Chapter 3
Machine Safety

We have learned in an earlier chapter that accidents are cause by the unwanted contact of energy with persons. A great deal of these accidents involve machines and their moving parts. To address this the Philippine Occupational Safety and Health Standards require that adequate consideration be given to the proper guarding of machines. Rule 1200 of said Standards deals specifically with this.

Rule 1202 states that: All moving parts of prime movers, transmission equipment and all dangerous parts of driven machinery shall be effectively guarded, unless so constructed or located as to prevent any person or object from coming or brought into contact with them.

Mechanical Hazards

Rule 1203 forms the foundation for the succeeding regulations, which will be discussed here. Essentially, the objective is to prevent unwanted contact with energy (e.g., moving parts, hot surfaces, etc.). The hazards we are likely to encounter are commonly in: **power transmission devices** (i.e., rotating shafts and couplings, belts or gears); **points of operation** (i.e., in-running nip points, parts that impact or shear, flying chips or sparks); and **other moving parts** (e.g., reciprocating, rotating or tangential moving parts, feed mechanisms, and other auxiliary machine parts). In-running nip points may be between two rotating parts, between parts with

rotating and tangential motion, or between rotating and fixed parts which shear, crush, or abrade.

Figure 3.1

Rotating parts can grip hair or clothing, and force the body into a dangerous position, and projecting parts increase risk of this – loose articles of clothing or even PPE (say, a harness lanyard) can easily get caught in rotating drive coupling, especially when coupling bolts protrude from the coupling flange.

Figure 3.2

Injury will often result from direct cutting action or from flying chips or sparks in drill or grinder operations. Other machines that can injure at the point of operation include punching, shearing and stamping/bending machines.

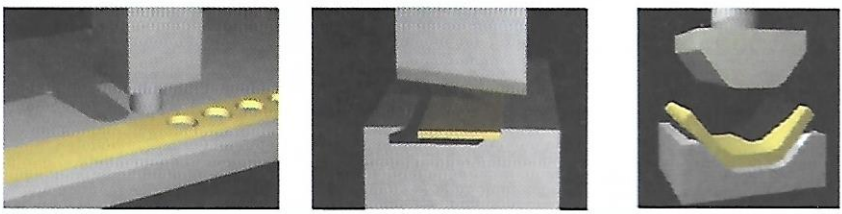

Figure 3.3

Reciprocating parts, such as that of a shaper or some elements in industrial robots will pose the risk of workers "getting caught in between" the reciprocating part and some stationary object. While robots are great control measures that preclude any contact between man and moving parts during machine operation as the machine itself is doing the job, and so no one is in the vicinity of the running machine, danger comes from unexpected energization while the machine is being serviced. This necessitates proper application of LOTO Procedures.

As can be seen here, there are probably as many hazards created by moving machine parts as there are types of machines. This makes it very important to put in controls that will protect the workers from the truly preventable injuries mentioned here.

Basic Requirements for Machine Safeguarding

Bearing in mind Rule 1202 of the Standards, we would need to have machine safeguards that will do the following:

- Prevent contact: The safeguard must prevent any part of a worker's body from making contact with dangerous moving parts. A good safeguarding system eliminates the possibility of the operator or another worker placing parts of their bodies near hazardous moving parts.
- Secure: Workers should not be able to easily remove or tamper with the safeguard. A safeguard that can easily be removed or

otherwise disabled is no safeguard at all. Guards and safety devices should be made of durable material that will withstand the conditions of normal use. They must be firmly secured to the machine.

- Protect from falling objects: The safeguard should ensure that no objects can fall into moving parts. A small tool which is dropped into a cycling machine could easily become a projectile that could strike and injure someone.
- Create no new hazards: A safeguard defeats its own purpose if it creates a hazard of its own such as a shear point, a jagged edge, or an unfinished surface which can cause a laceration. The edges of guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.
- Create no interference: Any safeguard which impedes a worker from performing the job quickly and comfortably might soon be overridden or disregarded. Proper safeguarding can actually enhance efficiency since it can relieve the worker's apprehensions about injury.
- Allow safe lubrication: If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce hazard exposure of operator or maintenance worker.

Other Hazards

While this chapter shall deal only with hazards from moving parts of machines and the corresponding control

measures available, it is also important to note that other hazards exist in machines, primarily from the source of power to drive the machines. Among the most frequently used power sources are electric power, hydraulic or pneumatic systems. High pressure lines and related devices in hydraulic and pneumatic systems need to be checked regularly for possible deterioration resulting from pulsations or vibration. These can lead to failures that may lead to leaks, explosions or flying objects.

Electrically powered and controlled machines, on the other hand, should be properly grounded, and equipped with correctly rate protection devices (i.e., circuit breakers, disconnect switches, GFCI). Frayed, exposed or defective wiring should be immediately replaced to protect workers from the risk of electric shock or electrocution. More on this topic in the next chapter.

These energy sources also pose grave danger to workers who deal with the maintenance and servicing of the machines, as many accidents have resulted from the unexpected start-up of the machine or unwanted release of energy, while being serviced, or electric shock/electrocution and even arc blasts from improperly isolated equipment. This is discussed in greater detail in the chapter on Safe Equipment Isolation and Return to Service (LOTO).

Noise is another hazard many machines produce, which can adversely affect workers in a variety of ways. Noise can disrupt worker concentration, and can interfere with effective communication, thus hindering the worker's safe job performance. Research has also linked noise to a whole range of harmful health effects, from hearing loss

and aural pain to nausea, etc. Engineering controls such as the use of sound-dampening materials; administrative controls that involve limiting the time of worker exposure; and personal protective equipment, such as ear plugs and muffs; help control the harmful effects of noise.

Machine Safeguarding Methods

There are many ways to safeguard machines. To determine the appropriate safeguarding method for the individual machine, we need to consider the following: type of operation, the size or shape of stock, the method of handling, the physical layout of the work area, the type of material, and production requirements or limitations.

As a general rule, power transmission devices, like belt drives, gears or couplings, are best protected by fixed guards (i.e., isolation of the hazard). For hazards at the point of operation, like those for punching/shearing/bending machines, where moving parts actually perform work on stock, several methods of safeguarding are available. One must always choose the most effective and practical means. The **Occupational Safety and Health Administration** of the US (**OSHA**) groups safeguards under five general classifications.

1. **Guards**

Guards are barriers which prevent access to danger areas associated with the operation of machines.

A. **Fixed guard** – a permanent part of the machine, not dependent upon moving parts

to perform its intended function, which may be constructed of sheet metal, screen, wire cloth, bars, plastic, or any other material that is substantial enough to withstand whatever impact it may receive and to endure prolonged use.

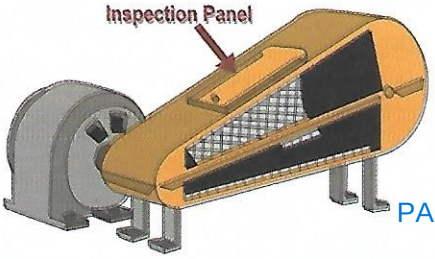

Figure 3.4

B. **Interlocked guard** – a guard whereby removal/opening of the guard will automatically trip the power and render the machine inoperable until the guard is put back in place.

C. **Adjustable guards** – are used to allow flexibility in accommodating various sizes of stock.

Figure 3.5

D. **Self-adjusting guards** – guards that adjust the opening automatically with the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock. After the stock is removed, the guard returns to the rest position.

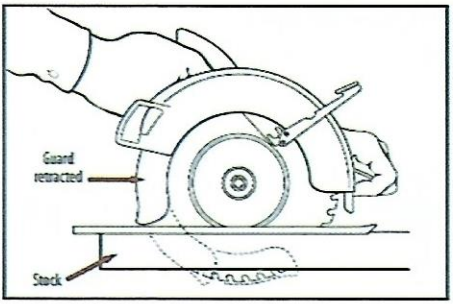

Figure 3.6

2. **Devices**

A safety device may perform one of several functions. It may stop the machine if a hand or any part of the body is inadvertently placed in the danger area; restrain or withdraw the operator's hands from the danger area during operation; require the operator to use both hands on machine controls, thus keeping both hands and body out of danger; or provide a barrier which is synchronized with the operating cycle of the machine in order to prevent entry to the danger area during the hazardous part of the cycle.

A. **Presence Sensing Device** – a device that stops a machine when the presence of a

worker or part of his body is sensed to approach the machine's danger zone.

a. Photoelectric (optical sensors) – a presence sensing device that uses light sources and controls.
b. Radiofrequency (capacitance) – uses a radio beam which is part of the machine's control circuit. A break in the capacitance field stops the machine and renders it inoperable until capacitance is re-established.
c. Electromechanical - has a probe or contact bar which descends to a predetermined distance when the operator initiates the machine cycle. If there is an obstruction preventing it from descending its full predetermined distance, the control circuit does not actuate the machine cycle.

B. **Pullback** – devices that utilize a series of cables attached to the operator's hands, wrists, and/or arms. This type of device is primarily used on machines with stroking action. When the slide/ram is up between cycles, the operator is allowed access to the point of operation. When the slide/ram begins to cycle by starting its descent, a mechanical linkage automatically assures withdrawal of the hands from the point of operation.

C. **Restraint** - (also called holdout device) utilizes cables or straps that are attached to the operator's hands at a fixed point. The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area. There is no extending or retracting action involved. Consequently, hand-feeding tools are often necessary if the operation involves placing material into the danger area.

3. **Safety Controls**

A. Safety trip control - provide a quick means for stopping the machine in an emergency situation.
   a. Pressure-sensitive body bar - when depressed, will deactivate the machine. If the operator or anyone trips, loses balance, or is drawn toward the machine, applying pressure to the bar will stop the operation.
   b. Safety tripod - when pressed by hand, the safety control deactivates the machine.
   c. Safety tripwire cable

B. Two-hand control – necessitates that both hands be used for operating the machine, at a safe distance from the danger area while the machine completes its closing cycle. Machine stops anytime one of the hands lets go of the controls.

C. Tripwire cable - located around the perimeter of or near the danger area. The operator must be able to reach the cable with either hand to stop the machine.

4. **Gates** - a movable barrier that protects the operator at the point of operation before the machine cycle can be started. Gates are, in many instances, designed to be operated with each machine cycle.
   A. Interlocked gate – gates that will deactivate the machine when they are opened, and render the machine inoperable until they are closed.

5. **Robots** - because they allow the work to be done with workers not in the vicinity of the work, robots are a good way of keeping the work safe. The danger arises when maintenance work has to be undertaken on the machine (unexpected energization can lead to accidents. Thus, it is imperative that maintenance work on robots begin only after the equipment has been properly isolated.

6. **Location/Distance**

   To consider a part of a machine to be safeguarded by location, the dangerous moving part of a machine must be so positioned that those areas are not accessible or do not present a hazard to a worker during the normal operation

of the machine. This may be accomplished by locating a machine so that the hazardous parts of the machine are positioned away from operator work stations or other areas where employees walk or work. An example of this is by positioning a machine with its power transmission apparatus against a wall and leaving all routine operations conducted on the other side of the machine. Additionally, enclosure walls or fences can restrict access to machines. Another possible solution is to have dangerous parts located high enough to be out of normal reach of any worker.

7. **Automatic/Semi-automatic Feeding and Ejection Methods**

With automatic or semi-automatic feeding mechanisms, the operator will not have to be exposed while feeding stock or while removing the completed parts, as he does not need to do this part of the process – it is done by the machine itself.

8. **Miscellaneous Aids**

While miscellaneous aids do not really give complete protection from hazards, they do give the workers an added safety buffer.

A. Awareness barriers - do not provide physical protection, but serve only to remind a person that he or she is approaching the danger

area. Generally, awareness barriers are not considered adequate when continual exposure to the hazard exists.

B. Miscellaneous protective shields - may be used to provide protection from flying particles, splashing cutting oils, or coolants.

C. Hand-feeding tools and holding fixtures - special hand tools used to place or remove stock, particularly from or into the point of operation of a machine, usually in conjunction with Restraint Devices.

While machine safeguards are a great help in protecting workers from injury, worker attitude is the primary determinant of workplace safety. No amount of redundancy in safety measures can replace workers behavior vis-à-vis safety. This is why developing a good safety culture in the workplace is imperative. Standard operating procedures (SOP) will incorporate appropriate safety considerations, and so following machine operating instructions will definitely make for a safe workplace. The most important tenets here are: not to operate unguarded machines, and not to remove guards unless the machine is properly shutdown and LOTO is applied. Whenever it becomes necessary to work near rotating equipment (e.g., adjustment of packing glands in pumps), always remove or cover items of jewelry, like wristwatch, bracelet, necklace, etc.

It should be noted that the machine safeguards discussed are invariably the product of some form of Risk Assessment and Control procedure that was done

on a particular machine or process. This led to the identification of hazards, assessment of risks and application of control measures – the machine safeguards mentioned here. These safeguarding methods will protect workers from injury while the machine is in operation. However, when work other than routine operation is to be performed on the machines, some degree of system-inherent hazard is introduced, precisely because control measures will need to be bypassed or removed. It is for this reason that safe systems of work (Lockout/Tagout Procedures, Permit-to-Work Systems, etc.) are needed – to address the hazards faced during non-operational work (i.e., maintenance activities).