

Risk Assessment and Control Measures for Cold Rolling Mill in Steel Industry

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ABSTRACT

For any industry to be successful, it is necessary to identify the hazards to assess the associated risks and to bring the risks to tolerable level. In cold rolling mill, due to complex nature of the operation, systems, procedures and methods always involves some amount of hazards. It is widely accepted within industry in general that the various techniques of risk assessment contribute greatly towards improvements in the safety of complex operations and equipment. The objective of risk assessment is to identify and analyze hazards, the event sequences leading to hazards and the risk of hazardous events. This paper deals in the control of hazards in cold rolling mill in stainless steel plant using Workplace Risk Assessment and Control (WRAC) technique to identify, analyze hazards and recommend necessary control measures for them.

Keywords: cold rolling mills, risk assessment, analyze hazards, WRAC.

I. INTRODUCTION

A critical part of any safety and health program is the identification, assessment, elimination and/ or the control of hazards in the workplace. It is impossible to eliminate all hazards, so the goal is to eliminate and/or control the hazards with critical and high potential and to reduce the rest of the hazards to the lowest reasonable risk level so as to protect workers from harm. This process is called risk assessment, and it is the evaluation of hazards to determine their potential to cause an accident.

When most people hear the term risk assessment, they immediately think of insurance and indemnification. In reality, risk assessment is something people do each and every day without giving it much thought. For example, when driving, we assess the condition and circumstances of the roadway and adjust our speed accordingly; or when caught in a rainstorm on the golf course, we assess the weather to determine if we play on or seek cover. These are simple

and, for the most part, effective risk assessments applied by most everybody. However, little thought is given to assessing risk on the job, when in fact steelworkers are exposed to risk each and every time they do a job. Because of this, we should be more informed on various risk assessment techniques available to us and how they can be applied in our facilities.

Some risk assessments are very complex and are best used in formal situations for specific purposes. These would include tools like failure mode and effects analysis (FMEA) or management oversight risk tree (MORT) analysis, Petri net analysis (PNA), fault tree analysis (FTA), and others.

The following is the brief review of the work carried out by different researchers in the field of risk assessment.

Risk is defined by Collins Concise Dictionary & Thesaurus (2006) as “the possibility of bringing about misfortune or loss” which also bear the same meaning as “danger, hazard, pitfall, peril and Uncertainty”. Taking this definition into economic perspective, risk is future uncertainty which need to be managed in order to avoid variety of consequences ranging from negative surprises to permanent loss (Triantis, 2000).

It is important to emphasize risk assessment in managerial activities. Firms manage risks for various reasons. For example, in current conditions where input suppliers hold their reserves to enjoy profits on surging market and higher prices, there is a need to enter into a contract with better terms thus agreed upon a specific price (Triantis, 2000); or face the risk of incurring higher input cost for production in the future. Firms should plan to maintain a steady cash flow so that the risk of falling short of earnings is avoidable (Triantis, 2000). Maintaining a “proper” flow of revenue is also part of tax strategy to avoid the risk of paying higher tax (Chapman, 2006).

Schütz (2003) reported in his article entitled “Steel Industry Risks” published in Regards, that the industry is highly concerned

about the risk of operational hazard especially when it comes to producing as mini-mill plant.

Jeong et al. (2008) made a qualitative analysis by Hazard and Operability Method (HAZOP) to identify the potential hazards and operability problems of decommissioning operations and concluded that the decommissioning of a nuclear research reactor must be accomplished according to its structural conditions and radiological characteristics and radiation exposure must be controlled to within the limitation of the regulation to perform the dismantling work under the ALARA principle safely.

Sam Mannan. (2014) narrated that Hazard identification and risk assessment are essential to loss prevention in process industry. It has become more challenging to conduct hazard identification as the depth of technology has increased, which hazard assessment heavily relies on.

Lambert et al. (2001) used Hierarchical Holographic Modeling (HHM) for identification and management of risk source and prioritize the identified source of risk based on their likelihood and potential consequences and provided with options of risk management in terms of their costs and potential impacts on the acquisition schedule.

Bell and Glade (2003) have done a risk analysis focusing on risk to life. They calculated land slide risk and occurrence of potential damaging events as well as the distribution of the elements at risk and proposed the following approach for risk evaluation:

$$\text{Risk} = \text{Hazard} * \text{Consequence} * \text{Element of Risk}$$

Frank et al. (2008) carried out a risk assessment using common risk management tools. In basic tools, they used diagram analysis and risk rating and filtering. In advanced tools they used fault tree analysis (FTA), Hazard and Operability Analysis (HAZOP), Hazard Analysis and Critical Control Points (HACCP), Failure Mode Effect Analysis (FMEA) and established a severity categorization table which divides severity of consequence into noticeable, important, serious, very serious and catastrophic.

II. METHODOLOGY

Workplace risk assessment and control (WRAC) is the process used to determine likelihood that people may be exposed to an injury, illness or disease in the workplace arising from any situation identified during the hazard identification process prior to consideration or implementation of control measures.

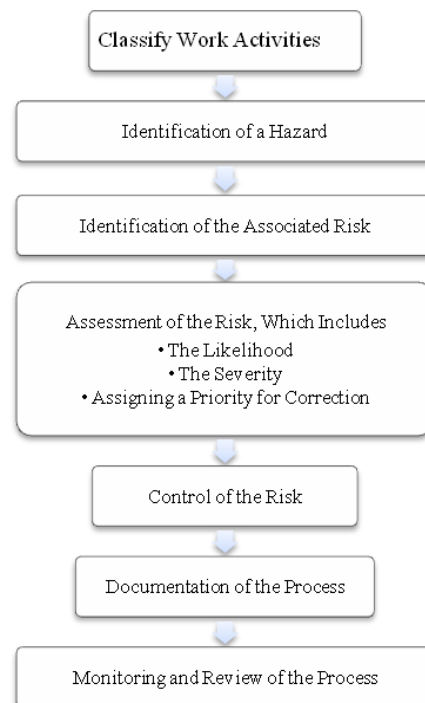
Risk occurs when a person is exposed to a hazardous situation. Risk is the likelihood that exposure to a hazard will lead to an injury or a health issue. It is a measure of the probability and potential severity of harm or loss.

The objective of risk assessment (WRAC) is to produce outputs that can be used to evaluate the nature and distribution of risk and to develop appropriate strategies to manage risk. Events or issues with more significant consequences and likelihood are identified as “higher risk” and are selected for higher priority mitigation actions to lower the likelihood of the event happening and reduce the consequences if the event were to occur.

Qualitative methods use descriptive terms to identify and record consequences and likelihoods of the events and resultant risk. Quantitative methods identify likelihoods as frequencies or probabilities. They identify consequences in terms of relative scale (orders of magnitude) or in terms of specific values (for example estimate of cost, number of fatalities or number of individuals lost from a rare species).

For both qualitative and quantitative methods it is important to invest time in developing appropriate rating scales for likelihood, consequence and resultant risk. The full range of risk situations likely to be encountered within the scope of the exercise should be considered when developing rating scales.

TABLE I RISK ASSESSMENT METHODOLOGY



A. Classify Work Activities

Cold rolling mill complex is equipped with the most modern stainless steel production lines, sourced from leading manufacturers of the world. Coil build up line, bell anneal furnaces continuous annealing and pickling lines, sendzimer mills, skin pass mill, strip grinding line, slitting and shearing lines to produce coils /sheets with precise dimensional tolerance and flatness with superior metallurgical characteristics.

B. Identification of a Hazard

This is a process of examining the work area and the work to be completed for the purposes of identifying all of the hazards inherent to the job or present at the job site.

Several things can help identify hazards in the work area and job site:

- Walking around the workplace to inspect what is in the general area.
- Asking other employees what they think about anything they have noticed.
- Reviewing a work instruction or job safety analysis.
- Inspecting an operator's manual.
- Reviewing previous incident reports.

C. Identify the Risk

Once a hazard has been identified, the risk associated with the hazard must be examined. Before starting a risk assessment; it is useful to identify factors that may contribute to the risk. A review of regulations, previous injury reports, audits, inspections, and other areas can be used to judge whether the hazard being observed actually can or has caused an injury.

D. Assess the Risk

It is then necessary to evaluate the likelihood of an injury occurring, along with an estimate of how severe the injury may be. Risk assessments therefore are based on two key factors:

- The likelihood that the injury (or illness) may actually occur.
- The severity of the injury (or illness) resulting from the hazard.

1) *Semi Quantitative Method:*

Semi-quantitative approaches to risk assessment are currently widely used to overcome some of the shortcomings associated with qualitative approaches. Semi-quantitative risk assessments provide a more detailed prioritized ranking of risks than the outcomes of qualitative risk assessments.

Semi-quantitative risk assessment takes the qualitative approach a step further by attributing values or multipliers to the likelihood and consequence groupings. Semi-quantitative risk assessment methods may involve multiplication of frequency levels with a numerical ranking of consequence. Several combinations of scale are possible.

Table II shows an example of semi-quantitative risk matrix where the likelihoods and consequences have been assigned numbered levels that have been multiplied to generate a numeric description of risk ratings. The values that have been assigned to the likelihoods and consequences are not related to their actual magnitudes but the numeric values that are derived for risk can be grouped to generate the indicated risk ratings. In this example, Extreme risk events have risk ratings greater than 15, High risks are between 10 and 15, and so on. A matrix is used to provide guidance as to whether the risk is acceptable or needs to be addressed.

Remember that not all risk can be eliminated. Urgent action is required for risks assessed as critical or high. These actions may include instructions for immediate cessation of the work and/or isolation of the hazard until permanent measures can be implemented. Documented control plans with responsibilities and completion dates need to be developed for moderate risks.

1) *Acceptable Risk:*

Risk that is acceptable to regulatory agency and also to the public is called acceptable risk. There are no formally recognized regulatory criteria for risk to personnel in the mining industry. Individual organizations have developed criteria for employee risk and the concepts originally arising from chemical process industries and oil and gas industries.

Because of the uncertainties linked with probabilistic risk analysis used for quantification of the risk levels the general guiding principle is that the risk be reduced to a level considered As Low as Reasonably Practicable (ALARP).

TABLE II A SEMI QUANTITATIVE METHOD FOR THE CLASSIFICATION OF RISKS

Risk Rank Likelihood x Consequence		Consequence Level(C.L)					RISK RATING (R.R)
		1	2	3	4	5	
Likelihood Level(L.L)	Descriptor	Injury	First Aid	Recordable Injury	Lost Time	Fatality	
5	Almost Certain	5	10	15	20	25	Extreme (16-20)
4	Likely	4	8	12	16	20	High (11-15)
3	Possible	3	6	9	12	15	Moderate (6-10)
2	Unlikely	2	4	6	8	10	
1	Rare	1	2	3	4	5	Low (1-5)

E. Control the Risk

New work procedures will need to be developed in relation to the new control measures. A good plan of action often includes many pieces, such as:

- Quick attention to critical or high-risk hazards.
- Effective temporary solutions until permanent fixes can be applied.
- Long-term solutions to those risks judged to cause long-term illness.
- Long-term solutions to those risks with the worst consequences.
- Arrangement for training workers on the main risks that remain and how they are to be controlled.
- Regular checks to make sure that control measures remain in place and it is clear who will take what action and by when.

By assigning a “risk rating,” the work at hand can prioritize hazards with the highest potential to cause an injury so that they can be eliminated first. (Table III)

TABLE III RISK CONTROL HIERARCHY

	Process Step	Effectiveness
Clearly State The Hazard	1. Eliminate The Hazard Completely.	100%
	2. Engineer: Create A Barrier Between The Person And The Hazard.	70–90%
	3. Administer: Write Regulation, Law, Procedures, Etc.	10–50%
	4. Provide Personal Protective Equipment.	20%

F. Document the Process

Documenting the process helps to ensure that the identified risk control measures are implemented in the way they were intended. It will also assist in managing other hazards and risks that may be in some way similar to ones already identified. Adequate record keeping of the risk management process should show that the process has been conducted properly. This information should include:

- Hazards identified.
- Assessment of the risks associated with those hazards.
- Decision on control measures to manage exposure to the risks.
- How and when the control measures are implemented.
- Evidence of monitoring and reviewing of the effectiveness of the controls.

G. Monitor and Review

Whichever method of eliminating and/or controlling the hazard is used, it is essential that an evaluation of its impact on the use of the equipment, substance, system, or environment is carried out to ensure that the control does not contribute to the existing hazard or introduce a new hazard.

It is also essential that all people involved are informed about the changes and, when necessary, provided with the appropriate information, instruction, training and supervision to ensure that each worker is safe from injury and risk to health. It is also recommended that after a period of time, the area supervisor carry out a review of the system or control to determine its ongoing suitability.

III. RISK ANALYSIS

Mechanical & Electrical Equipment Hazards							
Hazards And Consequences	L.L	M.C	R.R	Control Measures Immediate And Longer Term Actions	After Control Measures		
					L.L	M.C	R.R
Trapping of body parts between the rolls. Potential for trapping of worker body parts and crushing the worker.	4	5	20	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	2	5	10
Unguarded rotating, reciprocating and similar moving parts. Potential for severe head injury and fatality.	3	4	12	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	4	04
Sheet strip (scarp material) release for side trimming unit. Potential for severe skin injury, cutting of worker body parts and trapping of worker.	4	4	16	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	4	04
Crushing(crushed between one or more moving machine components) Potential for severe injury and fatality.	3	5	15	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	5	05
Entanglement(entangled in a rotating or moving component) Potential for severe injury and fatality.	3	4	12	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	4	04
Improper stacking of raw material (scrap bale) in storage garage which lead to fall of objects in path way. Potential for trip hazards, fall of objects on workers leading to severe head injury and fatality.	3	4	12	Immediate- stacking zone should be fenced and prohibited from unauthorized access. Longer term- provide training to the workers for efficient stacking of materials.	1	4	04
Improper ducting of cables was found in equipment panel boards. Potential for increased risk of electrocution causing burns, scalds, ventricular fibrillation.	2	4	08	Immediate-switch off, isolate the power supply and restrict the work in that zone. Longer term-proper ducting of electrical lines with insulation should be provided.	1	4	04
Cables or trailing leads across walkways-lead to portable electrical fan.(hand tools and appliances) Potential trip hazard-may lead to broken bones/bruising.	3	4	12	Immediate-place warning signage. Longer term-position equipments to avoid cables crossing pedestrian routes, use cable covers to securely fit to surface, restrict access to prevent contact.	1	4	04
Noise from trimming, shearing, operation. Potential for noise induced hearing loss, tinnitus, temporary threshold shift, acoustic trauma.	3	3	09	Immediate- stop the activity and provide information and instruction. Longer term- interrupt the pathway between the source and receiver by isolation, absorption and create acoustic heavens.	1	3	03
The wirings of electrical equipment near steel rolling mill were not properly insulated and are barely exposed to the flammable atmosphere. Potential for electric shock leading to severe burns, ventricular fibrillation.	2	4	08	Immediate-switch off the power supply and isolate the equipment Longer term- wires should be properly cabled and insulated. Maintenance of the equipment should be done periodically.	1	4	04
Improper ducting of cables was found in equipment panel boards. Potential for increased risk of electrocution causing burns, scalds, ventricular fibrillation.	2	4	08	Immediate-switch off, isolate the power supply and restrict the work in that zone. Longer term-proper ducting of electrical lines with insulation should be provided.	1	4	04
Cables or trailing leads across walkways-lead to portable electrical fan.(hand tools and appliances) Potential trip hazard-may lead to broken bones/bruising.	3	4	12	Immediate-place warning signage. Longer term-position equipments to avoid cables crossing pedestrian routes, use cable covers to securely fit to surface, restrict access to prevent contact.	1	4	04
Ergonomics & Manual Handling Hazards							
Manual carrying and lifting of large, bulky and/or heavy objects. Potential for leading to back pain, hernias, and tendon and ligament injury to the workers.	3	5	15	Immediate- stop the activity and provide instructions regarding safe lifting procedures. Longer term- use handling aids such as trolleys forklifts for carrying out lifting/implement automation of the work.	1	5	05
Repetitive work movements. (frequent reaching, lifting, carrying) Potential for low back pain-poor posture long duration for MSDs.	3	4	12	Immediate- provide variety in jobs to eliminate or reduce repetition. (over use of the same muscle groups) Longer term- modify work practices so that workers can perform in their "power zone" (above knees, below shoulders, close to body)	2	4	08
Awkward postures. Potential for low back pain-poor posture long duration for MSDs.(bending, twisting)	3	3	09	Immediate- adjust work schedules, work pace, or work practices. Longer term- modify work practices so that workers can perform in their "power zone" (above knees,	1	3	03

				below shoulders, close to body)			
Static postures (maintaining a fixed position for a long time) Potential for low back pain-poor posture long duration for MSDs.	4	3	12	Immediate-expand the variety of tasks performed throughout a shift. Longer term- change layout for easy to access to equipment and machinery. Provide workstations that can be used while either sitting or standing.	2	3	06
Too high a physical load. Potential for leading to back pain, hernias, and tendon and ligament injury to the workers.	3	3	09	Immediate-rotate workers through jobs that use different muscles, body parts, or postures. Longer term- modify work practices so that workers can perform in their "power zone" (above knees, below shoulders, close to body)	1	3	03
Sharp edge sheet handling.(without PPE) Potential for severe skin injuries may be caused by contact.	4	4	16	Immediate-provide for hand leathers, leather gloves or gloves with metal inserts. Longer term-provide mechanical aids and training of worker.	2	4	08
Pressure points (grasping loads, leaning against parts or surfaces that are hard or have sharp edges) Potential for white finger and severe skin injury occur.	3	4	12	Immediate-provide for hand leathers, leather gloves or gloves with metal inserts. Longer term-provide mechanical aids and training of worker.	1	4	04
Slippery or damaged surfaces. Potential for fall down-may lead to broken the leg bones and severe skin injury.	2	4	08	Immediate- place barrier and warning signage around pit area. Longer term- carry out repair to walkway/close the pit.	1	4	04
Insufficient work platform-poor posture of worker body. Potential for low back pain-poor posture long duration for MSDs.	3	3	09	Immediate-extend the work platform. Longer term-regular monitor for work posture of worker.	1	3	03
Damaged wooden platform. (fall down) Potential for fall down-may lead to broken the leg bones and severe skin injury.	3	4	12	Immediate-cover the damaged wooden platform. Longer term- repair the damaged wooden platform/replace the wooden platform.	1	4	04
Pit in walkway. Potential for fall down the pit-may lead to broken bones	3	3	09	Immediate- place barrier and warning signage around pit area. Longer term- carry out repair to walkway/close the pit.	1	3	03
Mechanical Energies Hazards							
Loss of control of a vehicle or other machineries. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	2	4	08	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians.	1	4	04
Road traffic in and out issues. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	2	3	06	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians	1	3	03
Interaction between mobile plant and pedestrians. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	2	3	06	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians	1	3	03
Poorly marked road ways with unfamiliar directional signs in site entrance. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	3	3	09	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians	1	3	03
Contact of mobile plant with overhead structures. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	3	4	12	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians.	1	4	04
Gravitational Energies Hazards							
Unguarded scarp pit. Potential for fall down the pit-may lead to broken bones.	2	4	08	Immediate- place barrier and warning signage around pit area. Longer term- carry out repair to walkway/close the pit.	1	4	04
Objects / structures falling on people. Potential for trip hazards, fall of objects on workers leading to severe head injury and fatality.	2	4	08	Immediate- critical zone should be fenced and prohibited from unauthorized access. Longer term- provide training to the workers.	1	4	04
Fall of things such as components, tool. Potential for trip hazards, fall of objects on workers leading to severe head injury and fatality.	2	3	06	Immediate- critical zone should be fenced and prohibited from unauthorized access. Longer term- provide training to the workers.	1	3	03
Dust, Chemicals and Hazardous Substances							
Dusts that can affect health such as interleaving paper dust and other dusts that can affect operations.				Immediate-provide for respiratory protective equipment.			

	2	3	06	Longer term-provide local exhaust ventilation in the work place.	1	3	03
Chemical such as oils, degreasers, solvents. Potential for persistent headache, nausea, vomiting etc.	3	3	09	Immediate-provide for respiratory protective equipment. Longer term-provide local exhaust ventilation in the work place.	1	3	03
Chemical fumes such as from welding/ cutting, grinding etc. Potential for persistent headache, nausea, vomiting etc.	3	4	12	Immediate-provide for respiratory protective equipment. Longer term-provide local exhaust ventilation in the work place.	1	4	04
Handling of hydrofluoric acid carboys manually from truck to ground.(without gloves, suits) MSDs might occur and potential for acid spillage on the worker lead to highly corrosive and readily penetrates the skin, causing deep tissue layer destruction.	3	3	09	Immediate-provide proper personal protective equipments like gloves and suits Longer term-use lifting aids such as jib cranes to lift the load from the truck to ground.	1	3	03
Work Environment Hazards							
Evacuation assembly points are not identified by signage. Potential for confusion in case of emergency evacuation-may not be able to identify if all staff have evacuation.	2	5	10	Immediate-fit signage at designated assembly points. Longer term-monitor to ensure signage remains visible and easy to read.	1	5	05
Wildlife such as dogs, spiders, insects. Risk of leptospirosis (leptospira bacteria) diseases from the rat's urine, dog's urine.	4	3	12	Immediate- clear the area immediately. Longer term-dispose the waste at regular intervals and give training to the workers about maintain good housekeeping and monitoring the work place.	1	3	03
Biological, such as exposure to work related diseases. Potential for lead to serious ill health (high fever, chills, red eyes) or fatality.	3	3	09	Immediate- clear the area immediately. Longer term-dispose the waste at regular intervals and give training to the workers about maintain good housekeeping and monitoring the work place.	1	3	03
Building maintenance / cleaning. Potential for slip/trip. Its lead to casualties, injuries.	2	4	08	Immediate- clear the area immediately. Longer term-dispose the waste at regular intervals and give training to the workers about maintain good housekeeping and monitoring the work place.	1	4	04
Fire exit and walkways are stored on rubbish. (unprocessed waste materials) This causes delayed escape of occupants during emergency situation which can lead to casualties, injuries. Frequent trips and falls.	3	5	15	Immediate- exit way should be cleared of obstructions (remove the rubbish) Longer term-liaise with tenants to ensure rubbish is disposed to correctly and posting signage and regular inspection of exit way should be done.	1	5	05

IV RESULTS AND DISCUSSION

In this plant 40 hazards were identified and their analysis was performed. They have been classified into 6 major categories. They are

- Mechanical & Electrical Equipment Hazards
- Ergonomics & Manual Handling Hazards

- Mechanical Energies Hazards
- Gravitational Energies Hazards
- Dust, Chemicals and Hazardous Substances
- Work Environment Hazards

The major hazards and their control measure in each category based on their risk rating are tabulated below.

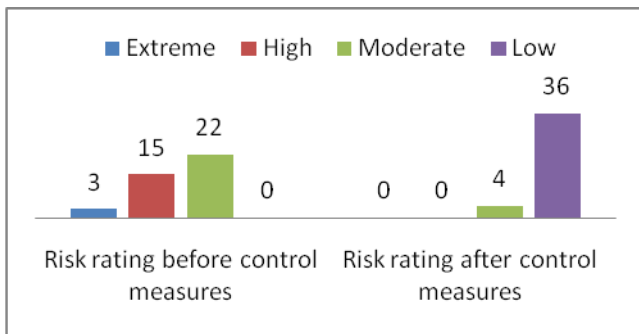
TABLE IV HAZARDS, CONSEQUENCE AND CONTROL MEASURE OF MAJOR HAZARDS HAVING RISK RATING ABOVE MODERATE

Mechanical & Electrical Equipment Hazards							
Hazards And Consequences	L.L	M.C	R.R	Control Measures Immediate And Longer Term Actions	After Control Measures		
					L.L	M.C	R.R
Trapping of body parts between the rolls. Potential for trapping of worker body parts and crushing the worker.	4	5	20	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	2	5	10
Unguarded rotating, reciprocating and similar moving parts. Potential for severe head injury and fatality.	3	4	12	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	4	04
Sheet strip (scarp material) release for side trimming unit.				Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.			

Potential for severe skin injury, cutting of worker body parts and trapping of worker.	4	4	16		1	4	04
Crushing(crushed between one or more moving machine components) Potential for severe injury and fatality.	3	5	15	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	5	05
Entanglement(entangled in a rotating or moving component) Potential for severe injury and fatality.	3	4	12	Immediate-place warning signage. Longer term- erect the fixed guard/adjustable guard.	1	4	04
Improper stacking of raw material (scrap bale) in storage garage which lead to fall of objects in path way. Potential for trip hazards, fall of objects on workers leading to severe head injury and fatality.	3	4	12	Immediate- stacking zone should be fenced and prohibited from unauthorized access. Longer term- provide training to the workers for efficient stacking of materials.	1	4	04
Cables or trailing leads across walkways-lead to portable electrical fan.(hand tools and appliances) Potential trip hazard-may lead to broken bones/bruising.	3	4	12	Immediate-place warning signage. Longer term-position equipments to avoid cables crossing pedestrian routes, use cable covers to securely fit to surface, restrict access to prevent contact.	1	4	04
Cables or trailing leads across walkways-lead to portable electrical fan.(hand tools and appliances) Potential trip hazard-may lead to broken bones/bruising.	3	4	12	Immediate-place warning signage. Longer term-position equipments to avoid cables crossing pedestrian routes, use cable covers to securely fit to surface, restrict access to prevent contact.	1	4	04
Ergonomics & Manual Handling Hazards							
Manual carrying and lifting of large, bulky and/or heavy objects. Potential for leading to back pain, hernias, and tendon and ligament injury to the workers.	3	5	15	Immediate- stop the activity and provide instructions regarding safe lifting procedures. Longer term- use handling aids such as trolleys, forklifts for carrying out lifting/implement automation of the work.	1	5	05
Repetitive work movements. (frequent reaching, lifting, carrying) Potential for low back pain-poor posture long duration for MSDs.	3	4	12	Immediate- provide variety in jobs to eliminate or reduce repetition. (over use of the same muscle groups) Longer term- modify work practices so that workers can perform in their "power zone" (above knees, below shoulders, close to body)	2	4	08
Static postures (maintaining a fixed position for a long time) Potential for low back pain-poor posture long duration for MSDs.	4	3	12	Immediate-expand the variety of tasks performed throughout a shift. Longer term- change layout for easy to access to equipment and machinery. Provide workstations that can be used while either sitting or standing.	2	3	06
Sharp edge sheet handling.(without PPE) Potential for severe skin injuries may be caused by contact.	4	4	16	Immediate-provide for hand leathers, leather gloves or gloves with metal inserts. Longer term-provide mechanical aids and training of worker.	2	4	08
Pressure points (grasping loads, leaning against parts or surfaces that are hard or have sharp edges) Potential for white finger and severe skin injury occur.	3	4	12	Immediate-provide for hand leathers, leather gloves or gloves with metal inserts. Longer term-provide mechanical aids and training of worker.	1	4	04
Damaged wooden platform. (fall down) Potential for fall down-may lead to broken the leg bones and severe skin injury.	3	4	12	Immediate-cover the damaged wooden platform. Longer term- repair the damaged wooden platform/replace the wooden platform.	1	4	04
Mechanical Energies Hazards							
Contact of mobile plant with overhead structures. Potential for collision with other vehicles and pedestrians causing injury and fatality to persons involved.	3	4	12	Immediate- restrict to one way traffic in that area and provide traffic warden to facilitate safe movement. Longer term-enforce traffic management procedure/segregate traffic and pedestrians.	1	4	04
Dust, Chemicals and Hazardous Substances							
Chemical fumes such as from welding/ cutting, grinding etc. Potential for persistent headache, nausea, vomiting etc.	3	4	12	Immediate-provide for respiratory protective equipment. Longer term-provide local exhaust ventilation in the work place.	1	4	04
Work Environment Hazards							
Wildlife such as dogs, spiders, insects. Risk of leptospirosis (leptospira bacteria) diseases from the rat's urine, dog's urine.	4	3	12	Immediate- clear the area immediately. Longer term-dispose the waste at regular intervals and give training to the workers about maintain good housekeeping and monitoring the work place.	1	3	03
Fire exit and walkways are stored on rubbish. This causes delayed escape of occupants during emergency situation which can lead to casualties, injuries. Frequent trips and falls.	3	5	15	Immediate- exit way should be cleared of obstructions Longer term-liaise with tenants to ensure rubbish is disposed to correctly and posting signage and regular inspection of exit way should be done.	1	5	05

The table V clearly shows that the major hazards having risk rating moderate and above has been reduced to low risk hazards when their control measures were applied.

TABLE V RISK RATING BEFORE AND AFTER CONTROL MEASURES



V. CONCLUSION

The first step for emergency preparedness and maintaining a safe workplace is defining and analyzing hazards. In this paper the process of the Cold Rolling Mill is learnt. The risk analysis of all the hazards has been done using WRAC. The results of the analysis are that the hazards having high risk rating and above have been reduced to low risk when the control measures were applied. Thus Risk Assessment helps in identifying hazards and ensuring proper control measure thereby reducing accidents occurring in the Cold Rolling Mill.

REFERENCES

1. A Qualitative Identification and Analysis of Hazards, Risks and Operating Procedures for A Decommissioning Safety Assessment of A Nuclear Research Reactor, Kwansong Jeong, Donggyu Lee, Kunewoo Lee, Hyeonkyo Lim, *Annals of Nuclear Energy*, Volume 35, Issue 10, October 2008, Pages 1954–1962.
2. Abdullah, MA & Bakar, MI. (Eds.) *Small and Medium Enterprises in Asian Pacific Countries*. Volume 1: Roles and Issues. Nova Science Publishers Inc, Huntington, NY; 2000.
3. Ashraf Labib and Martin Read (2012) Learning From Failures through Risk and Reliability Analysis, *Safety Science* 51 (2013) 397–413.
4. Bettis RA. *Modern Financial Theory, Corporate Strategy, and Public Policy: Three Conundrums*. *Academy of Management Review* 1983, 8 Risk Analysis Of A Typical Chemical Industry Using ORA Procedure original Research Article, Faisal I. Khan, S.A. Abbasi, *Journal Of Loss*

- Prevention In The Process Industries, Volume 14, Issue 1, January 2001, Pages 43-59.
5. Triantis A. Real Options and Corporate Risk Management. *Journal of Applied Corporate Finance* 2000; 13(2):64-73.
6. Trigeorgis L. Real Options and Interaction with Financial Flexibility. *Financial Management* 1993b; 4(3):202-224.
7. Wang C, Walker E & Redmond J. Explaining the Lack of Strategic Planning In Smes: The Importance of Owner Motivation. *International Journal of Organisational Behaviour* 2007; 12(1):1-16.
8. Safety Packages of Cold Rolling Mills [Http://Www.Industry.Siemens.Com/Datapool/Industry/Industry_solutions/Metals/Siroll/En/:405–414](http://www.industry.siemens.com/datapool/industry/industry_solutions/metals/siroll/en/405-414).
9. Bierman H. *Implementing Capital Budgeting Techniques*. Revised Edition. Cambridge; 1988.
10. Bowman EH. A Risk/Return Paradox for Strategic Management. *Sloan Management Review* 1980; 21(3):17–31.
11. Bowman EH & Hurry D. Strategy through the Option Lens: An Integrated View of Resource Investments and the Incremental-Choice Process. *Academy of Management Review* 1993; 18(4):760–782.
12. Chapman R. *Simple Tools and Techniques for Enterprise Risk Management*. John Wiley & Sons, West Sussex; 2006.
13. *Collins Concise Dictionary & Thesaurus*. Harpercollins; 2006.
14. Culkin N & Smith D. An Emotional Business: A Guide to Understanding the Motivations of Small Business Decision Takers. *Qualitative Market Research: An International Journal* 2000; 3(3):145-157.
15. Culkin N & Smith D. An Emotional Business: A Guide to Understanding the Motivations of Small Business Decision Takers. *Qualitative Market Research: An International Journal* 2000; 3(3):145-157.
16. Elizabeth Bluff (2014) Safety in Machinery Design and Construction: Performance for Substantive Safety Outcomes, *Safety Science* 66 (2014) 27–35.
17. Frank Y. Shih Et Al. (2007), An Intelligent Sensor Network for Object Detection, Classification and Recognition, *Journal of Information Science and Engineering* 23, 1955-1969 (2007).