Journal of the National Academy of Forensic Engineers®

http://www.nafe.org
ISSN: 2379-3252

Vol. 37 No. 1 December 2020

Machine Safeguarding: Theory, Practice, and Case Studies

By Nicholas A. Petrucci, PE, CSP (NAFE 650M)

Abstract

A machine is a device that uses energy to perform some type of useful mechanical work. Therefore, it must have at least one (and more often many) moving parts. A safeguard is a measure taken to protect someone from physical harm. The sources of harm from a machine typically stem from moving parts and/or electric current. Effective machine safeguards substantially reduce personnel exposure to these hazards and/or the resulting harm, and, as a result, optimize machine productivity. A common image that comes to mind in regard to a machine safeguard is a physical barrier that prevents a worker from inadvertently placing a body part into a hazardous space of a large industrial machine. While this is one important aspect of machine safeguarding, it is a much broader topic that requires a more in-depth analysis to achieve the goal of ensuring personnel safety without unduly compromising machine productivity. Different types of machine safeguards will be discussed in this paper. The safeguarding hierarchy will be presented, which is a guide to determine what safeguarding method(s) should be employed. Case studies of injuries that were caused, at least in part, by various machine safeguarding deficiencies will be presented. Relevant matters that arose during an OSHA National Emphasis Program on Amputations audit at a manufacturing facility will also be discussed. These topics will provide insight on how to better develop and employ more effective machine safeguards.

Keywords

Machine, safeguard, hierarchy, lockout, tagout, OSHA, pinch point, guarding

History

Safeguards are by no means unique to machinery. One of the earliest safeguards was likely a sheath for a knife or a sword, which helps protect its user from being cut when the blade is not in use.

Moskowitz provided a chronology of machine safeguarding[1]. Patents for machine guards were issued in the 1890s. "The Prevention of Factory Accidents" by John Calder, published in 1899, defines hazards and describes methods for elimination or mitigation. The National Safety Council (NSC) was established in 1913, which advanced machine guarding and many other aspects of safety. The NSC published the "Accident Prevention" manual from 1946 through 1974, which was widely accepted by machine operators and designers.

The American Standards Association (ASA) was founded in the 1920s, which became the present-day American National Standards Institute (ANSI). The first ASA standard on power transmission guarding was published in 1927.

Although many ASA/ANSI standards applied to specific machinery and were generally accepted, the standards were largely legally unenforceable until incorporated into or adopted by the Occupational Safety and Health Administration (OSHA), which was established in 1970. OSHA's first standard related to machine safeguarding was adopted in 1989[2].

Current Requirements

OSHA's Machinery and Machine Guarding standard states:

> **1910.212(a)(1)**
> *Types of safeguarding*. One or more methods of machine safeguarding* shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating*

Nicholas A. Petrucci, PE, CSP, 2366 Golden Mile Hwy. #452, Pittsburgh, PA 15239, forensic@petrucciengineering.com
DOI: 10.51501/jotnafe.v37i1.138

		Safeguard Required	
Exposure Likelihood	**High**	**Maybe**	**Yes**
	Low	**Unlikely**	**Maybe**
		Low	**High**
		Potential Injury Severity	

Figure 1
Machine safeguard requirement chart.

parts, flying chips and sparks. Examples of guarding methods are barrier guards, two-hand tripping devices, electronic safety devices, etc.

The author added the word "safe" to the original language above to update it to current usage, as indicated by the asterisks.

This is a broad requirement. Some machine hazards are obvious. Other not-so-obvious hazards are too often not discovered until they cause, or contribute to, an injury. Many incidents involve personnel performing unsafe acts, negligently, recklessly, or even intentionally. Whether such acts were reasonably foreseeable and should have been safeguarded against is often a central matter, if not the central matter, in machine safeguarding litigation.

Machine Safeguarding — What and How?

The following are two key questions that must be answered to properly safeguard a machine, along with general guidance on how to respond to them:

1) What machine hazards should be safeguarded?

To best answer this question, the following two factors should be evaluated:

- Likelihood of exposure to the hazard. This would generally be considered "high" if it is reasonably foreseeable that someone would be exposed to the hazard.
- Severity of potential injury from the hazard. This would generally be considered "high" if a reasonably foreseeable injury from exposure to the hazard will require the attention of a medical professional.

Figure 1, a basic risk assessment matrix developed by the author, illustrates how to determine if a safeguard is required based on the above factors:

2) How should the machine hazard be safeguarded?

Quite simply, a machine hazard should be safeguarded with an effective machine safeguard, which has the following characteristics:

- Reduces the likelihood of exposure to the hazard to an acceptable level (i.e., one where the exposure is not reasonably foreseeable).

  and/or

- Reduces the harm from being exposed to the hazard to an acceptable level.

  and

- Does not unduly compromise machine productivity.

There are various ways to reduce the likelihood of exposure to a machine hazard, several of which will be discussed in the next section. Reducing harm from exposure to a machine hazard is most often accomplished with personal protective equipment (PPE).

Note that reducing the likelihood of exposure to a hazard and reducing harm from exposure to a hazard are two separate concerns. Hazard elimination, guarding, engineering controls, etc., reduce the likelihood of exposure to the hazard. PPE reduces the harm from an exposure that one has already been exposed to. The author has personally had the benefit of safety glasses, safety shoes, work gloves, welding jackets, auto-dimming welding helmets, etc., as protection from harm from many hazards that could not have been reasonably avoided.

If a safeguard unduly compromises the productivity of a machine, there is a good chance that it will be removed or otherwise disabled, thereby rendering it ineffective.

Machine Safeguarding Hierarchy

The purpose of the machine safeguarding hierarchy is to categorize safeguarding methods based on their effectiveness, which will hopefully result in the most effective safeguard being employed. The safeguarding hierarchy has been established by various technical

Safeguard Methods	Examples
Hazard Elimination	New design without the hazard. Eliminate/reduce human interaction (automation).
Hazard Substitution/Mitigation	Energy reduction (speed, force, voltage, etc.).
Physical Guard	Belt/chain/gear drive cover. Retractable circular saw blade guard. Switch guards (foot pedal guard). Relocate hazard to less accessible location (a.k.a. guarding by location).
Engineering Controls	Presence sensing devices (light curtain, safety mat). Interlocks. Two-hand switch. Control logic (manual reset required if the emergency stop button is pressed).
Awareness	Visual/audible alarms. Danger/warning labels.
Administrative Controls	Safety training. Procedures (lockout/tagout).
Personal Protective Equipment	Safety glasses. Safety shoes. Ear plugs. Work gloves.

Figure 2
Machine safeguarding hierarchy from most effective at the top to least effective at the bottom.

organizations, such as the American National Standards Institute[3]. There are some variations to the hierarchy among these organizations, which, for the most part, are relatively subtle. **Figure 2** shows examples of the most common safeguarding methods in the safeguarding hierarchy.

There are exceptions; that is, a safeguarding method lower on the hierarchy can be more effective than a higher one. For example, utilizing well-trained, safety-conscious personnel is often one of the most effective ways to prevent machine-related injuries. Although highly desirable, a well-trained and safety-conscious workforce is by no means justification for not having other effective safeguards in place.

Another example that the author has witnessed on numerous occasions is that a physical guard of some type unduly interferes with the operation of the machine, and as a result, is removed. Although lower on the machine safeguarding hierarchy, a presence-sensing device is often more effective in many of these cases.

Safety and Productivity/Economics

Although it is typically bad practice to sacrifice safety for economic considerations, it is done every day. If, for example, automobile manufacturers truly put safety above all other concerns, cars would look like tanks and be cost prohibitive to just about everyone. The impact on the overall quality of life would be detrimental. Similarly, if every machine had to be redesigned and/or completely safeguarded against any and all possible hazards, they would be prohibitively expensive, difficult to operate, nonproductive, etc. This approach would substantially increase the cost of nearly all manufactured products, which would be detrimental to society. Nonetheless, the safety of personnel working on or otherwise exposed to machine hazards must be paramount. The likelihood of personnel exposure to a machine hazard, coupled with the potential severity of the resulting injury, should be the primary factors used to determine if a machine hazard should be safeguarded, by which method, and to what degree. Economic and productivity concerns are secondary to safety, but nonetheless are also important factors that warrant consideration when selecting a method of machine safeguarding.

A safe workplace is requisite for a productive workplace. The "safety first" approach must be upheld. This requires spending the necessary time, effort, and resources to determine how to make safety and productivity complementary instead of competing interests.

Case Studies

The following are three case studies of personal injury incidents that were caused, at least in part, by machine safeguarding deficiencies. Each includes a description of the incident and an examination of what machine safeguards were in place compared to those that should have been in place to prevent the resulting injuries.

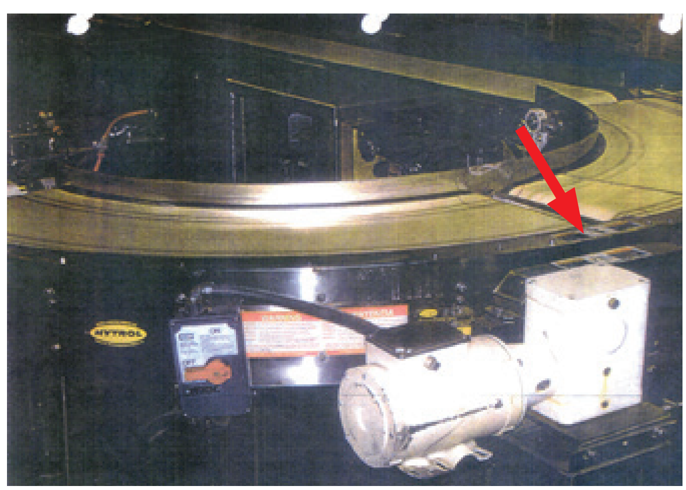

Figure 3
Arrow shows where worker was injured between two 90° conveyor sections while removing cookie nuggets from the conveyor. Product flows from left to right.

Figure 4
Incident pinch point showing how a worker severed her right thumb. Product moves from right to left.

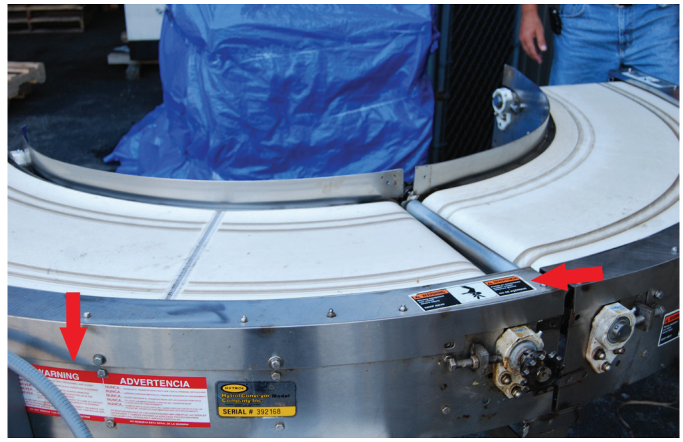

Figure 6
Warning labels in the vicinity of the incident location.

Case 1: Frozen Cookie Bags Conveyor

Bags of frozen cookie nuggets were being transported by a conveyor system. One of the bags ripped open, which resulted in frozen cookie nuggets spilling onto the conveyor. As a worker was gathering the cookie nuggets by hand near the interface of two 90° conveyor sections (**Figure 3**), she unknowingly placed her right thumb into a gap between the moving conveyor belt and the conveyor frame (**Figure 4**). This resulted in her thumb being severed from her hand.

This incident unfortunately was caused by the absence or ineffectiveness of various machine safeguards. Consider the following:

Hazard Elimination

There are inherent dangers at the interface of two conveyor sections. The incident pinch point would have been eliminated by using a single 180° conveyor section instead of two abutting 90° sections (compare **Figures 3** and **5**). However, similar hazards would still have existed at the interfaces between other abutting conveyor sections.

Figure 5
180° conveyor section.

Physical Guard

The conveyor manufacturer claimed that it sold the unit with "filler plates" that covered the gaps between the conveyor belt and the frame, thereby guarding the incident pinch point. Why these guards were not in place at the time of the incident is unknown. Having an interlock fitted to the four guards at each conveyor interface may have been impractical. However, a conspicuous "Danger — Install Guard Before Operating Conveyor" label that would be exposed when a guard was removed would not have been unduly burdensome.

Awareness

There was a conspicuous label in the immediate vicinity containing the text, "Warning — Moving equipment can cause severe injury. KEEP AWAY." Another less conspicuous nearby warning label contained the text: "NEVER…PUT YOUR HANDS ON THE CONVEYOR OR IN THE CONVEYOR WHEN IT IS RUNNING" (see **Figure 6**).

Administrative Controls

The worker testified that her training did not include what to do if frozen cookie nuggets were dispersed on the conveyor belt from a ripped bag — or how to stop the conveyor belts. Representatives from her employer testified that she was trained on how to stop the conveyor belts; however, they were unsure if she was specifically trained on what to do if frozen cookie nuggets spilled onto the conveyor — and it would have been appropriate for her to stop the conveyor belts if that occurred.

This incident is a good example of the greater effectiveness of methods higher on the safeguarding hierarchy (e.g., hazard removal and physical guards) than those

Figure 7
Wheelchair lift in the lowered position. Upper arrow shows the inboard roll stop in the vertical position. Lower arrow shows the outboard roll stop in the horizontal position.

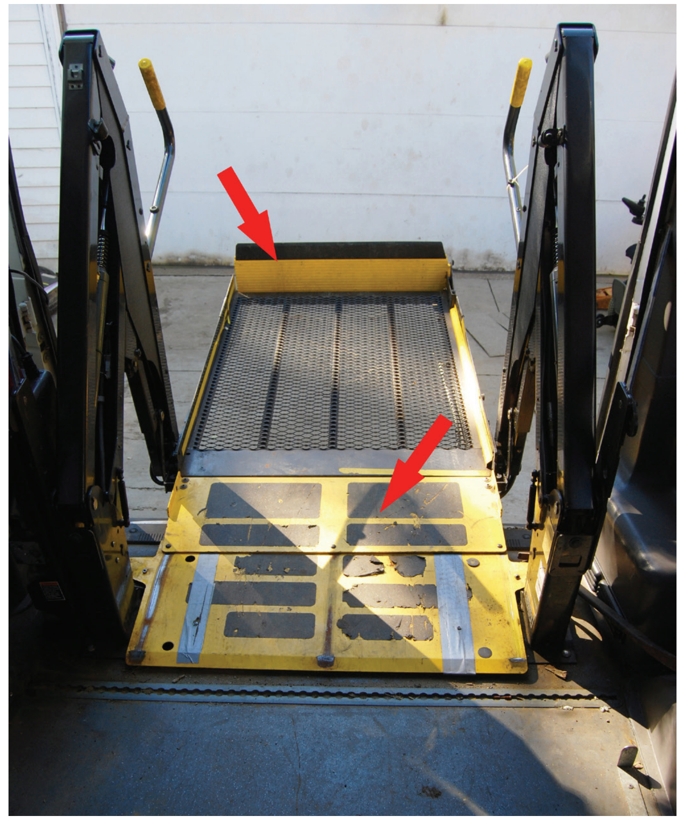

Figure 8
Wheelchair lift in the raised position. Upper arrow shows the outboard roll stop in the vertical position. Lower arrow shows the inboard roll stop in the horizontal position.

lower on the safeguarding hierarchy (e.g., awareness and administrative controls).

Case 2: Wheelchair Lift

An individual in a wheelchair was being lifted from the ground to the floor level of a transport vehicle (**Figure 7**). There were vertically oriented inboard and outboard roll stops that prevented the wheelchair from rolling off of the ends of the lift platform. When the lift platform was at the ground level, the outboard roll stop was oriented horizontally to allow for loading and unloading of the wheelchair passenger. Similarly, when the lift platform was at the transport vehicle floor level, the inboard roll stop was oriented horizontally (**Figure 8**). During the initial portion of the lift, the wheelchair occupant's right foot entered the approximate 1.5-in. gap between the inboard edge of the platform and the inboard roll stop (**Figure 9**). When the lift was near its raised position, the inboard roll stop transitioned to the horizontal position, the gap between the inboard roll stop and the platform closed, and the occupant's right foot was crushed (**Figures 10** and **11**).

Figure 9
Inboard roll stop in the vertical position. Arrow shows an approximate 1.5-in. gap between the inboard roll stop and the platform.

This incident unfortunately was caused by the absence or ineffectiveness of various machine safeguards. Consider the following:

Hazard Elimination

The incident pinch point between the inboard roll stop and the platform should not have existed. An example of

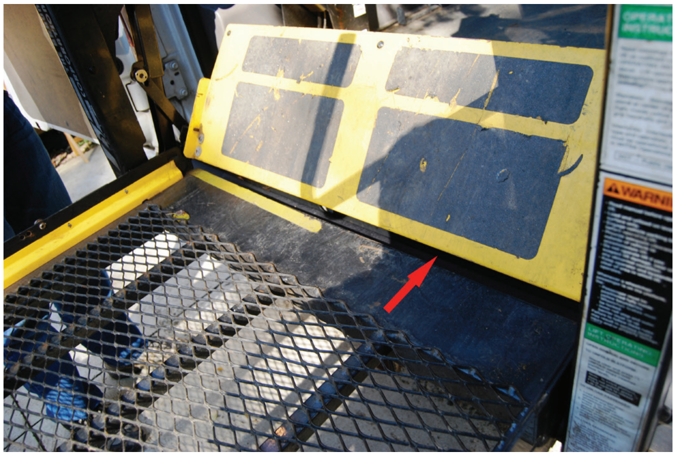

Figure 10
Inboard roll stop about halfway between its vertical and horizontal positions. Arrow shows the reduced gap between the inboard roll stop and the platform.

Figure 11
Inboard roll stop in the horizontal position. Arrow shows essentially no gap between the inboard roll stop and the platform.

an alternative design without the pinch point is an inboard roll stop that rotates about a hinge that is always coplanar with the platform (i.e., there would never be a gap between the roll stop and the platform).

A representative from the lift manufacturer testified that, "In a couple of our international lifts, we use a similar type… hinge (connecting the inboard roll stop to the lift platform) because it was requested by the customer… I've been told that the continuous hinge is less expensive." There was no mention of an operational or other benefit for the incident inboard roll stop design.

Physical Guard

A less desirable, but nonetheless likely effective, safeguard would have been the installation of a guard to prevent accessing the pinch point.

Awareness

A warning placard on the wheelchair lift frame contained the text: "Read manual before operating lift," and "Load passenger onto platform and lock wheelchair brakes." The operator's manual contained the following text: "Inboard facing of wheelchair lift passengers is **not prohibited**, but outboard facing of passengers is **recommended**". These awareness safeguards were inadequate as an explicit warning of the pinch point was not included, nor was the requirement to face the wheelchair occupant outboard during the lift.

Administrative Controls

What, if any, training the lift operator received is unknown. Such training should have included locking the wheelchair brakes during the lift and facing the occupant outboard or at least well away from the inboard roll stop during the lift.

The most effective safeguard, eliminating the hazard with a hinge connecting the inboard roll stop to the lift platform, was reportedly the least costly. It is the author's opinion that this is an example of spending too much time and effort on awareness safeguards — warning labels in particular. Many of these could be considered self-preserving, and unfortunately appeared to have stifled the manufacturer's ability to identify and relatively easily eliminate a clear hazard. Further, although a manufacturing company's legal counsel may advise otherwise, awareness safeguards should contain few words and include some type of relevant pictorial. Wordy awareness safeguards may reduce legal exposure, but are frequently not read, which compromises safety.

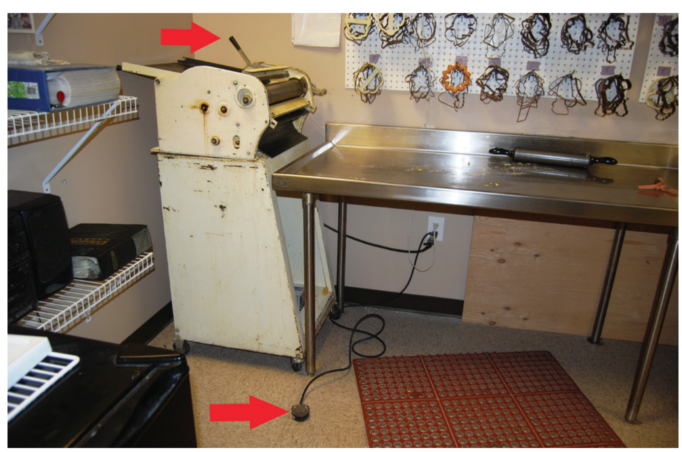

Figure 12
Dough rolling machine. Upper arrow shows its handle control. Lower arrow shows its foot pedal control.

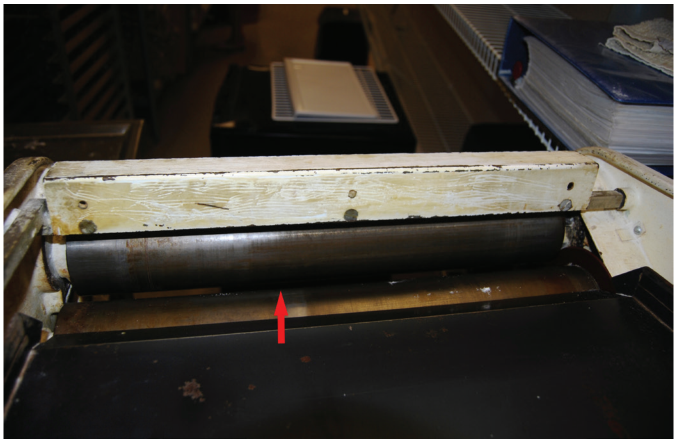

Figure 13
Pinch point between the rollers where the worker injured her hand.

Case 3: Dough Rolling Machine

As a worker was cleaning the rolls of a dough rolling machine, she inadvertently stepped on the foot pedal that controlled the operation of the rollers. This resulted in her hand being injured as it was pulled through the ½-in. gap between the rollers (**Figures 12** and **13**).

Before examining how the safeguarding hierarchy applies to this incident, a few noteworthy complicating factors that contributed to this incident will be presented.

1. The dough roller was manufactured in 1965. OSHA was established in 1971. OSHA's first standard related to machine safeguarding was adopted in 1989. Applying the requirements of a standard to a machine that was manufactured 24 years before the standard came into existence can be a challenge.

2. Although who did what and when could not be established, the dough roller was likely modified after it was manufactured. A representative from the dough roller manufacturer testified that the dough roller was controlled by the movement of a black handle (**Figure 12**). This handle could be pressed downward about $^3/_8$ in. with little effort, and subsequently returned to its original position upon release. It was not confirmed, but the intended operation of the dough roller was likely for its rollers to rotate when the handle was pressed downward, and for the rollers to stop when the handle was released. This would keep one of the operator's hands away from the rotating rollers. However, when the dough rolling machine's electrical plug was inserted directly into a 120V outlet, the rollers rotated when the handle was pressed downward and continued to rotate when the handle was released.

3. Nonetheless, the electrical plug of the dough roller was inserted into the plug connected to a foot pedal that was in turn inserted into a 120V wall outlet. This configuration allowed the operation of the rollers to be controlled by the foot pedal, which likely required a modification of the dough roller controls as noted in Item 2 above.

Based on the information above, and other factors, the author concluded that the foot pedal was not supplied by the dough roller manufacturer and was added sometime after the machine was put into service. Whether using a foot pedal to control the operation of the rollers was acceptable is a reasonable question. However, the incident foot pedal was unguarded; therefore, it was not suitable to control the operation of a machine such as a dough roller. There was a label affixed to the side of the foot pedal containing the text: "WARNING TO AVOID PERSONAL INJURY, DO NOT USE THIS CONTROL ON MACHINERY WITH AN UNGUARDED POINT OF OPERATION." This warning is consistent with OSHA's foot pedal guarding requirement noted in the following section.

The modification of the dough roller control system rendered it unsafe specifically because its rollers were controlled by an unguarded foot pedal. The following machine safeguards would/may have prevented the incident:

Hazard Elimination/Mitigation

The small gap between the rollers is a point of operation pinch point and necessary for the dough roller to function. However, this hazard could have been mitigated when cleaning the rollers by increasing the gap between them.

Physical Guard

The dough roller could have been fitted with a point of operation guard, such as a hopper, that would have prevented contact with the rollers during its normal operation. However, the incident occurred during a cleaning operation, and any such guard would likely have been removed to clean the rollers. In addition to preventing personnel from putting a body part into a hazardous area of a machine, physical guards can also prevent the inadvertent energization or activation of a machine. In these cases, hinged or limited access guards are placed over machine switches (see **Figure 14**).

Figure 14
Toggle switch guard (left). Foot pedal guard (right).

The following is an excerpt from OSHA's Machinery and Machine Guarding Standard:

> **1910.217(b)(4)(i)**
> *The (foot) pedal mechanism shall be protected to prevent unintended operation from falling or moving objects or by accidental stepping onto the pedal.*

The incident foot pedal did not meet this requirement. If it had, the incident likely would not have occurred.

Engineering Controls

At the time of the incident, the dough roller did not have an operational engineering control safeguard. To the contrary, the likely modification of its control logic, coupled with the addition of an unguarded foot pedal had a detrimental effect to its operational safety and was causal to the incident.

Awareness

It would be difficult to argue that a reasonable person would not have been aware of the danger associated with the pinch point between the two rollers. Nonetheless, an associated warning label may have prevented the incident. It is not known if such a label was installed on the dough roller when it was manufactured.

Administrative Controls

The owner of the dough roller and the establishment where it was located demonstrated how the rollers were cleaned, which was done daily for many years. The rollers were sprayed with a cleaning solution and wiped by hand with a rag. Hands were then removed from the rollers, the rollers were rotated slightly by tapping the foot pedal, and the process was repeated several times. This was how the injured worker was trained to clean the rollers. Although this method of cleaning was performed without incident for many years, it was unsafe to do so with an unguarded foot pedal.

Although more time consuming, the rollers could have been removed from the machine to clean them.

Personal Protective Equipment (PPE)

Apart from the rollers being removed for cleaning, it was necessary to jog the rollers to clean them and thereby not to de-energize the machine. Cleaning the rollers is a minor, routine, and repetitive operation that takes place during normal production operations. It should have been performed with a sponge on a utensil, or a similar wipe-down device, that does not require one's hand to be at the point of operation. Such a device would have been an acceptable safeguard during the cleaning of the rollers. This safeguard not only would have kept the operator's hands out of harms way, but may also have allowed the rollers to be rotated continuously during the cleaning operation, thereby shortening the process.

OSHA National Emphasis Program on Amputations

The author performs various engineering and safety consulting services at a medium-size manufacturing facility. One day an OSHA inspector made an unannounced visit and informed company executives that the facility had been randomly selected for an audit as part of OSHA's National Emphasis Program on Amputations. Shortly thereafter, the author was summoned to a meeting with company management and the OSHA inspector, and was assigned to be the required main contact person for the inspector.

Although not always enjoyable, the ensuing multiple-visit and several month-long audit process was a valuable experience that has served the author well. Many machine safeguarding issues were raised, addressed, debated, etc., during the audit. While a discussion of these issues may be valuable to safety professionals, many are beyond the scope of this paper. Nonetheless, the following are three selected issues raised during the audit that a forensic engineer who investigates machine safeguarding matters may find to be of value.

Engineering Controls vs. Physical Guards

When a physical guard unduly interferes with the operation of the machine, an engineering control can be used as a safeguard, provided that its effectiveness can be proven. One example is that a presence-sensing device must be far enough away from the hazard it is safeguarding, such

Figure 15
Sheet metal press safeguarded by a light curtain (see arrow).

that the hazard must be eliminated (e.g., stroke of a power press stopped) before someone can contact it.

Figure 15 shows a sheet metal power press with a presence-sensing light curtain. A stopping time of 0.360 seconds was measured from when the light curtain was tripped until the downward stroke of the press ram was stopped. This time coupled with OSHA's stipulated 63 in./second hand speed yielded a minimum safety distance of 22.68 in.[4]. The actual shortest distance from the light curtain to the press was approximately 25 in., which was acceptable (**Figure 16**). It should be noted that if the presence-sensing device is too far from the hazard, other safeguards may be necessary between these two items.

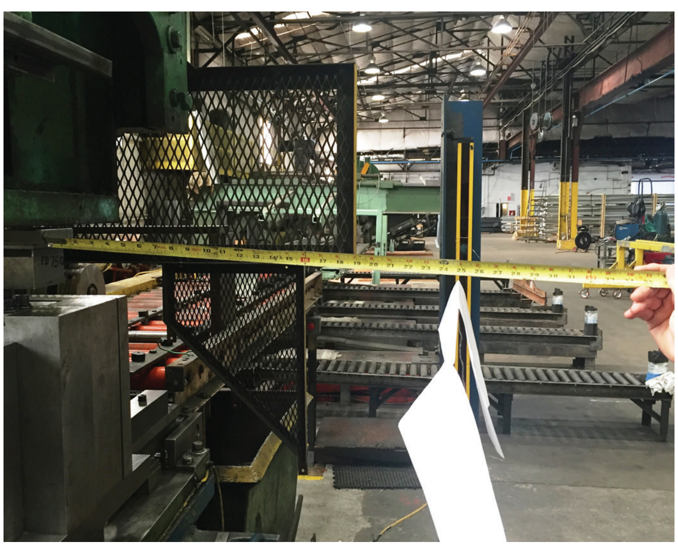

Figure 16
Distance of approximately 25 in.
from the light curtain to the closest hazard of the press.

Lockout/Tagout Procedures

To help prevent the uncontrolled discharge or release of energy while a machine is being repaired, serviced, modified, etc., it is important that all forms of energy (e.g., electrical, hydraulic, pneumatic, potential, kinetic, etc.) first be secured or otherwise eliminated. Properly written and followed lockout/tagout procedures ensure that this occurs and serves as a means of hazard elimination.

If an injury occurred while someone was working on a machine that was not operational, and related to the uncontrolled release of energy, the investigating forensic engineer should request the lockout/tagout procedure of that machine. The procedure, which should have been audited during the past year, should be reviewed for effectiveness and proper implementation. All switches, valves, gauges, etc., noted in the lockout/tagout procedures should be clearly labeled. Whether or not relevant personnel received proper lockout/tagout training should be determined.

Lockout/tagout procedures for machines with only one form of energy, typically electrical, are generally not required as long as other related criteria are met per OSHA 1910.147(c)(4)(i). However, that form of energy should still be locked out while the machine is being worked on.

OSHA Lockout/Tagout Minor Servicing Exemption

There are many instances when machinery must be serviced, adjusted, or otherwise modified, and performing a full lockout/tagout procedure between each iteration of these activities would be unduly burdensome. Recognizing this dilemma, OSHA developed a lockout/tagout exemption that applies when ALL of the following conditions are met:

First, the activity must be conducted during normal production operations (i.e., while the machine or equipment is actually performing its intended production function).

Second, the activity must be:

- *Routine*: The activity must be a regular course of operation and be in accordance with established practices.
- *Repetitive*: The activity must be regularly repeated as part of the production process.
- *Integral*: The activity must be essential to the production process.

Figure 17
Worker cleaning weld tips on a resistance welder while standing on a safety mat that secures power to the machine.

Third, if all of these apply, the employer must use alternative measures to provide effective protection from the hazardous energy. Acceptable alternative measures include specially designed tools, remote control devices giving the operator exclusive control of the machine, interlocked barrier guards, local disconnects, and control switches under the exclusive control of the employee performing the minor servicing[5].

Figure 17 shows a worker cleaning tips of a resistance welding machine, which meets all of the above criteria. The alternative safeguard in this case is the safety mat that prevents the welder from being energized while the worker is standing on the safety mat.

Conclusion

Machine safeguarding is a vital component of safety in many industries and consumer products. A good criterion is that if it is reasonably foreseeable that someone could be exposed to part of a machine that could cause them bodily harm requiring the attention of a medical professional, a safeguard should be employed to eliminate, ideally, or substantially mitigate the associated exposure likelihood and/or the severity of harm.

An effective machine safeguard is one that prevents machine hazards from harming personnel by substantially reducing the risk of exposure to the hazard and/or the severity of the associated harm. The safeguard also must not unduly interfere with the productivity of the machine; otherwise, the safeguard is more susceptible to being removed or otherwise disabled by its operator/user.

The safeguarding hierarchy is a valuable tool for selecting the appropriate method(s) for safeguarding a machine hazard, and it should always be given due consideration. However, a solid understanding of the machine hazards, operation, and maintenance, along with human factors, must also be considered to develop an effective machine safeguard.

A closing thought for consideration: It is easy and wrong to make safety and productivity competing interests. It is difficult and right to make safety and productivity complementary interests. Do the right thing!

References

1. Moskowitz L. History and practices of machine guarding. Journal of the National Academy of Engineers. 1991; 8(1); 53-58.

2. Occupational Safety and Health Administration. Washington (DC): United States Department of Labor [accessed 2018 July]. https:www.osha.gov. https://www.osha.gov/osha40/OSHATimeline.pdf.

3. ANSI B11.0-2015. Safety of Machinery. Washington, D.C; American National Standards Institute.

4. Occupational Safety and Health Administration. Washington (DC): United States Department of Labor [accessed 2018 July]. https:www.osha.gov. https://www.osha.gov/SLTC/etools/machineguarding/presses/safetydistance.html.

5. Occupational Safety and Health Administration. Washington (DC): United States Department of Labor [accessed 2018 July]. https:www.osha.gov. https://www.osha.gov/dts/osta/lototraining/hottopics/ht-relche-1-2.html.