Implementing a Machine Hazard Assessment Program

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Introduction

Every workplace presents a set of hazards, unsafe conditions and behaviors, which given the right circumstances can produce an undesired event resulting in worker injury. The challenge for management is to eliminate or control access to those hazards so that the event and injury does not occur. Management systems, which incorporate ongoing, thorough workplace assessments to identify hazards, are desirable as a first step in the quest to attain a safe workplace. Identification and reduction of machine related hazards must be part of this process.

It is the writer's experience that detailed machine assessments are often initiated as a result of a severe, machine related, workplace injury (or death), or a history of such injuries

Described below are three real cases where old equipment and exposed machine hazards resulted in serious accidents.

Case 1**:** A maintenance employee is trouble-shooting a problem on an engine lathe. The lathe is used to fabricate stator tubes for the oil industry. The long, 50 foot, metal tubes are placed into the lathe with one end slightly protruding out from the chuck. The entire tube rotates while a tool moves into the end of the tube to trim off excess lining material. At the back side of the lathe, approximately 40 feet of tube rotates on a single support. Tubes are usually rotated at low speed (50 rpm) but in this case the maintenance operator, as part of his trouble-shooting, switches the rotation to high speed (200+ rpm) and the unsupported section of the tube, sticking out of the back side of the lathe deflects and radically bends from the imbalanced tube and higher revolutions per minute. The maintenance worker is struck in the head and killed.

Corrective Action: Special supports are constructed for the back side of the tube to securely hold it in place. The new supports are interlocked to the machine so they must be in place before the machine will operate. Perimeter guarding is added around the tube support area and equipped with an interlocked entry gate so the operations will shut down upon entry into the area. Management realizes they have no production need for the lathe "high speed" function and they physically prevent (lock) access to the high speed control setting.

Case 2: A worker operates a large paper winding machine. The machine winds paper around the metal core of a large electrical bushing. The paper moves between two unguarded, in-running rollers. The machine operator, who has run this particular machine for over 15 years without incident, tries to fix a wrinkle in the paper as it moves into the rollers. The hand gets caught between the rollers resulting in a total loss of the hand with muscle and tendon damage to the arm and shoulder.

Corrective Action: Light curtains and barrier gates are properly installed, preventing access to the exposure.

Case 3: An automotive seat assembly conveyor has large pallets with a fully assembled passenger and driver car seat resting on the pallet. The conveyor design has rollers spaced about 6 inches apart. The seat pallets rest on the rollers and the rollers are driven by a tension belt that moves under the rollers and provides the power to move the pallets. A pallet jams and the worker moves onto the conveyor, standing on the conveyor tension belt for the purpose of clearing the jammed pallet. A pallet at another location in the system moves past a proximity sensor and turns the conveyor section on while the worker is standing on the belt. The belt forces the workers foot under the roller and results in a compound fracture of the worker's leg.

Corrective Action: Perimeter guarding is built around the conveyor. Entry into the area to clear pallet jams or for any reason is through an interlocked gate, which is designed to be "control reliable" and shut the system down in a fail safe manner. Later, the manufacturer builds the conveyors with roller end slots that allow the rollers to pop up. This design change reduces the possibility and severity of a future occurrence.

In each of these cases, a properly conducted assessment would have identified the related hazards, and risk reduction could have been implemented, preventing each of the accidents. The hazards existed in the workplace for many years; they were identifiable but were only dealt with after deadly or severe accidents occurred. Administrative controls were relied upon to keep people safe when there were better options available on the risk reduction scale. Energies and resources were directed to those options only after death and severe injury created the incentive to bring necessary resources together.

Machine guarding can be tough to sell if it can not be linked to direct, immediate financial benefit. Plant managers are on limited budgets, looking for an immediate return for every dollar spent. The "lean and mean" approach makes management resources tight with little time to deal with the complex initiative of identifying machine hazards and exploring risk reduction options. A typical example may be an old, unguarded, widget machine with exposed in-running rollers and reciprocating machine parts. The machine presents multiple hazards with severe accident potential. It has been in the workplace for over 30 years. There has never been an accident on the machine. The machine makes great quality parts and is paid for. The cost to guard the equipment is considerable. The only thing keeping people out of harms way is the workers awareness of the machine hazard. People can often behave safely for a long time; however an unsafe act is inevitable over the long term. The result is that the machine is operated without an accident for 5, 10, maybe 30 years. Typically, the machinery, and others like it, will remain unguarded until a serious accident occurs.

The benefit of a machine hazard assessment program is that it identified exposures, ideally all machine hazards and numerically quantifies the exposures based upon the hazards potential severity, likelihood of occurrence and frequency of exposure. This allows management to look at the big picture and begin the process to allocate resources toward the reduction of those hazards. Hopefully, this is done proactively, before an accident occurs.

The Journey

Implementation of a machine hazard assessment program is an endless journey. A well planned assessment initiative can take several years to implement for a high volume manufacturing operation where there are multiple machine systems, "home grown" machines, and unique processes. The steps involved in this process are:

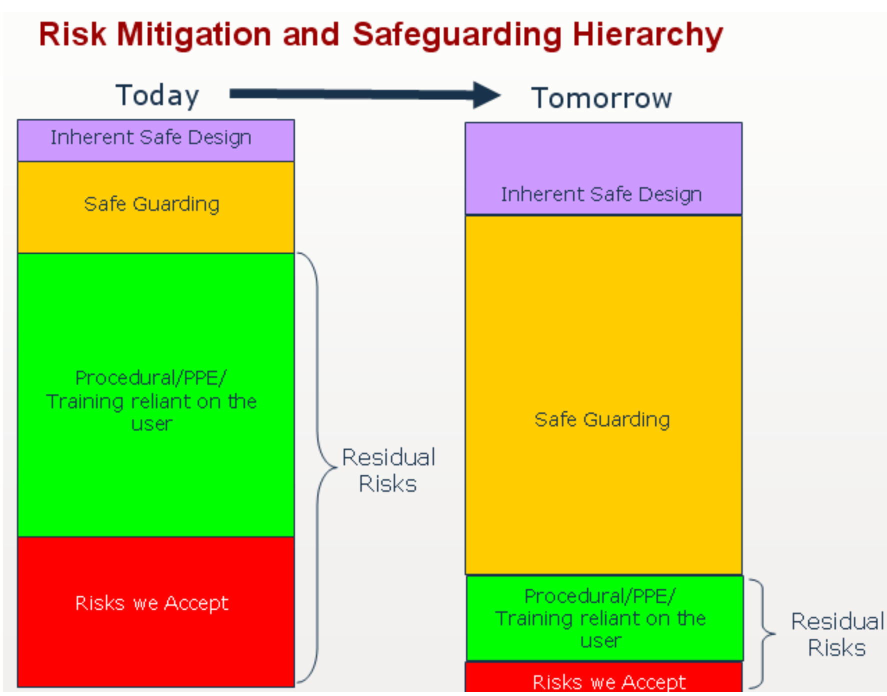
1. Establishment of machine guarding and risk assessment policies for both new and existing equipment.
2. Dedicating resources for assessment and remediation.
3. Assessing existing machinery.
4. Implementing risk reduction measures.
5. Training management, machine operators and employees at each facility on machine assessment and guarding.

Before discussing each of these items, it is important to note that machine hazards are treated just like any other workplace hazard regarding corrective actions. There is a hierarchy of control that falls into three general levels (Jensen 30), these are:

Priority 1: Control by eliminating the hazard.

Priority 2: Control by designing for effectiveness with minimal human effort.

Priority 3: Control through human effort and behavior.



Above the safety program goal is to move forward in time with larger numbers of machine hazards eliminated through design or addition of safe guards and less administrative controls and workplace risk that is accepted.

The level of preferred control is based upon the risk assessment process. This process examines a machine hazard and subjectively attempts to quantify the level of severity, frequency of exposure to the hazard and if exposed to the hazard, the probability of occurrence. Various industry consensus standard offer scales to quantify each category and the sum of this quantification directs you to a priority level for hazard control. One of the better US consensus standards to reference for this type of risk assessment process is ANSI/RIA 15.06, which relates to robotic operation. Similar processes are presented in ANSI B11 series documents and EN (EN 954) standards as well (to name a few). Some form of this type of risk assessment process must be adopted and integrated into a company's policies for review of old, existing equipment and specification of new equipment and processes.

Establishment of machine guarding and risk assessment policies

Depending upon your company production operations the machinery in use may or may not have well developed industry standards that address the construction, care and use of the equipment from a hazard assessment point of view. The following are some industry standards that address a hazard assessment process:

- The ANSI B11 series consensus standards address machine tools, such as mechanical power presses, hydraulic presses, press brakes, etc. These standards are being rewritten as they come up for review with hazard assessment and risk reduction in mind.

- The Robot Industry Association standards for industrial robots (ANSI/RIA 15.06) does an excellent job of establishing risk assessment criteria for determining guard and control systems reliability for robotic operations.

- All European Community equipment falls under standards that require up front risk assessment to determine design criteria related to guarding and control systems reliability.

There are many machine manufacturers that have not adopted this process. Old equipment on the production floor may be grandfathered from existing consensus standards. For successful implementation of a machine hazard assessment program, company policy must be developed which incorporates hazard assessment methodology and requires the review of existing equipment. This policy should establish standards for machine hazard review, risk assessment and reduction strategy for existing equipment. Policy content should address the following:

- Hazard Assessment Methodology – As described in the previous paragraph, the assessment process must identify machine exposures and attempt to rate severity, frequency of exposure and probability of occurrence. The rating will suggest a hierarchy of control. The goal will be to attempt to reach this level of control through risk reduction.

- Machine guarding standards – Risk reduction will most often be achieved through machine guarding. Standards of guard design and construction should be spelled out. OSHA does not provide clear guidance related to guard design and construction. ANSI B11.19 and ANSI/RIA 15.06 establish some excellent design requirements that can be applied to other non-related equipment. Administrative controls do not work in the long term. The objective for any Program is to ensure the only way a worker can gain access to hazardous machine exposures is by consciously and deliberately "going out of their way" to circumvent the guarding. With this in mind, the following are some standards that should be best practices for safeguarding design.

- Guards and/or devices should prevent access to the hazard from going in, under, around or through the guarding.

- Openings in guards should meet the size/distance scale (gotcha stick) as established in the mechanical power press requirements, OSHA 1910.217, table O-10.

- Guards should be attached with fasteners that require special tools for removal, where the tools are not readily available in the workplace, or be equipped with electrical interlocks that are difficult to defeat.

- Interlock and circuit design, should be predicated upon the hazard assessment rating for the level of design control reliability. Interlocks should be designed to fail safe. Reference ANSI/RIA 15.06 for an example of this.

- Perimeter guarding requirements should be standardized. Perimeter guarding should be a consistent barrier that extends from floor level to an agreed upon height. OSHA established no guidelines for perimeter guarding. A best practice is to have the guarding extend from the floor to a height of at least 60 inches (or higher). Any gaps at the bottom of the guarding should not be large enough for persons to crawl under. It is understood that in some instances hoses, wires and other equipment must be allowed to enter through the guarding. ANSI B15.1 relates to power transmission guarding and this document provides a table guide for guard height versus horizontal distance from the guard and vertical height of the hazard above the floor.

- Devices such as light curtains and other presence sensing technology must meet safety distance requirements and be control reliable. The machine stopping action must be reliable. Electrical circuit and mechanical control reliability should be based upon the hazard assessment rating.

Don't overlook machine hazards associated with new production equipment and processes. If new equipment is not properly reviewed and specified, it is possible to end up with machine hazards that the end user must deal with. This is often costly and the hazard reduction options may be limited. If custom production equipment is being developed there needs to be standards established for risk assessment and risk reduction as part of the design process. Corporate level procedures should guide the specification and design of new equipment and processes.

The writer was asked to participate in the development of a corporate new machine specification standard. The original specifications only focused on performance criteria and failed to spell out safeguarding controls. The company depended on the vendor to meet implied standards. Checks and balances did not ensure new equipment was designed with safety in mind.

As such, the company decided to create global machine specifications incorporating hazard assessment methodology to determine physical safety and machine control reliability design. A machine specification team was formed consisting of internal design engineers, Corporate Risk and Legal, Corporate Safety and outside consulting (Bureau Veritas). The team used existing standards, specifically EN, ANSI B11.19 and B11.TR3 as guidelines. This standard addressed general requirements for guards and devices, E stop circuit design, electrical safety design, pneumatic and hydraulic systems design, noise and ergonomics. The standard took over two years to develop and was reviewed by sixty-seven engineers worldwide.

A spreadsheet tool, developed to evaluate existing and new equipment for safety, came out of this process. The tool is used to establish a prioritization number for implementation of machine safe guards. The use of this tool is discussed further below.

Dedicated Resources for Assessment and Remediation

Management must allocated sufficient resources to complete the project or it will not succeed. The resources should include capital expense dollars and human resource. The resources are defined as follows:

Capital Expense

The cost for such a program can be substantial. As such, cost factors need to be defined as closely as possible. Where possible, provide a return on investment vs. the cost. This helps justify and sell the program. Some cost factors for consideration include:

- New equipment purchase
- Engineering design
- Fabrication of guards
- Purchase of guards and electronic safeguards

Human Resource

No single person can be responsible for putting together a hazard assessment program. It will take the efforts of many who have a variety of skills. The group should meet to establish their objectives and how to reach them. This enables everyone to share the work effort as well as provide input from their discipline perspective. Examples of who should be on the task force:

- Engineering
- Training Department
- Safety
- Upper Management
- Maintenance
- Purchasing

As part of the task force, a skilled assessment team should be formed. The team should consist of a cross section of members. This greatly reduces self interests and agendas.

Assessing Existing Machinery

As mentioned, the review of existing machinery should be done by an assessment team. Teams can be assembled at the plant level or can be brought together from various plants to form a corporate assessment team. Outside consulting services can be incorporated into the team if additional expertise is needed. As noted above this group should have specific expertise in the area of electrical and mechanical engineering. I have found that excellent workplace assessments can be conducted with the assistance of well trained and experienced maintenance personnel.

Assessments are completed using a machine guarding checklist. The checklist is designed to spot machine exposures at the point of operation, power transmission and any other area where there is mechanical motion or hazards from electrical, chemical, heat, or potential and/or kinetic energy. It is important that members of the assessment team have specific knowledge of any ANSI or industry consensus standard relating to the equipment safety.

Consider an example of a mechanical power press equipped with light curtains. If this press is run in the automatic, continuous mode, the light curtains can provide adequate coverage and meet all OSHA and consensus requirements. If we find this equipment operated in the single stroke, hand in die, mode of operation the assessment team must have membership that is familiar with this equipment and the respective OSHA and ANSI requirements. In this operating mode the press must be equipped with a brake monitoring system. The presence of a functional brake monitor must be verified as part of the assessment, as well as proper safety distance for the light curtain.

Specific expertise is needed for specific equipment. In the example above, we could find such a press equipped “in appearance” with guards and devices that prevent access to the point of operation from in, under, around or through, but the lack of a brake monitor does not provide the level of control reliability needed by standard (and through the use of a risk assessment process). Clearly, with such machinery additional expertise is needed for proper evaluation of the equipment.

A tool was mentioned in this article. This tool is a spreadsheet that incorporates a risk assessment rating system. The spreadsheet is intended for use to prioritize equipment based upon severity, frequency of exposure and probability of occurrence. It is a tool to flag equipment in need of immediate attention. It is valuable for operations with a large number of pieces of equipment and can help focus resources to reduce the more serious hazards first.

The equipment evaluator would use the spreadsheet to record any machine exposure where the guarding does not meet 100% of “best practice” standards (mentioned earlier). If the safeguarding is missing one small element of our “best practice” standard, then we assume the equipment has “no safeguarding” and the exposure is listed and rated for severity, frequency of access and probability of occurrence. For example, if a fixed guard at a machine point of operation has an opening that does not meet the size/distance standard, then we list the machine exposure as if it was not guarded. If a fixed guard is not interlocked or attached with fasteners that require special tools for removal, then we treat the hazard as if it was completely unguarded. If the safety distance of a light curtain was not established and documented based upon the machine stopping time, then it is listed as an unguarded exposure.

The advantage of this type of assessment is that the most severe exposures can be singled out and addressed first. To remove a listed exposure from this work list may be as simple as closing up a hole in a fixed guard, or documenting a machine stop time to verify the light curtain safety distance is proper. On the other hand, other exposures may require custom safeguarding with prototype design and major allocation of resources. The bright side to this process is that it is one of continuous improvement and the workplace is safer today than it was yesterday.

There are many forms of machine hazards and it takes a trained eye and a structured, proactive, approach to identify these hazards in the workplace. It is easy to miss machine hazards and the more people involved in the assessment process, the better chance of identifying hazardous exposures without overlooking something. Machines have different operating modes and it is important to discuss operations with operators and area managers to properly assess the equipment for all production uses and modes of operation. The safeguarding setup observed at one point in time, may not be present for another production run on the equipment. In these instances, it is important that management systems exist, which address the safety of various machine setups.

Press brake operations are an excellent example of a type of operation that must be carefully examined. Light curtains may provide coverage for two out of three bends on a metal part; however the changing configuration of the part (or parts) will not permit the continued use of the guarding system. In cases like this, other safeguarding approaches or technology must be brought into the process.

Implementation of risk reduction

Once machine hazards are identified and assessed for risk, the process of risk reduction can begin. An excellent article on risk reduction strategies was recently published in Professional Safety magazine by Roger Jensen (Jensen 26). Three basic hierarchies of reduction were listed. In this article Jensen lists nine basic reduction strategies for consideration. These are:

1. Eliminate the hazard
2. Moderate the hazard
3. Avoid releasing the hazard
4. Modify the release of the hazard
5. Separate the hazard from that which needs to be protected
6. Help people perform safely
7. Use PPE
8. Improve the resistance of that which needs to be protected
9. Expedite recovery.

When machine hazards are involved we do not want to rely on administrative controls. Numbers 6-9 above are in the realm of administrative controls. We are mostly focused on separating the hazard from that which needs to be protected, i.e. machine safeguarding. We accomplish this with either guards or devices. Guards prevent access to the hazard and devices control access by shutting down the machine when our presence is sensed in a hazard zone or blocking/preventing access to the hazard during a danger portion of a machine cycle.

Our main, guiding thought in the risk reduction process is to ensure that the only way a person can get access to a machine hazard is by a conscious, deliberate action to physically remove guarding and/or defeat safety devices.

Risk reduction for some equipment can be time consuming and challenging. In the accident scenario described in this article's introduction (case 2), where the machine operator lost a hand when it was caught between rollers, the final resolution involved a consultant, a control systems specialist, an outside guard fabricator and internal management and maintenance personnel. Guarding on the equipment was prototyped and an assessment was redone to determine if additional hazards were being created by the guard installation, in this case interlocked gates and light curtains. It took over two weeks with all these specialists and in house staff, in a focused effort, to properly guard this older equipment.

Of course elimination of the hazard via re-engineering is most desirable but not often achievable in a cost effective manner, particularly when dealing with older machinery. An additional consideration when re-engineering (modification of the equipment) is involved, centers on product liability issues. If a machine design or control system is altered it must be done correctly, since the designer assumes new liabilities. This article does not address the liability issue but there are companies that were willing to take on this liability and/or hired specialists for the design process.

In some cases the amount of machine force needed can be reduced to a safe level where the accident severity is minimized. For instance, a large amount of force is not needed to move pizza boxes on a conveyor. A slip clutch that will disengage the drive motor before serious injury would result should a person get caught on the conveyor could be used. One thing that must be included in the design of the clutch mechanism is the control reliability. A design that will always fail safe and allow the clutch to disengage when the component parts begin to wear out is needed.

There are some pieces of equipment that are inherently unreliable for what they are intended to do. In other words, the equipment jams often, needs constant adjustment and/or frequently breaks down. If this is the case, guarding becomes very difficult since constant access to the equipment is needed. The first objective would be to try to make the equipment reliable and then add machine safeguarding. If the design problems are bad enough, new, more reliable equipment should be sought.

The main objective of risk reduction is to reduce the risk to the lowest level possible. ANSI B11.TR3 refers to "tolerable risk", which is defined as, "Risk that is accepted for a given task and hazard combination (hazardous situation)." For the purposes of this article what is "tolerable", is that any machine that presents hazardous exposures with high severity, i.e. potential for death or a disabling injury, should not rely on the operator's awareness of the hazard for protection. This opinion creates some dilemmas when considering some machine operations such as forge machine operations, where the operator uses tongs to flip metal parts in a large press bed with no point of operation guarding. This is one example of many where administrative controls are considered to reduce risk to a tolerable level, although it should be noted very often robots were installed to place and pick the parts in lieu of human operators. Unfortunately, tolerable risk can not be defined in finite terms. What is considered "tolerable" is influenced by financial factors.

Training of management, machine operators and employees

There are key training points related to machine guarding for workers at all levels. In the recent past only the most obvious or severe machine hazards were guarded. After all, “only an idiot would put their hand in there!” I have investigated enough accidents to realize when people are caught in a machine, they are usually trying to facilitate production and the “idiot” turns out to be an experienced, intelligent and cherished employee of the company.

At the outset of a machine hazard initiative it is essential that the new standards for guarding be presented. Management, employees and especially machine operators must recognize that guards are never to be removed or defeated. General awareness training is needed to get this point across. Remember we are promoting a level of safety that says the only way a worker can get caught in a machine (during normal production mode) is to consciously and deliberately defeat the guarding. Guarding standards need to be understood and enforced.

For personnel on a guarding assessment team the level of training is more detailed and technical. These individual need to be trained to recognize machine hazards and determine if the current machine safeguarding provides the level of protection needed by the company policies. These individuals must have a core understanding of the following:

- Machine Guarding Philosophy –no access.
- Overview of regulations and standards pertaining to machine safeguarding.
- Machine hazards requiring safeguarding.
- Machine areas requiring guarding.
- Machine Guarding Techniques – guards and devices.
- Guard types and requirements.
- Guard interlock requirements.
- Safeguarding Devices and requirements.
- Concepts of Machine Control Reliability.
- Machine Hazard Assessment Process (ANSI B11.TR3 and EN Standards of Hazard Assessment).
- Selection of machine safeguards for specific machines types and risk reduction options
- General requirements for machine controls.

The team should have membership of persons from specific disciplines such as electrical and mechanical engineering. The expertise of these persons is necessary to make decisions related to the machine control systems reliability, which is important for the proper selection of risk reduction options.

Summary

There are forces in industry that continuously compete for time and money. These forces can distract management from conducting proactive machine hazard assessment and risk reduction initiatives. Severe machine exposures are often not safeguarded; rather employee awareness of the hazard is employed as an administrative control to keep the worker safe. This can be effective for many years and give an impression that higher levels of protection are not needed, or necessary. Machine exposures can exist in the workplace for many years before an employee is injured. To avoid these often severe, sometimes fatal, accidents, machine hazard assessment is needed. Great advances toward a truly safe workplace can be realized through proactive hazard assessment; a machine hazard assessment program is a part of this process. More information on this subject can be obtained by contacting Paul Price at 800 323-9585.

A successful machine hazard assessment program is an ongoing process, which should be sponsored in an organization from the top down. The process involves the development of corporate policies that form and address machine hazard recognition philosophy, risk assessment methodology, and "best practices" standards of what constitutes proper machine safeguarding/guarding. Organizations that have old equipment should be assessed for hazards and considered for hazard reduction. New equipment safety should be meticulously specified by company policy and guidelines. All employees must understand the policies and management must consistently enforce safeguarding standards. The machine hazard assessment process can be technical and require specific expertise. Assessment teams should be made up of personnel who are trained and have technical and machine specific expertise so that a thorough assessment can be done. Thorough assessment incorporates risk assessment. Risk assessment should subjectively rate hazardous machine exposures for severity, frequency of access to the hazard and probability of occurrence for injury. This rating can be used to establish a time table as well as the level of safeguarding and machine control reliability. An excellent standard for reference is the Robot Industry Standard, ANSI/RIA 15.06.

Risk reduction regarding machine hazards is most often achieved through installation of machine guards and devices. Risk reduction for some existing equipment can be challenging and time consuming. Risk reduction attempts to achieve the highest level of control by first engineering hazards out of equipment, then separating the hazard from that which needs to be protected and finally, as a last resort implementing administrative controls.

Bibliography

Jensen, R. "Risk Reduction Strategies." *Professional Safety*. Jan. 2007: 24-30