

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

## Layers of Protection used in Machine Safety - Assessment and Awareness

Mrrithunjay J, Michael Reagon, Abhishek Nandan, Prasenjit Mondal

University of Petroleum and Energy Studies, Health Safety and Environment Engineering, Dehradun, India

University of Petroleum and Energy Studies, Health Safety and Environment Engineering, Dehradun, India

Assistant Professor, Department of HSE, University of Petroleum and Energy Studies, Dehradun, India

Assistant Professor, Department of HSE, University of Petroleum and Energy Studies, Dehradun, India

**ABSTRACT:** There are various layers of protection when it comes to machines, all of these have a significant purpose and are activated based on the need. Machine Safety is basically the safeguards that are provided to the machine and the operator who work on it. This is highly essential as there is an increase in number of accidents happening while working on machines. This paper deals with the various types of guarding that are used for machines, the principles of guarding, the requirement for Machine Safety Risk Assessment and its benefits. A machine plays an integral part in the case of an industry and a problem in any one machine cause the failure of the whole system. The application of technology is clearly seen in the case of the machine guarding, if technology is incorporated with machine guarding, this can ensure the safe operation and also provide a safe working atmosphere for the personnel handling that particular machine. The Assessment of the machines at particular intervals also plays a major role in the

### I. INTRODUCTION

Machine Safety is basically the safeguard that is present for the machine and the operator. There are generally 5 types of guards that are used. Guards, Devices, Automated feeding and Ejection mechanisms, Machine location or distance and Miscellaneous aids. These include all the various protection devices that are installed in the machines to provide a safe work atmosphere. When it comes to the assessment of the machines, it is basically done with a certain clause on assessment sheets and the gaps can be identified using the inference table. There are 3 basic types of hazards when it comes to machines, Hazardous motions, points of operation, pinch points and shear points. Based on all of these factors the type of guarding has to be applied to the machine. Uncontrolled and sudden release of power and the unguarded moving part of machines can cause severe injuries. The Safe Working Procedure has to be prepared and followed and the personnel who are supposed to work in that particular machine should be given adequate Machine Specific Training. This is to make sure that the person is aware of all the risks and hazards associated with the machine. At the same time, the actions to be performed during the case of an emergency should also be inculcated. The major causes of accidents while working on machines are, loose clothing, inadvertent starting of machine, materials ejected from the machine, lack of preventive maintenance, contact with sharp edges. Etc. with the help of the Risk Assessment Sheets, the various gaps can be identified and based on each specific gap the control measures can be provided. This is also used to rate the current condition of the machine and assessing the safety performance. The major hazardous points of machine can be marked based on the severity of the previous accidents and also the frequency.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

## II. METHODOLOGY

Initially the safeguards have to be categorised based on the type of the machine and the purpose of use. Usually there are five types of safeguards used in a machine:

- Interlocks
- Presence sensing devices
- Push buttons
- Emergency Stop
- Biometric Sensor

### Interlock

This is basically to monitor the position of the guard or gate. This is used in machines that can cause physical hazards such as crush, cut etc. A door interlock is attached to the guard and the machine, when there is no contact in between the two, the machine stops functioning and only when the door remains closed the work resumes. This provides a safe work atmosphere for the worker as there cannot be any interruptions or violations when the work is taking place. The movable parts are interconnected with the control system. The interconnections are electrical, mechanical, hydraulic or pneumatic. This type of guards makes sure that the machinery does not operate unless the guard is closed. These guards generally do not affect the production. Even the machine is interrupted, the process resumes once the guards are closed. The only drawback about this type of guarding is that it is slightly expensive and requires extensive maintenance. The system relies on the manual reset system.

### Presence sensing devices

- Photo electric light curtains
- Infra-red scanners
- Pressure mats

The above-mentioned guards fall under this category. These are the devices that work on the basis of detection of a person or a part of a person in dangerous areas and stops the machinery. Examples of these can be grooving machine, riveting machine etc., The major requirement when it comes to this type of guarding is that the guards have to be placed exactly covering the pinch and shear points. Pinch points are basically the moving parts or parts of the machine where the person is likely to get caught and causes harm to the person. Hence the placement of these guards should be in such a way that it covers the whole area and there is no gap in which the person can be in contact with the hazardous space.

### Push Buttons

Push buttons are generally of two types:

- Single Hand push button
- Two hand push buttons

The basic principle of this is that the machine functions only if the buttons are pushed continuously throughout for the operation of the machine. This is mainly to make sure that the worker's hands are engaged in pushing the button and the worker cannot use any other means to get in contact with a portion of the machine during its operation. These controls are generally added onto the machine which are to be handled by a single person and doesn't allow multiple personnel to work on the machine simultaneously. When it comes to the two hand control, it requires constant pressure on both pads to activate the machine and it gives hands on control at a safe distance while the machine is in a dangerous cycle.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

## Emergency Stop

This is also known as a Kill switch. This is a safety mechanism that is used to shut off the machinery during an emergency. This can also be called as EPO- Emergency Power Off. This comes under the mechanical component category. An emergency situation can be defined as an immediate hazardous situation that has to be averted quickly. Hence, in such cases where the situation is out of control, this stop button comes in as a solution to abort the system. This is usually present in all machinery that perform hazardous activities and the standard colour of the button is Red. This has to be periodically inspected and checked. As per the international standards, the E stop function should be initiated by one-person action using a manually actuated control device.

## Biometric switch

This is basically used for authentication purpose and this is mainly for the security of the system. This is to make sure that only the right person is allowed to work in the machine and doesn't allow any unauthorized entry or functioning of the machine. This is a device that is present at the first step of operating the machine. Only after this is cleared. The person is allowed to perform the task on the machine. This is considered to be safer than the traditional method like the authentication passwords that can be shared or lent. This allows multiple registrations also, like for example, based on the needs the number of identities can be increased and it will allow the registered identities. This is a complicated component and cannot be easily by passed. Hence, this is an effective safety as well as security measure that can be added to a particular machine.

## Machine Safety Risk Assessment

This is an Assessment to be performed to the machines in the plant initially during the commissioning and also on a periodic basis so that the current scenario can be identified and corrective actions can be provided. This helps to identify the current situation, the maintenance need and the effectiveness of the safety functions of the machine. This majorly requires the machine safety handbook as the reference and the manuals of all individual machines on which the MSRA is going to be performed. And another major requirement for this is the clauses based on which the assessment is going to be performed. Every organization has their own specific requirement and based on that; the assessment sheet can be prepared. The clauses can be prepared in such a way that the component that has to be given the most priority is mainly concentrated upon based on the organizational needs.

Some the main components of this Assessment sheet are:

- Equipment Control Systems
- Start-Stop-Emergency Stop
- General Risks
- Risks by moving parts
- Maintenance and setup activities
- Prohibited activities
- Instructions, trainings and manuals
- Miscellaneous

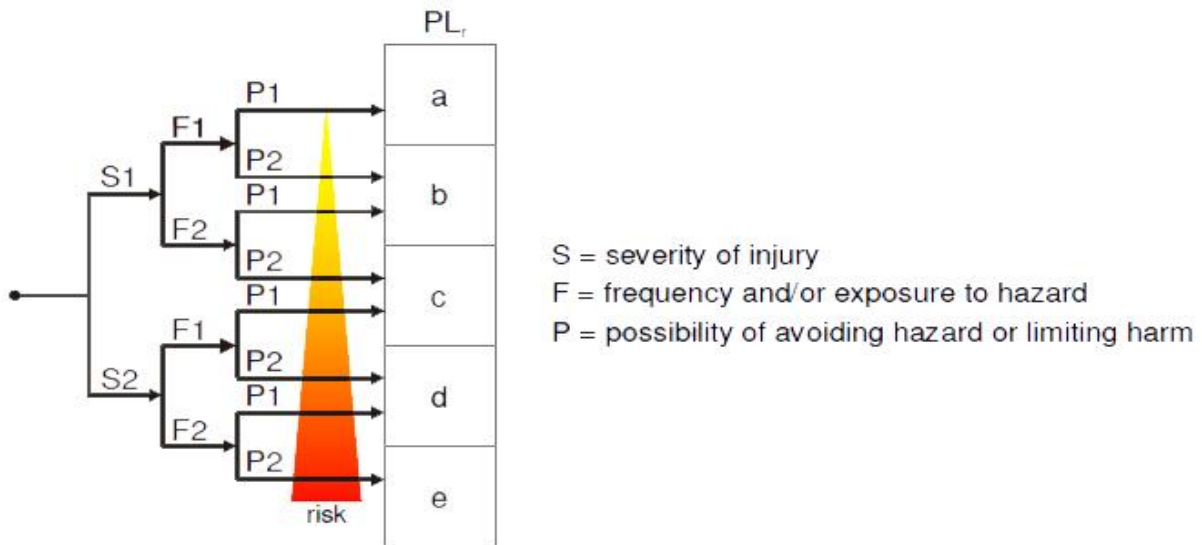
These are the components that can be considered for the preparation of a questionnaire and the assessment can take place with a simple Yes/No and remarks column. The performance level and the safety category can be derived as an outcome of this process. The main requirement of this is the Machine Safety Handbook

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020



S1 = Minor Injury

S2 = Serious Injury

F1 = Exceptionally, Low Frequency or short period of time.

F2 = Continuously, High Frequency or longer period of time.

P1 = Potential is present

P2 = No possibility to averting the danger

Based on the above figure, the performance level can be derived. Hence, based on this risk, the level of protection that has to be provided is assigned to each and every machine in a particular plant.

### Preparing an inference table:

In this step, the assessment sheet of one particular machine is to be considered, all the remarks have to be noted down. Then on, the sheet contain a column comprising of the images of the machine and then the gaps that are identified are to be circled in red. The column beside this is for the recording of the hazards, based on the type of the hazard, it has to be named and categorised, all the hazards currently present in the machine is to be noted down. Then comes the main step, the gaps are categorised into 4 types, namely:

- Administrative gap
- Operational gap
- Maintenance gap
- Design gap

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

## Administrative gap:

This is the significant finding that is related to the administration department of the plant. The personnel related to this have sort the issue in a given time so that the hazard can be eliminated and there is no further harm because of this. These are mostly not the hazards but the missing content that are mandatory when it comes to use of the machine. These are not related to the working or operation of the machinery. Few of the administrative gaps are listed below:

- Warning signs not posted
- Mandatory PPE Sign board missing
- Local language sign board missing
- Improper marking
- Signage stickers for equipment not posted

## Operational gap:

This is the significant gap that is related to the operation of the machine. This is the kind of work and the requirement of instruction for working the particular machinery. The procedure that has to be followed by the person who is going perform a particular task on the machine. This is a significant gap that can result in a huge injury. As this gap is identified in the documents and also by visually observing the person performing a task on the machine. Few of the operational gaps are mentioned below:

- Standard Operating Procedure for cleaning not present
- Standard Operating Procedure for Maintenance not machine specific

## Maintenance gap:

The significant gap that is related to the maintenance of the machinery. Machine maintenance is a very vital task and there has to be regular checks, cleaning and inspection of the machinery to check if it is safe to work and all the parts of the machine are in an operating condition. This is a main task that has to be performed. When this is not completely satisfactory, the maintenance gaps are identified. This involves the poor maintenance of parts and the surrounding of the machine. As every machine comes with a lot of buttons and parts that are energised or moving, it is important to make sure that all of this is well maintained. Few of the maintenance gaps are mentioned below:

- Emergency button colour faded
- Button clogging
- Worn out stickers
- Broken parts
- Damaged buttons

## Design gap:

The significant gap that arises due to the absence of a standard requirement that cannot be rectified now but could have been added at the design stage of the machine is known the design gap. This is mainly identified so that the personnel can give a feedback to the machine manufacturer to make sure that the additional requirement can be added on to the upcoming machines and it is also a way of assessing the manufacturer. These gaps can only be changed or altered at the design stage of the machine. Few of the Design gaps are listed below:

- No hooter fixed to the alarm
- The holder is not connected at the appropriate joint
- Easy Bypass of interlock is possible

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

- The Light curtain doesn't cover the complete hazardous area
- Manual functioning turns OFF the curtains

After the gaps are categorised and mentioned in the table. The recommended solutions can be suggested by listing down all the points in the column beside. The solutions can be based on all the significant gaps observed, it can be either individual or can be a common solution.

By this methodology, the layers of protection in a machine can be thoroughly assessed and also this is can be documented for further reference. This methodology is not very time consuming. When this is followed on a periodical manner, the level of machine safety can be exponentially increased. Further, after the Machine Safety Assessment is performed and the inference table is also made. The next step in the process is the preparation of the Machine Specific Training Module.

## Preparation of Machine Specific Training Module:

This is a very vital part of the task. When a person is assigned to a particular machine, the person has to be aware a certain point, namely:

- Machine Information
- Machine Specific Hazards, Risk & Elimination
- PPE Adherence, Ergonomics, Do's & Don'ts
- Startup Inspection
- Emergency Shutdown
- Past Incidents

This has to be provided to the worker who is assigned to a particular task on the machine. Only after the completion of this induction. The person should be allowed to work on the machine. The General safety induction only gives an overview of safety. After the general safety induction, an area specific induction is to be conducted and after this, the Machine Specific Induction has to be done. During this induction, all the above-mentioned contents are to be explained. All of the machine specific hazards are to be highlighted, the required PPE is to be mentioned and this will also serve as a documentation of training and after this, the worker can be assessed on a periodic basis on the understanding the machine. The training evaluation can be performed.

### Machine Information

contains the purpose and the use of the machine.

### Machine Specific Hazards, Risk and Elimination

contains the type of hazards associated with the machine and the risk involved and the how to eliminate the following risks.

### PPE Adherence, Ergonomics, Do's and Don'ts

The required PPE to operate the machine is to be mentioned. When it comes to ergonomics, the factors such as the postures and the time interval has to be mentioned. Then the things that are to be done and the things that are prohibited are to be mentioned in this category

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 9, Issue 1, January 2020

## Start-up Inspection

This is the initial step that has to be performed at every shift. The machine has to be thoroughly checked and the functioning of all the buttons have to be checked before the start of operation. Mainly, the push buttons and the Emergency Stop button should be checked.

## Emergency Shutdown

This procedure is to be clearly mentioned in the case of the machine. The worker should be competent and aware about dealing with the emergency situation that can arise from the machine. Clear cut procedure is required and ample training is to be provided.

## Past Incidents

This is a kind of a awareness in which the person who is exposed to gets to know about the dangerous spots and the consequence of a mistake. This gives a sense of awareness and fear into the person which will allow the person to work consciously and follow the procedure without bypassing and carelessness.

## III. CONCLUSION

Due to high demand and stressful work life the risk for injury has been increased drastically among the workers. Reducing the risk at the source by altering the design and construction in terms of safety will reduce the risk involved to an acceptable level. Accidents caused by ignorance plays a major role, and these techniques will majorly help to avoid such instances and to improve the work culture.

The above methods will cover a large proportion of injuries which can be prevented by implementation and proper machine guarding. Due to the interventions like this, process is getting improved and workers are less prone to the risk caused by the machines. These methods not only target the risk but its root cause as well so that unnecessary events are avoided.

Since the gaps in the organisations has been addressed, we will be able to calculate the annual and capital expenditure involved for these interventions to be implemented and we be able to track the progress as well. This technique after implementation will help us to estimate and calculate the risk, severity and performance level can be compared with the previous company records. This concept can also be easily understood and compared with the real-life accidents. This proposed technique can be implemented in various sectors as per the company needs.

## REFERENCES

1. Yamin, S., (2014). "National Machine Guarding Program: design of a machine safety intervention." Safety Science Monitor (Sweden) 18(1): 1174-1183.
2. Lazarus, H. and P. Kurtz (2003). "Noise Emission—A Part of Risk Assessment With a View to Machine Safety." International Journal of Occupational Safety and Ergonomics 9(3): 351-364.
3. Möller, N. and S. O. Hansson (2008). "Principles of engineering safety: Risk and uncertainty reduction." Reliability Engineering & System Safety 93(6): 798-805.
4. Fryman, J. and B. Matthias (2012). Safety of industrial robots: From conventional to collaborative applications. ROBOTIK 2012; 7th German Conference on Robotics, VDE.
5. Manuele, F. A. (2005). "Risk assessment and hierarchies of control." Professional Safety 50(5): 33-39
6. Demichela, M., (2014). "Human factor analysis embedded in risk assessment of industrial machines: Effects on the safety integrity level." International Journal of Performability Engineering 10(5): 487-496.
7. Grundmann, V. and L. Floyd (1973). Plastic injection molding machine safety mechanism, Google Patents.
8. Fillich, N. and R. A. Owen (1987). Method and apparatus for machine safety, Google Patents.
9. Hevko, M., (2018). "Improvement of machine safety devices."