Don’t forget dimensions of the load itself)

Three types of Robot Spaces (previously called Envelopes)
ANSI/RIA R15.06-2012 - Means for limiting motion

Combination of Safeguarding Devices
Limiting Devices on arms and elbows

Mechanical: physically restrain the robot from moving beyond a designed limit (like hard stops)

Non-mechanical: initiate a stop through the robot control system (like limit switches)

Limiting Devices on robot waist

ANSI/RIA R15.06-2012 5.10.4.3… Interlocked Movable Guards

Door must swing out, not in

Door (or) must open laterally or away from the hazard and not into the safeguarded space

Robotsically-fed Press Brake with Perimeter Light Curtain

Interlocked Perimeter Guard

Robotsically-fed Press Brake with Guards and Light Curtains

Machine Safeguarding Seminar

These and others are free downloads; cemanet.org

Conveyor Equipment Manufacturers Association

ANSI/RIA R15.06-2012 5.4.3

Means for limiting motion

12 inch sweep and 60 inch height (ANSI/RIA-1999)

6 inch sweep, 72 inch height (CSA-2003)

5.4.2 The “Safeguarded Space shall be established by Perimeter Guarding

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