

# Hazard Identification and Risk Assessment in Construction Industry

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## Abstract

In industrial arena, if any industry to be successful, it has to be safe, reliable, and sustainable in its operations. The industry has to identify the hazards and assess the associated risks and to bring the risks to tolerable level.

Hazard Identification and Risk Assessment (HIRA) is carried for identification of undesirable events that can lead to a hazard, the analysis of hazard of this undesirable event, that could occur and usually the estimation of its extent, magnitude and likelihood of harmful effects. It is widely accepted within industry in general that the various techniques of risk assessment contribute greatly toward improvements in the safety of complex operations and equipment.

The objective of this work of hazards and risk analysis is to identify and analyze hazards, the event sequences leading to hazards and the risk associated with hazardous events. Many techniques ranging from the simple qualitative methods to the advanced quantitative methods are available to help identify and analyze hazards. The use of multiple hazard analysis techniques is recommended because each has its own purpose, strengths, and weaknesses.

**Keywords:** Hazard Operability Studies (HAZOP), Failure Mode Effect Analysis (FMEA), Process Hazard Analysis (PHA), Layer of Protection Analysis (LOPA).

## INTRODUCTION

For any industry to be successful, it has to be safe, reliable and sustainable in its operations. the industry has to identify the hazards and assess the associated risks and to bring the risks to tolerable level.

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As the part of the work. Hazard identification and risk analysis was carried out for construction activities and the hazards were identified and risk analysis was carried out. The different segments of activities were divided in to high, medium and low depending upon their consequences and likelihood. The high risks activities have been marked in red color are un-accepted and must be reduced. The risks which are marked in yellow color are tolerable but efforts must be made to reduce risk without expenditure that is grossly disproportionate to the benefit gained. The risks which are marked in green have the risk level so low that it is not required for taking actions to reduce its magnitude any further.

Hazard identification and risk analysis (HIRA) is a collective term that encompasses all activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public or the environment are consistently controlled within the organizations risk tolerance level. These studies typically address three main risk questions to a level of detail commensurate with analysis, objective, life cycle stage, available information, and resources.

Tools for simple hazard identification or qualitative risk analysis include hazard and operability analysis (HAZOP), what -if/checklist analysis, and failure modes and effect analysis (FMEA)

Tools for simple risk analysis include failure modes, effects and critically analysis (FMECA) and layer of protection analysis (LOPA), and

Tools for detailed quantitative risk analysis include fault trees and event trees. For example some companies may judge the mere existence of an explosion hazard to be an unacceptable risk, regardless of its likelihood. Others may be willing to tolerate an explosion risk if proper codes and standards are followed. Still there could be some those may be unwilling to accept an explosion risk unless it can be shown that the expected frequency of explosion is less than 10<sup>-6</sup>/yr. HIRA encompasses the entire spectrum of risk analysis, from qualitative to quantitative. A process hazard analysis (PHA) is a HIRA that meets specific regulatory requirement in the U.S.

Construction is the process of constructing a building or infrastructure. Construction differs from manufacturing typically involves mass production of similar items without a designated purchaser, while construction typically takes place on location for a known client. Construction as an industry comprises 6 to 9 percentage of the Gross Domestic Product (GDP) of developed countries. Construction starts with planning, design and financing and continues until the work is built and ready for use.

**HIRA:**

To manage risk, hazards must first be identified, and then the risk should be evaluated and determined to be tolerate or not. The earlier in the life cycle that effective risk analysis is performed, the more cost effective the future safe operation of the process or activity is likely to be. The risk understanding developed from these studies forms the basis for establishing most of the other process safety management activities undertaken by the facility. An incorrect perception of risk at any point could lead to either inefficient use of limited resources or unknowing acceptance of risks exceeding the true tolerance of the company or the community.

**HIRA Operation:**

HIRA reviews may be performed at any stage in a works life cycle-conceptual design, detailed design, construction, Commissioning, on-going operation, decommissioning or demolition. In general, the earlier that a hazard is identified (eg during conceptual design). The more cost-effectively it can be eliminated or managed. studies performed during the early design stages are typically done at corporate or engineering offices. Studies performed once a process is near start-up, during operation or before decommissioning are typically done in a plant environment.

A HIRA study is typically performed by a team of qualified experts on the process, the materials , and the work activities-personnel who have formal training on risk analysis methods usually lead these teams, applying the selected analysis technique with subject matter experts from engineering ,operations, maintenance and disciplines as needed. A simple early-in-life hazard identification study may be performed by a single experts: However, a multidiscipline team typically conducts more hazardous or complex process risk studies, especially during later life cycle stages involving operating and maintenance personnel early in the review process will help to identify hazards when they can be eliminated or controlled most cost- effectively. When the study is complete, management must then decide whether to implement any recommended risk reduction measures to achieve its risk goals.

**Procedure for HIRA:**

At each stage in the work life cycle, a review team questions process experts about possible hazards and judges the risk of any hazards that are identified. Several common methods exist for questioning a design, ranging from simple qualitative checklists to complex quantitative fault tree analysis. The result of the review process are typically documented in a worksheet form, which varies detail, depending on the stage of the work and the evaluation method used. Risk studies on operating processes are typically updated or revalidated on a regular basis.

The purpose of this work is to identify the hazards and risk by analyzing each steps involved in various activity in the construction, and to give suggestion in order to eliminate or

reduce the risk assessment (HIRA). Industry becomes successful by not only meeting the production requirements but also should have high employee satisfaction by providing the safety requirements in the workplace. The Hazards and risk assessment should be done and actions to be taken to convert the risk to a tolerable level on regular basis.

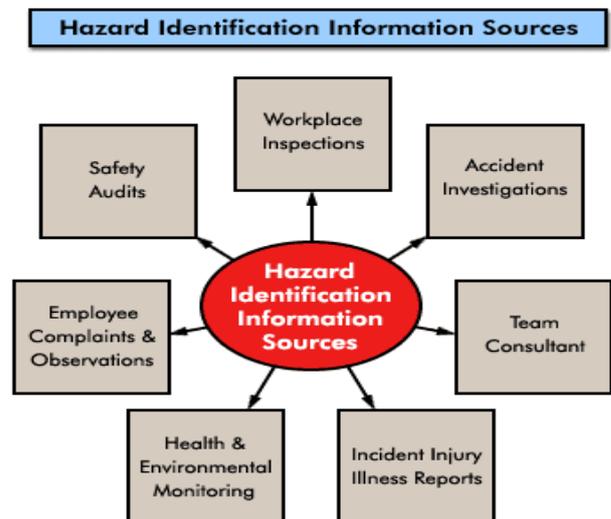
**HIRA Process:**



HIRA Process it consist of four steps as follows:

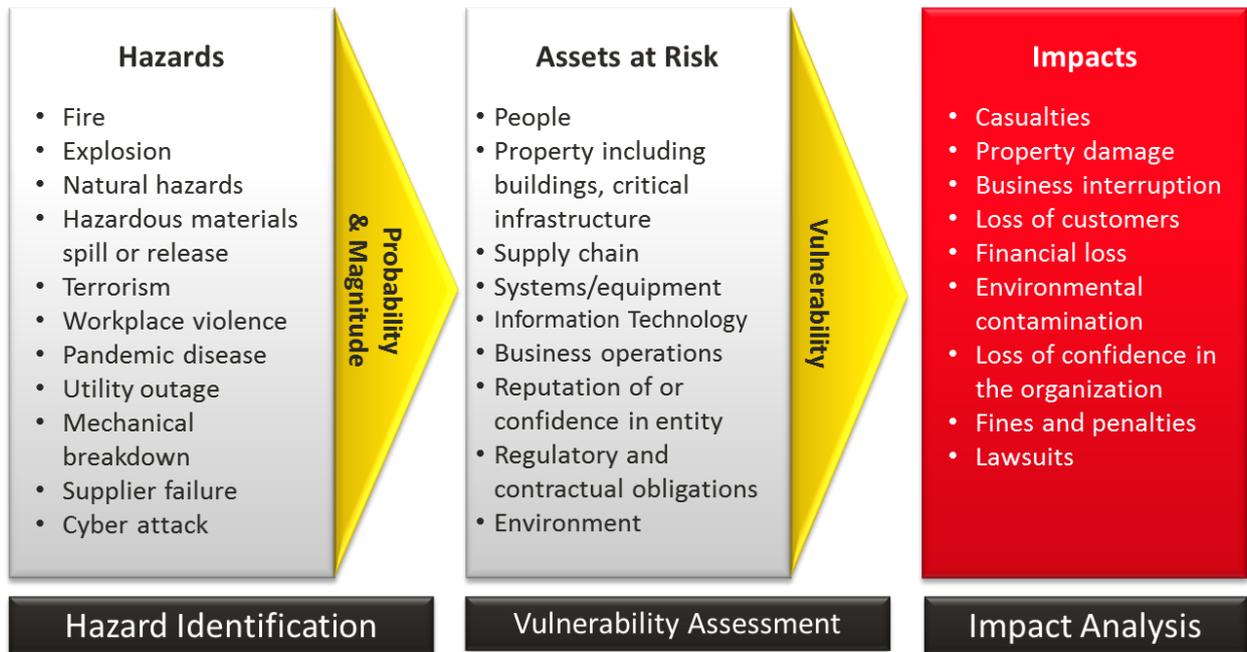
- I. Hazard identification
- II. Risk assessment
- III. Risk analysis
- IV. Monitor and review

**Hazard identification-**



Workplace hazards can be identified in a number of ways. Inspections provide a system of recognizing hazardous conditions so that those conditions can be corrected. The data collected while performing inspections will be used to identify hazards and barriers to working safely and in an environmentally protective manner so that they can be addressed such as procedure changes or purchasing different PPE. The data also will be tracked as a protective measure of acceptable HSE behavior on the site. reports and safe work observation information will be shared with employees at toolbox safety meetings.

**Assessment –**

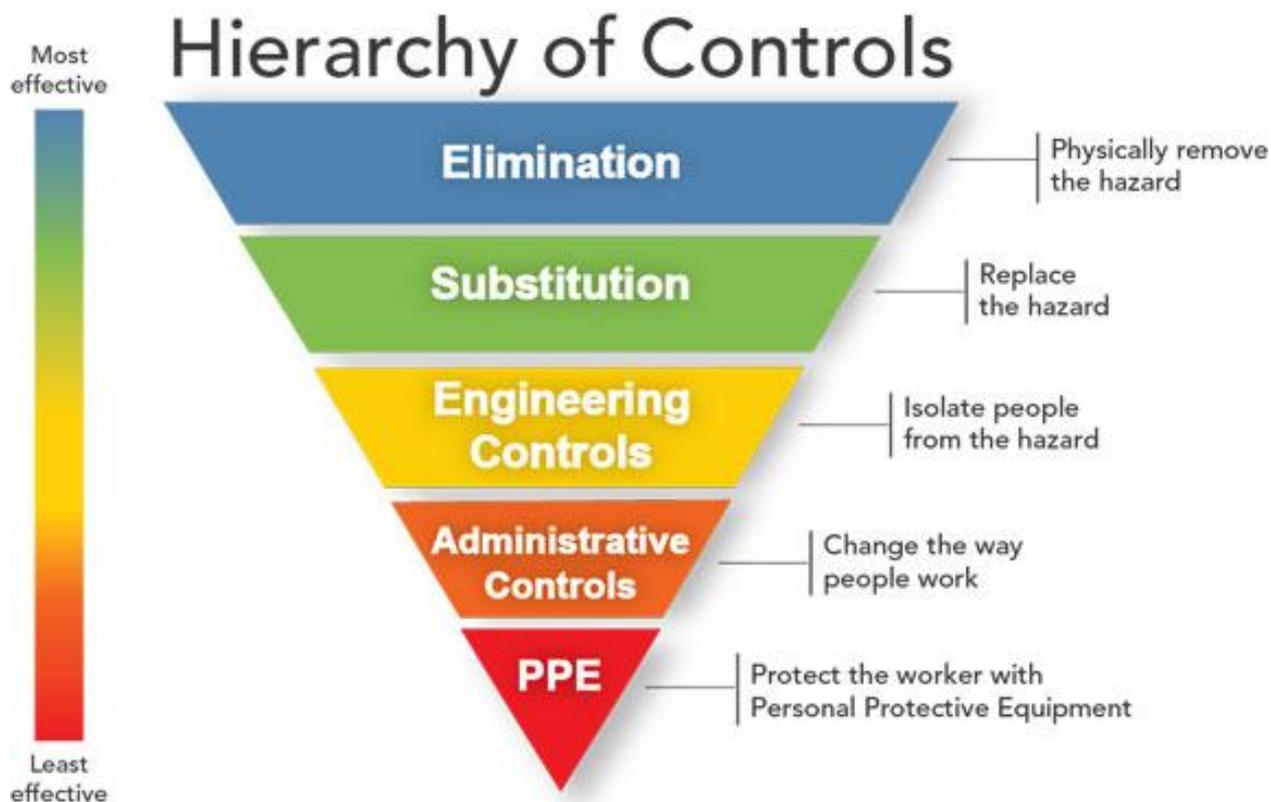


Once the hazard have been identified, it is necessary to assess what risk they pose to employees in the workplace. In this way we can establish a measure of the risk and determine what priority they should have for corrective actions. The risk assessment step is that part of the process that assesses the probability (likelihood) and consequences (severity) of hazard that have been identified. Once we have estimated the probability and consequences for each hazard then we can allocate it a priority for corrective action. Generally, risk

assessment is estimating: what are the chances (probability) of an accident happening, and if it does happen, what are the chances that someone will be hurt? What will be the extent of equipment or environmental damage, and how bad will it be (severity)? The level of risk is dependent on the exposure to the hazard and the probability and consequences of an event occurring.

**Risk analysis-**





The risk analysis determined the frequency and potential impact of hazards on business operations, community, associated stakeholders, related infrastructure, and the environment. Historical occurrences, changing circumstances, outside influences and similar occurrences happening elsewhere are examined when analyzing risks.

#### Frequency:

The HIRA is not intended to be a scientific assessment of the frequency of the different hazards, but is a risk assessment which must consider how likely it is that a hazard will occur with enough strength to result in an emergency situation. Some hazards do not have a long historical record and their frequencies can be only estimated based on the best sources available. Ideally, the frequency would be calculated based on the number of times that the event has occurred, rather than in years. Impact Different hazards have different potential impacts. The information from this research was gathered and analyzed. Past impacts and current mitigation measures were considered to determine to the extent possible whether comparable damages could be expected in the future if similar events were to occur.

Impact was split into five groups:

**Human Impacts** - The direct negative effects of an incident on the health of people including; fatalities, injuries or evacuations.

**Property Impact** - The direct negative effects of an incident on buildings, structures and other forms of property.

**Business Impact** - The negative economic or social losses due to an incident.

**Critical Infrastructure Service Disruptions/Impact** - The negative effects of an incident on the networks of institutions, services, systems and processes that meet vital human needs, sustain the economy, protect public safety and security, and maintain continuity of and confidence in government. This category is divided into two; Damage to Critical Facilities and Damage to Lifelines.

**Environmental Damage** - The negative effects of an incident on the environment, including the soil, water, air and/or plants and animals.

**Review and monitor** – A HIRA is part of the emergency management process. The risk assessment will be used to prioritize which risks require further development of treatments to prevent, mitigate, accept, or transfer the risks associated with hazards or threats.

**Control**-this stage is the process of determining and implementing appropriate measures to control risk. practicable means considering Severity of the hazard in question State of knowledge about the hazard or risk and ways of removing or mitigating it. Availability and suitability of ways to remove or mitigate that hazard or risk

Cost of removing or mitigating the hazard.

Hierarchy of controls-

Having identified the potential hazards, the team is further responsible for identifying solutions to those hazards, the preferred hierarchy for developing solutions/controls is provided below.

Elimination-eliminating toxic substances, hazardous equipment or processes that are not necessary for a system of work.

Substitution-where hazardous materials /chemicals have been identified as a hazard, the preferred option is to replace the material with a less hazardous one.

Engineering-the removal of potential hazards by reengineering the job is a preferred option. This includes design modification, guards, permanently fixed physical barriers, interlocked physical barriers, physical barriers, presence sensing systems, enclosures, ventilation, automation and isolation.

Administrative controls-the application of administrative controls to hazards may include such actions as limiting the time of exposure, rotating employees, and training of employees.

PPE-the provision of PPE does not eliminate the hazard, but only shields the individuals from it. Such action may have to couple with training in the correct use of the equipment

Evaluation-this steps means checking to see whether the introduced changes reduce the risk previously assessed. it may involve repeating the process of hazard identification, risk assessment, and risk control to verify that all risks to health.

#### **Need for risk assessment:**

Risk assessments will help the mine operators to identify high, medium and low risk levels. Risk assessments will help to priorities risks and provide information on the probability of harm arising and severity of harm by understanding the hazard, combine assessments of probability and severity to produce an assessment of risk and it is used in the assessment of risk as an aid to decision making. In this way, mine owners and operators will be able to implement safety improvements. Different types of approaches for the safety in mines various tools and appropriate steps have to be taken to make mining workplace better and safer.

A Hazard Identification and Risk (HIRA) analysis is a systematic way to identify and analyse hazards to determine their scope, impact and the vulnerability of the built environment to such hazards and its purpose is to ensure that there is a formal process for hazard identification, risk assessment and control to effectively manage hazards that may occur within the workplaces.

#### **LITERATURE REVIEW**

Literature Review A review of the literature was done to ensure that a methodology was chosen which reflected recommended practices and was useful at the territorial level. The review included HIRAs from Canadian provinces, cities

and American states as well as federal guidelines on all hazard risk assessment and Canadian and international standards.

The following is the brief review of the work carried out by different researchers in the field of hazard identification and risk analysis (HIRA).

**Qureshi (1987)** had done a Hazard and Operability Study (HAZOP) in which potential hazards and identified by looking at the design in a dynamic manner:

To identify the nature and scale of the dangerous substances;

To give an account of the arrangements for safe operation of the installation, for control of serious deviations that could lead to a major accident and for emergency procedures at the site; To identify the type, relative likelihood and consequences of major accidents that might occur; and

To demonstrate that the manufacturer (operator) has identified the major hazard potential of his activities and has provided appropriate controls.

**Khan and Abbasi (1995)** proposed optimal risk analysis (ORA) which involved the following:

Hazard identification and screening.

Hazard analysis using qualitative hazard assessment by optimal hazard and operability study (HAZOP).

Probabilistic hazard assessment by modified fault tree analysis (MFTA).

Consequence analysis which include development of accident scenarios and damage potential estimates.

**Carpignano et al. (1998)** applied quantitative risk analysis (QRA) for drawing conclusions concerning serious accidental events with the occurrence frequency and the consequences. The QRA approach they selected was based on reservoir analysis and management systems (RAMS) such as Preliminary Hazard Analysis (PHA), Failure Mode Effect and Critical Analysis (FMECA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA) and Cause Consequence Analysis and were able.

To identify accident initiating events and accidental sequence.

To classify these sequences in to frequency categories

**Duijm (2001)** identified hazards for six different techniques for disposing decommissioned ammunition. Use has been made of functional modeling as a basis for hazard identification. Risk levels are estimated based on general accident rates in the chemical industry. The disposal techniques are "open burning" (OB), "open detonation" (OD), "closed detonation" (CD), "fluidized bed combustion" (FBC), "rotary kiln (RK) incineration", "mobile incineration" and Comparative risk levels for alternative disposal techniques for ammunition have been derived using hazard identification based on functional modeling of the techniques in combination with the required manpower to perform the operations.

**Khan et al. (2001)** developed safety weighted hazard index (SWeHI). In quantitative terms SWeHI represents the radius

area under moderate hazard (50% probability of fatality/damage).

In mathematical term it is represented as

$$SWeHI = B/ A$$

Where B = Quantitative measures of damage that can be caused by unit/ plant.

A= credits due to control measures and safety arrangements.

**Lambert et al. (2001)** used Hierarchical Holographic Modelling (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:

$$RISK = HAZARD * CONSEQUENCE * ELEMENT OF RISK$$

**Jelemensky et al. (2003)** applied quantitative risk analysis followed by qualitative hazard identification to determine potential event sequences and potential incidents. From quantitative risk analysis risk estimation is done and individual fatality rate was calculated.

**Kecojevic and Radomsky (2004)** studied about loader and truck safety and found out the severity and number of accidents involving loader and trucks are higher when compared to other operations. They established fatal categories and causes of accidents and control strategies are discussed and evaluated to increase hazard awareness.

**Dziubinski et al. (2006)** studied basic reasons for pipeline failure and its probable consequences taking individual and societal risk into consideration and proposed methodology of risk assessment for hazards associated with hazardous substance transport in long pipelines. Taking that methodology as example, subsequent stages of risk analysis were considered paying special attention to the applied techniques and calculation models. A specific feature of this methodology was a combination of qualitative and quantitative techniques which offer a possibility of a full risk assessment for long pipelines.

**Laul et al. (2006)** identified hazards (chemical, electrical, physical, and industrial) and potential initiators that could lead to an accident. Hazard analysis is used to evaluate identified hazards. Hazard analysis is done by "what if check list", Hazard and Operability (HAZOP) analysis, Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA) and provided methods together with the 8 advantages and disadvantages, for developing a safety document for chemical, non-nuclear facilities.

**Jeong et al. (2007)** 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.

**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.

**Nor et al. (2008)** studied risk related to loaders and dozers and were assessed and ranked. The hazards "failure to follow adequate maintenance procedure" and "failure of mechanical / electrical/ hydraulic components" were the most severe and frequent hazards for the loaders and they fell into the category of high risk.

**Hassan et al. (2009)** carried out a Quantitative Risk Assessment (QRA) into basic steps including system definition, Hazard Identification, Frequency Analysis, Consequence Modelling, Risk calculations and Assessment to determine the safest route for the transportation of hazardous material.

**Kecojevic and Nor (2009)** studied reports on equipment related fatal incidents and showed that underground mining equipment including continuous miners, shuttle cars, roof bolters, LHD's, long wall and hoisting contributed total of 69 fatalities. The study revealed the major hazards resulting in fatal incidents for continuous mining equipment, shuttle cars, roof bolters, LHD's and hoisting system were due to failure of victim to respect equipment working area, failure of mechanical component, working under unsupported roof, failure of management to provide safe working conditions, and failure of mechanical components.

### Hazards in Construction and their analysis

Construction sites are dangerous places where injury or death or illness can cause to workers. These can happen due to electrocution, falling from height, injuries from tools, equipment and machines; being hit by moving construction vehicles, injuries from manual handling operations, illness due to hazardous substance such as dust, chemicals, .etc. Even a nail standing up from a discarded piece of wood can cause serious injury if trodden on in unsuitable shoes.

### In context to Indian scenario:

The construction is the second largest economic activity in India after agriculture which is maintained at the first level. It

has accounted for around 40% of the development investment, during the past 50 years. Around 16% of India's working population depends on construction for its livelihood.

The Indian construction industry employs over 35 million people and creates assets worth over Rs.200 billion. Construction accounts for nearly 65% of the total investment in infrastructure. Investment in construction accounts for nearly 11% of India's GDP. The market size of the construction industry for the 12th Five Year Plan period indicate that the aggregate output of the industry during the period 2012-13 to 2014-17 is likely to be 52.31 lakh crores.

There are a number of Indian regulations dealing with the working conditions of construction workers. The main Indian regulations are:

Building & Other Construction Workers (Regulation of Employment and Conditions of Services) Act, 1996.

Building & Other Construction Workers (Regulation of Employment and Conditions of Services) Central Rules, 1998.

Building & Other Construction Workers Welfare Cess Act, 1996.

These rules came into force on 19-11-1998. These rules apply to all buildings and other construction work relating to any establishment in which appropriate government is the Central Government. Some of the other statutory provisions/codes in force to take care of the working conditions of the construction workers are:

The Fatal Accidents Act, 1885,

The Factories Act, 1948,

The Workmen's Compensation Act, 1923,

The Employees State Insurance Act, 1948,

The Central Labor (Regulation & Abolition) Act, 1970,

The National Building Code of India, 2005

**SITE PREPARATIONS :** Preparation of a construction site is an important aspect which should focus on a good site layout, easy access to the site and easy movement of vehicles in the site.

**Site Layout:** A badly planned and untidy construction site can lead to many accidents at construction sites, which may arise from: (i) fall of materials, (ii) collision between the workers, (iii) plant or equipment. To avoid the above causes of accidents, a good layout of the site is a must. While preparing the site layout, at-most care should be taken to avoid overcrowding the site. Also enough space should be provided for the movement of men, material and construction equipment within the site.

**Movement of Vehicles:** It is a common sight on the construction site that many vehicles (trucks, cranes, fork lifts, etc.) carrying construction materials move criss-cross on the construction site, which results in a number of accidents and mishaps. Construction sites often operate on ground, which is muddy and uneven, and where driver visibility is poor. People

walking on the site are injured or killed by moving vehicles especially reversing ones. Many workers, particularly drivers and operators are killed by overturning vehicles. Hence, at-most care should be taken for the movement of vehicles on the construction sites. The following points should be taken into consideration, while moving the vehicles on the construction site:

Vehicles and pedestrians should be kept apart on site, i.e. separate them as much as possible using barriers.

Adequate clearance should be provided around vehicles.

As far as possible, avoid reversing the vehicles. It is better to use one-way system.

Vehicles used on the sites must have reversing alarms/sirens.

**SITE OPERATIONS:** The type of operations/activities carried out in a construction site are many (See Fig.01) and they vary from site to site. However, all of them should be carried out only with due regard to safe operations. Some of the routine work/operations carried out in construction sites are listed below:

Excavation Work

Scaffolding Work

Crane Operations

Hoisting Operations

Forklift Operations

Ladder Safety

Electrical Safety



**Figure 1.** A typical view of a construction site

**Excavation Work:** Excavation work is an important activity in the construction sites. However, many fatal accidents do occur in excavation work, if proper precautions are not taken. Many lives are lost being buried alive in the trenches. It should be remembered here that there is no safe ground that will not collapse and therefore, any trench sites can collapse without any warning.

All excavation work deeper than 1.25 meters must be shored

or battered.

Excavation deeper than 2 meters must be guarded by rails or barriers.

Vehicles working, too close to the side of the trench or rubble piled on the sides may cause collapse and therefore at most care should be taken.

Vehicles tipping into the excavation work must use stop blocks, so as to avoid the collapse of the trench.

Make sure that the excavation work is inspected daily.

Make sure that you know where the position of underground pipes and electric cables are laid in the site, so that you will not hit them during the excavation work.

**Scaffolding Work:** Scaffolds are temporary structures of steel work, timber or bamboo. The criteria for their erection are the same as those for permanent structures. The strength of the scaffolding depends upon the combined strength of individual members. Failure of one or two of them can result in the collapse of the entire structure. Modern scaffolds are invariably made of steel tubes, pre-fabricated in convenient units.

They are safer and turn out good quality work. Of course, the steel scaffolds are too costly, but, it would be cheaper in the long run. In spite of the fact that the steel scaffolds are much safer, many of the smaller and medium size builders in India, neglect the safety aspects and prefer to use timber or bamboo scaffolds (See Fig.02) in order to cut the cost. In any case, while erecting the scaffolds, the workers should be forced to wear necessary safety belts with fall arrestors and helmets, so that the fall accidents can be avoided.



**Figure 2.** A typical view of bamboo scaffolding

**Crane Operations:** Various type of cranes are used in construction sites, which includes (i) Portable Cranes (See Fig.03) (ii) Tower Cranes (Sig Fig.04). A number of accidents are reported in the use of cranes, and many of them could be averted by adopting safe methods of operations. Some of the

methods to be adopted for safe crane operations are given below:

The weight of the load intended to be lifted by the crane must be carefully estimated.

The crane must be fitted with an automatic safe load indicator.

The crane must always work on a hard, level base.

The load must be properly fixed and secured.

The signal man must be trained to give clear signals.

The ropes, hooks, chains, slings, etc. used in the lifting operations, must be inspected regularly for their worn out.

When mobile cranes are used, care must be taken to prevent overturning of cranes.

Wear appropriate personal protective equipment.



**Figure 3.** Demonstration of a typical mobile crane in operation



**Figure 4.** A typical view of tower cranes – Courtesy: cwmag.com

**Hoisting Operations:** Hoists are used to move heavy objects and equipment. The Fig. 05 shows various parts of hoists. As the hoists consists of various components, failure of any one component can lead to disastrous accidents. Therefore these

components should be inspected daily.



Figure 5. Parts of a hoist – Courtesy: disability work tools

The thumb rule is: if there is any doubt about the working conditions of a hoist, do not use it. The hoist inspections should cover the following aspects: (i) The hooks on all blocks, including snatch blocks, must have properly working safety latches, (ii) All hooks on hoisting equipment should be free of cracks and damage, (iii) The maximum load capacity for the hoist must be noted on the equipment, (iv) Electric cables and wiring should be intact and free of damages. When using hoists, some basic safety rules should be observed, which are given below:

Never walk, stand or work beneath a hoist.

Isolate hoisting area with barriers, guards and signs as appropriate.

Never exceed the capacity limits of your hoist.

Wear gloves, helmets and other personal protective equipment as appropriate, when working with hoists and cables.

Ensure that hoists are inspected regularly.

When the work is completed, always rig the hoist down and secure it.

When the load block or hoist is at floor level or its lowest point of travel, ensure that at least two turns of rope remain on the drum.

Be prepared to stop operations immediately if signalled by the safety watch or another person.

Ensure that the hoist is directly above a load before picking up. This keeps hoist from becoming stressed.

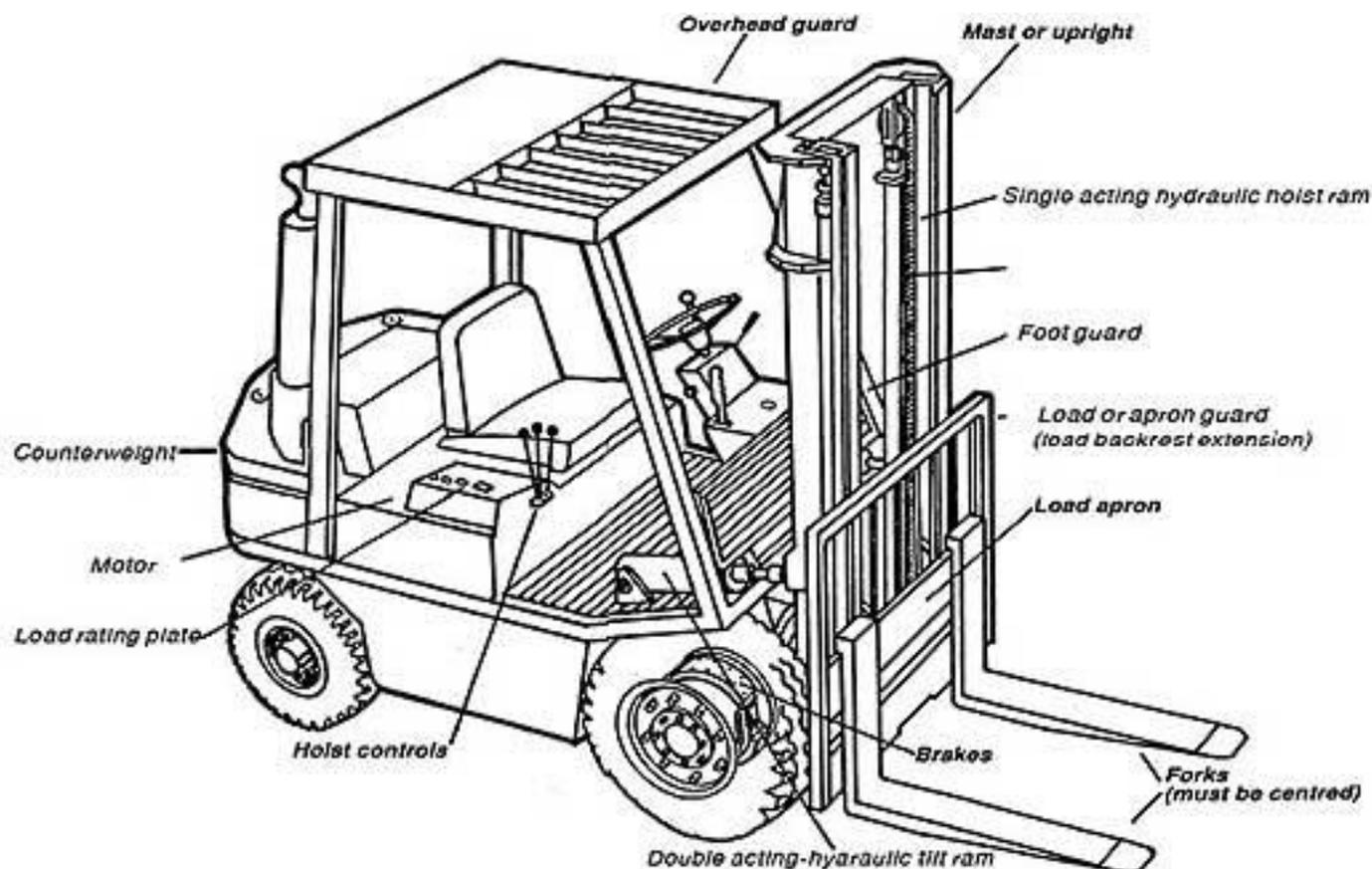
Picking up loads at odd angles may result in injury to people or damage to the hoist.

Do not pick up loads by running the cable through, over or around obstructions. These obstructions can find the cable or catch on the load and cause an accident.

Do not hoist load when any portions of the hoisting equipment within 6 feet of high-voltage electrical lines or equipment.

If you need to hoist near – voltage electrical lines or equipment, obtain clearance from your electrical supervisor first.

Fork Lift Operations: Fork Lifts are very commonly used in construction sites for movement of many construction materials and stacking them at heights. The Fig.06 shows a line diagram of a Fork Lift with various parts. While operating the Fork Lifts, the following general safety guidelines should be observed:



**Figure 6.** Parts of a fork lift truck

Do not walk, stand or work under the elevated portion of a fork lift even if it is not loaded?

Ensure that the fork lift has an overhead barriers to protect the operator from falling objects.

Do not allow riders on the fork lift.

Do not raise people on a fork lift.

Always work within the capacity limits of your fork lift.

Before modifying the operation or capacity limits of a fork lift, consult with the manufacturer.

Do not operate a fork lift in an area with hazardous concentrations of acetylene, butadiene, hydrogen, ethylene or diethyl ether, or other explosive environment.

Never lift a load while moving a fork lift. Wait until you are completely stopped before raising the mast.

Be sure, the top load sits squarely on the stack. Remember uneven load could topple the fork lift.

When you want to travel with loads, slightly lift the loads back to provide stability.

Make sure that you travel with loads at the proper height. A stable clearance height is usually 4 to 6 inches at the tips and 2 inches at the heels of the fork blades.

When preparing to leave the fork lift unattended, lower the mast, neutralize the controls, shut the power off, and set the brakes.

If you cannot see over the load, drive in reverse. Do not try to look around a load and drive forward.

**Ladder Safety:** Ladders are one of the most popular item used in the construction sites for working at heights. However, if not used safely, it can kill a lot of people. The Fig.07 & Fig.08 will depict the wrong and right way of using the ladders. The following safe methods should be adopted while operating ladders:

Always have a firm grip on the ladder and keep a good balance.

Never allow more than one person on a ladder.

Use tool belts or hand line to carry objects when you are climbing the ladder.

Do not lean out from the ladder in any direction.

If you have a fear of heights – don't climb a ladder.

Do not allow others to work under a ladder in use.

Do not use a defective ladder.

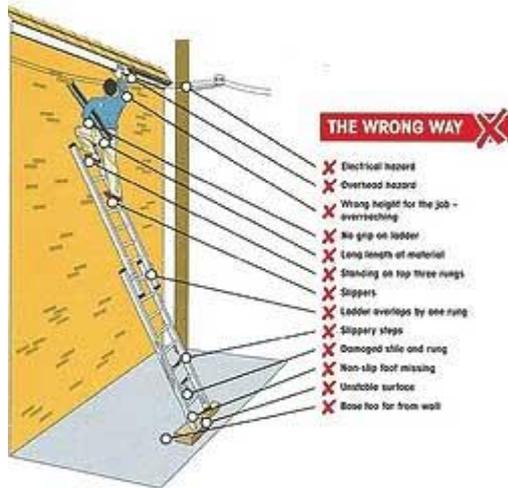


Figure 7. Wrong way of using a ladder



Figure 8. Right way of using a ladder

**Electrical Safety:** Electricity can cause great damage to both people working in the construction sites and property. Contact with the electric current can trigger other accidents, like falls from ladders or scaffolding. Electrical shocks or flashes can cause serious injuries such as burns. Electric shock may also cause the victim to stop breathing and nerve centers may be temporarily paralyzed.

The heart beat may fluctuate or the heat rhythm may actually be interrupted, thus causing a stop in the circulation of blood throughout the body. Apart from human injuries like shock, burns or falls, another major hazard is the situation in which an electrical fire or explosion may occur. Fires and explosions generally cause extensive property & equipment damage. Electrical Fires often start when an overloaded circuit becomes overheated – igniting the insulation around the wires. If cords and cables are frayed or worn out, bare wires might touch each other, thus causing a short circuit that could spark a fire.

If the workers find a fault or malfunctioning piece of equipment, they should take it out of operation, and make the necessary arrangements to have the equipment repaired. Make sure that the workers at the construction site understand the importance of electrical safety and recognize, that abusing or misusing electrical equipment is an invitation to an accident. The workers should also make sure that the work area is safe and free from all electrical hazards. Provide necessary personal protective equipment in particular, electrical gloves & breathing apparatus

## TYPES OF HEALTH AND SAFETY HAZARDS ON CONSTRUCTION SITE

Height

Slips and trips

Equipment, machinery, tools and transport

Electricity

Fire

Manual handling

Noise

Chemical substance

Dust

*There are no fixed rules about how the risk assessment should be under taken. The following steps could be used as guidance.*

Initiating the HIRA

Identify the hazard

Identify all parties affected by the hazard and determine how they can be affected

Evaluate or assess the risk

### Step 1: Initiating the HIRA and selecting the approach

Two principles should be taken in consideration before an assessment is carried out: Structure the assessment to ensure that all relevant hazards and risks are addressed. This should be done to ensure that tasks like night security that might take place “out” of working hours, is not overlooked. When a hazard is identified, the first option should always be to eliminate it first.

A number of approaches (and combinations thereof) to risk assessment can be adopted to perform the HIRA.

The approaches to risk assessment at work which are used are normally based upon:

Observation of the workplace environment (e.g. means of access, conditions of floors; machinery safety; dust and fumes, temperature, lighting; noise; etc.)

Identification of tasks carried out at the workplace (to identify all tasks so that they are all included in risk assessment).

Consideration of tasks carried out at the workplace (evaluation of risks from the different tasks).

Observation of work in progress (check that procedures are as laid down or predicted, and that there are no other risks arising).

Consideration of patterns of work (to assess exposure to hazards).

Consideration of external factors that could affect the workplace (e.g. weather consideration for outdoor workers).

Review of psychological, social and physical factors which might contribute to stress at work, how they interact together and with other factors in the workplace organization and environment.

Consideration of organization to maintain conditions, including safeguards (e.g. that systems are in place to assess risks from new plant, materials and so on to update information on risks).

After the selection of the desired HIRA approach, the following information should be completed by the above mentioned assessor(s).

**Date:** Insert date that assessment form is completed. The assessment must be valid on that day, and subsequent days, unless circumstances change and amendments are necessary.

**Assessed by:** Insert the name, designation and signature of the assessor or in the case of a team the names, designations and signatures of all the team members.

**Checked by:** Insert the name and signature of someone in a position to check that the assessment has been carried out by a competent person who can identify hazards and assess risk, and that the control measures are reasonable and in place. The checker will normally be a line manager, supervisor, principal investigator, etc. Checking will be appropriate for most risk assessments.

**Validated by:** Use this for higher risk scenarios, e.g.- where complex calculations have to be validated by another "independent" person who is competent to do so, or where the control measure is a strict permit-to-work procedure requiring thorough preparation of a workplace. The valuator should also be a competent engineer or professional with expertise in the task being considered. Examples of where validation is required include designs for pressure vessels, load-bearing equipment, lifting equipment carrying personnel or items over populated areas, and similar situations.

**Location:** Insert details of the exact location, e.g. building, floor, room or laboratory etc.

**Task / premises:** Insert a brief summary of the task, e.g. typical office activities such as filing, DSE work, lifting and moving small objects, use of misc electrical equipment. Or, research work [title] involving the use of typical laboratory hardware, including fume cupboards, hot plates, ovens, analysis equipment, flammable solvents, etc.

**Activity:** use the column to describe each separate activity covered by the assessment. The number of rows is unlimited, although how many are used for one assessment will depend on how the task / premises is sub-divided. For laboratory work, activities in one particular lab or for one particular work might include; use of gas cylinders, use of fume cupboard, use of computer or other electrical equipment, use of lab ovens, hot plates or heaters, use of substances hazardous to health, etc

**Hazard:** for each activity, list the hazards.

## **Step 2: Identify the hazards**

The importance of this element cannot be over emphasized. It is by far the most important element of the risk assessment process and should be performed in a systematic manner.

Gathering and analysis of information before the assessment

The gathering and analysis of information is an essential task before the risk assessment can start. This would normally be conducted by the safety practitioner or person responsible for health and safety and it is one of his more important duties. The person should access the databases on the business to assess the types and major underlying causes of past accidents and incidents. It is advisable to also review accident reports and investigations together with other records such as those maintained by engineering staff, log books and audit reports. Externally, he or she may be able to gather information from government and industry organizations or from publications and databases.

During the physical assessment or after the assessment

The adoption of some systematic way of allowing relevant persons to "see" or "spot" the hazards present in the workplace. If the hazard identification is not carried out carefully, the subsequent analysis of risk and the development of risk control measures become pointless. The identification of hazards is not only an essential part of the risk assessment process, but also acts very effectively to change the way people think, causing them to act more safely and so become more proactive in hazard awareness. When you work in a place every day it is easy to overlook some hazards. There are many techniques and tools that can be used as part of the hazard identification process, here are some tips to help you identify the ones that matter:

**Observation** - walk around your workplace and look at what could reasonably be expected to cause harm.

**Communication** - ask your employees what they think. They may have noticed things that are not immediately obvious to you.

**Information** - check "manufacturers" instructions or MSDS for chemicals and equipment as they can be very helpful in spelling out the hazards and putting them in their true perspective.

**Records** - Have a look at your incident and sickness records – these often help to identify the less obvious hazards.

Visit relevant Websites to gain information. Increasingly, the internet is a valuable means of gathering international data. All this data needs to be assimilated and converted into a useful format to prepare the team who undertakes risk assessment. Calling legal your labor inspector at the labor centre. Consultation with the workplace health and safety committee and representatives. Brainstorm ideas and group under appropriate risk headings. Consider the effects on people (staff, students and other people), information, physical assets and finances, reputation. Write the final list onto the table (risk assessment summary). Data from health surveillance program. Consulting with subject matter experts or consultants. SABS codes and standards.

**Minimum standard legislation.**

Analyze specific scenarios, this is mostly a preventative method used for the identification of hazards and is performed by stating or picturing certain possibilities or scenarios and then breaking it down, examining and studying the possibly outcome of the event or activity.

Remember to think about long-term hazards to health (e.g. high levels of noise or exposure to harmful substances) as well as safety hazards.

**Step 3: Identify all parties affected by the hazard and determine how they can be affected**

Next you need to identify who might be harmed; it will help you identify the best way of managing the risk. That doesn't mean listing everyone by name, but rather identifying groups of people (e.g. people working in the storeroom or kitchen). In each case, identify how they might be harmed, e.g. what type of injury or ill health might occur.

**Remember:**

Some workers might be more vulnerable like new and young workers, new or expectant mothers and people with disabilities, lone workers.

Cleaners, visitors, contractors, maintenance workers etc, who may not be in the workplace all the time.

Members of the public, if they could be hurt by your activities.

If you share your workplace, you will need to think about how your work affects others present.

As well as how their work affects your staff – talk to them; and ask your staff if they can think of anyone you may have missed.

Identify groups or people who may be affected.

Examples of people at risk	
Employees	Cleaners
Temporary workers	Security personal
Shift workers	Children
Contactors	Volunteers
Visitors	Students
Customers	Tenants
Members of the public	Relief workers

Examples of vulnerable people:	
New or expectant mothers	Lone workers
Employees, customers or visitors with disabilities	Students
Young people	Non-English speakers
Inexperienced workers	

If the risk assessment is job-specific, use the individual's job title, not their name.

**Step 4: Evaluate or assess the risk**

Having identified the hazards, you then have to decide what to do about them. Legislation requires you to do everything “reasonably practicable” to protect people from harm.

**RISK RATING**

One of the most simplistic forms of risk assessment is to rate the remaining risk as high, medium or low, depending on how likely the activity is to cause harm and how serious that harm might be. This is called “Risk rating”.

**LEVEL OF RISK**

Low risk items-Need to be considered, but there is a smaller chance that they will cause the entire work to go off the rails. It is most unlikely that harm would arise under the controlled conditions listed, and even if exposure occurred, the injury would be relatively slight.

Medium risk items-These types of risks are ones that could cause issues, but that there is still a lower chance that they will cause your work to fail. It is more likely that harm might actually occur and the outcome could be more serious (e.g. some time off work, or a minor physical injury).

High risk items-These are the risks that take the highest priority. They can cause your work to fail, and you need to plan for these risks ahead of time. If injury is likely to arise (e.g. there have been previous incidents, the situation looks like an accident waiting to happen) and that injury might be serious (broken bones, trip to the hospital, loss of consciousness), or even a fatality.

**RISK RANKING MATRIX**

<b>RISK ASSESSMENT MATRIX</b>				
<b>SEVERITY</b> <b>PROBABILITY</b>	<b>Catastrophic (1)</b>	<b>Critical (2)</b>	<b>Marginal (3)</b>	<b>Negligible (4)</b>
<b>Frequent (A)</b>	<b>High</b>	<b>High</b>	<b>Serious</b>	<b>Medium</b>
<b>Probable (B)</b>	<b>High</b>	<b>High</b>	<b>Serious</b>	<b>Medium</b>
<b>Occasional (C)</b>	<b>High</b>	<b>Serious</b>	<b>Medium</b>	<b>Low</b>
<b>Remote (D)</b>	<b>Serious</b>	<b>Medium</b>	<b>Medium</b>	<b>Low</b>
<b>Improbable (E)</b>	<b>Medium</b>	<b>Medium</b>	<b>Medium</b>	<b>Low</b>
<b>Eliminated (F)</b>	<b>Eliminated</b>			

In order to do a ‘risk rating’, we normally make use of a matrix scoring system. Numerical scores are given to the different elements (e.g. consequence, exposure, likelihood) of risks and these scores are added or multiplied to get a rating for the risk. For the initial risk evaluation, consider the risks identified in the worst case scenario before any controls are applied.

Example: Electricity is a hazard, it can kill but the risk of it doing so in an office environment is low providing the components are insulated, the metal casing is properly earthed and appliances are used correctly and tested regularly.

**Elements of risk:**

Consequence/ severity (How serious)

Consequences are the expected severity. The severity is expressed in terms of the effect on the person, whether injury or ill health, and ranging from minor injury to death. Think about how serious the likely outcomes would be if harm from a hazard was realized. The risks are clearly higher if an accident is likely to result in serious injury or death, for example, than a bruise or a scratch.

Probability/ Likelihood (How likely)

By evaluating the risks associated with each hazard you have identified, you're deciding how likely it is that harm will occur from the hazard. The likelihood is the probability of loss when a sub-standard act occurs or sub-standard condition exists.

The likelihood should be based on the worst case scenario, ranging from a remote possibility to the inevitable. Factors affecting the likelihood include:

- Number of times the situation occurs
- Location of the hazard
- Duration of the exposure
- Environmental conditions
- Competence of the people involved and
- The condition of equipment
- Frequency (How often)

How often is the activity involving the hazard taking place? How many people come into contact with it? Risks are higher when frequency of contact is higher.

**Risk assessment sheet –In an Indian Industry:**

Sub Task	Activity	Hazard / Risk	Initial Risk Factor				Existing Control Measures	Actual Risk Factor				Priority	Responsibility	
			E	S	P	R		E	S	P	R		By Whom	By When
1.	Shifting of structural materials from yard to blasting / painting area and back to fabrication yard (By using of hydra, crane & trailer)	1.Unathorized Operation of Vehicle. 2.Carrying Unauthorized Passengers 3.Intoxicated Driving	6	4	3	72	1.Area Survey to be done before moving the crane  2. Designated persons are only allowed to travel in the cabin of trailer / truck.	6	4	0.5	12	4	Execution Team	Before / During Job
2.	Manual Material Handling / Material	1.Hazards during manual materials handing. 2.Pinching of leg/hands while handing of materials. 3. Improper stacking of Material.	6	4	3	72	1. Don't allow the person to lift more than 30 kg for materials shifting from one place to other. Provide Trolley for materials shifting. Person handing the material should be physically fit to do work.  2.Use hand gloves during material handing. All mandatory PPE's shall be use at site..	6	4	0.5	12	4	Execution Team	Before / During Job
3.		1.Unauthorized Operation of crane. 2.Inadequate space for access/ egress. 3.Improper illumination.	6	7	3	126	1.medical Fitness of Crane operators shall be check  2.The space for access &egress should be proper, clear & adequate.	6	7	0.5	21	3	Execution Team	Before / During Job
4.	Gas cutting Activity Storage, Handing & use of Gas Cylinders at site.	1.Improper unloading process- damage of cylinder resulting fire & explosion, injury while handling. 2.Improper Storage – Un tied cylinders. 3.Fire, burn injury while using at site.	6	7	3	126	1.Cylinders should keeping at upright direction only.  2.Providing Flash back arrestor each side of gas cutting set.	6	7	0.5	21	3	Execution Team	Before / During Job
5.	Grinding Work	1.Struck by grinding wheel. 2.breaking of wheel. 3.Poor electrical connection.	6	7	3	126	1.All the grinding m /c's shall be used with wheel guard.  2.Check expire date of grinding wheel and use approved product of wheel.	6	7	0.5	21	3	Execution Team	Before / During Job
6.	Welding Work	1.Electricution due to improper electric connection. 2.Welding fumes / Health hazard. 3.Fire hazard due to welding spark.	6	7	3	126	1.Welding goggles shall be provided to welder's helper for eye protection.  2.Area shall be cleared of Flammables and combustibles before commencing welding.	6	7	0.5	21	3	Execution Team	Before / During Job

**The frequency of exposure indicates how often a dangerous situation can arise. It could be an exposure to a toxic chemical or working and handling of a dangerous machine.**

Factor	Description
0.5	Very Rarely (less than one per year)
1	Rarely (few times per year)

2	Sometimes (12 times per year)	
3	Now and then (one per week)	
6	Frequently (daily)	
10	Continuous (more than two times per day)	
<b>Severity Rating</b>		
<b>The apparent effect indicates the seriousness of the arising situation</b>		
<b>Factor</b>	<b>Description</b>	
1	Minor (injury without time / work restriction FAC)	
4	Major (injury with time /work restriction MTC/RWC)	
7	Serious (irreversible effect handicap LWC)	
15	Critical (single fatality immediately or afterwards)	
40	Disaster (multiple fatality immediately or afterwards)	
<b>Probability Rating</b>		
<b>Factor</b>	<b>Description</b>	
0.2	Virtually impossible (>20 years, one in a life time, only theoretical case)	
0.5	Conceivable but improbable (once in a career (1/20 years)	
1	Improbable / borderline case, (1/10 years)	
3	Unusual (one can think of a (unusual ) scenario (1/3 years)	
6	Possible (once every 6 months)	
10	To be expected (one per week)	
<b>Risk Rating</b>		
<b>Risk = Exposure x Severity x Probability</b>		
<b>Risk Score</b>	<b>Priority</b>	<b>INTERPRETATION</b>
>20	4	Very limited risk – acceptable
20-69	3	Take additional measure to mitigate the risk level close to priority 4
70-199	2	Immediate measures required
>=200	1	Stop work until measures are taken

## HAZARD IDENTIFICATION AND RISK ASSESSMENT

The purpose of this guideline is to provide a systematic and objective approach to assessing hazards and their associated risks that will provide an objective measure of an identified hazard as well as provide a method to control the risk. It is one of the general duties as prescribed under the Occupational Safety and Health Act 1994 (Act 514) for the employer to provide a safe workplaces to their employees and other related person.

### TERM AND DEFINITIONS:

The purpose of this guideline is to provide a systematic and objective approach to assessing hazards and their associated risks that will provide an objective measure of an identified hazard as well as provide a method to control the risk. It is one of the general duties as prescribed under the Occupational Safety and Health Act 1994 (Act 514) for the employer to provide a safe workplaces to their employees and other related person.

Hazard-means a source or a situation with a potential for harm in terms of human injury or ill health, damage to property,

damage to the environment or a combination of these.

Hazard control means the process of implementing measures to reduce the risk associate with a hazard.

Hierarchy of control means the established priority order for the types of measures to be used to control risks.

Hazard identification means the identification of undesired events that lead to the materialization of the hazard and the mechanism by which those undesired events could occur.

Risk means a combination of the likelihood of an occurrence of a hazardous event with specified period or in specified circumstances and the severity of injury or damage to the health of people, property, environment or any combination of these caused by the event.

Risk assessment means the process of evaluating the risks to safety and health arising from hazards at work.

Risk management means the total procedure associated with identifying a hazard, assessing the risk, putting in place control measures, and reviewing the outcomes.

**BASIC CONCEPTS:**

**Risk:**

Risk is something that we as individuals live with on a day-to-day basis. People are constantly making decisions based on risk. Simple decision in daily life such as driving, crossing the road and money investment all imply an acceptance risk. Risk is the combination of the likelihood and severity of a specified hazardous event occurring.

In mathematical term, risk can be calculated by the equation -  
 Risk = Likelihood x Severity

Where,

Likelihood is an event likely to occur within the specific period or in specified circumstances and, Severity is outcome from an event such as severity of injury or health of people, or damage to property, or insult to environment, or any combination of those caused by the event.

**PLANNING AND CONDUCTING OF HIRA :**

The purpose of HIRA are as follows:-

To identify all the factors that may cause harm to employees and others (the hazards);

To consider what the chances are of that harm actually be falling anyone in the circumstances of a particular case and the possible severity that could come from it (the risks); and

To enable employers to plan, introduce and monitor preventive measures to ensure that the risks are adequately controlled at all times.

HIRA activities shall be plan and conducted.

Process of HIRA requires 4 simple steps:

Classify work activities;

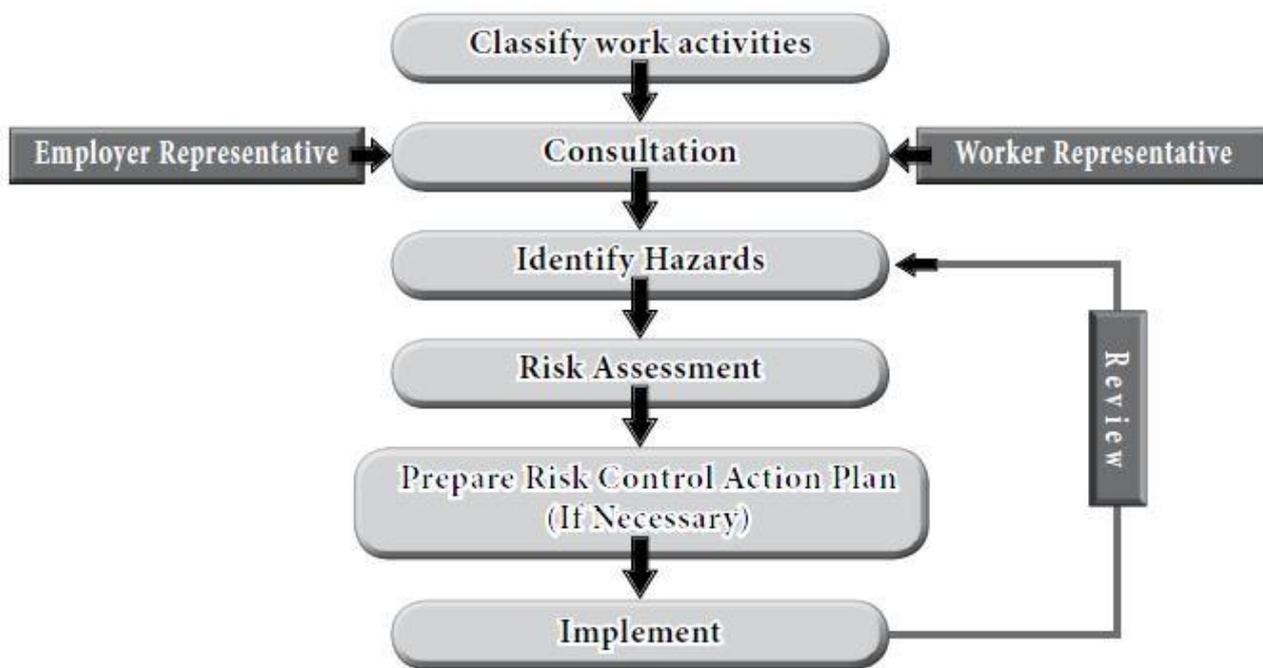
Identify hazard;

Conduct risk assessment (analyze and estimate risk from each hazard), by calculating or estimating -

Likelihood of occurrence, and Severity of hazard;

Decide if risk is tolerable and apply control measures (if necessary).

Flow chart for HIRA process



Classify work activities:

Classify work activities in accordance with their similarity, such as :

Geographical or physical areas within/outside premises;

Stages in production/service process;

Not too big e.g. building a car;

Not too small e.g. fixing a nut; or

Defined task e.g. loading, packing, mixing, fixing the door.

**HAZARD IDENTIFICATION:**

The purpose of hazard identification is to highlight the critical operations of tasks, that is, those tasks posing significant risks to the health and safety of employees as well as highlighting those hazards pertaining to certain equipment due to energy sources, working conditions or activities performed. Hazards can be divided into three main groups, health hazards, safety hazards, and environmental hazards.

Health hazards:



(chronic) problems. All or part of the body may be affected. Someone with an occupational illness may not recognize the symptoms immediately. For example, noise-induced hearing loss is often difficult for the affected individual to detect until it is well advanced. Health hazards include chemicals (such as battery acid and solvents), biological hazards (such as bacteria, viruses, dusts and molds), physical agents (energy sources strong enough to harm the body, such as electric currents, heat, light, vibration, noise and radiation) and work design (ergonomic) hazards.

An occupational health hazard is any agent that can cause illness to an individual. A health hazard may produce serious and immediate (acute) affects, or may cause long-term

Safety hazards:

**Focus Four Hazards**

- Falls
- Caught-In or -Between
- Struck-By
- Electrocutation

### Top 16 hazards in construction sites

Source: Department of Municipal Affairs      Graphic: Supplied      ©Gulf News

A safety hazard is any force strong enough to cause injury, or damage to property. An injury caused by a safety hazard is usually obvious. For example, a worker may be badly cut. Safety hazards cause harm when workplace controls are not adequate.

Some examples of safety hazards include, but are not limited to:

Slipping/tripping hazards (such as wires run across floors);

Fire hazards (from flammable materials);

Moving parts of machinery, tools and equipment (such as pinch and nip points);

Work at height (such as work done on scaffolds);

Ejection of material (such as from molding);

Pressure systems (such as steam boilers and pipes);

Vehicles (such as forklifts and trucks);

Lifting and other manual handling operations; and Working alone.

Environmental hazards:



**Figure - Environmental Hazard**

An environmental hazard is a release to the environment that may cause harm or deleterious effects. An environmental release may not be obvious. For example, a worker who drains a glycol system and releases the liquid to a storm sewer may not be aware, of the effect on the environment. Environmental hazards cause harm when controls and work procedures are not followed.

#### **HAZARD IDENTIFICATION TECHNIQUE:**

The employer shall develop a hazard identification and assessment methodology taking into account the following documents and information:

- Any hazardous occurrence investigation reports;
- First aid records and minor injury records;
- Work place health protection programs;
- Any results of work place inspections;
- Any employee complaints and comments;
- Any government or employer reports, studies and tests concerning the health and safety of employees;
- Any reports made under the regulation of Occupational Safety and Health Act, 1994
- The record of hazardous substances; and
- Any other relevant information.

#### **THE HAZARD IDENTIFICATION AND ASSESSMENT METHODOLOGY:**

The hazard identification and assessment methodology shall include:

Steps and time frame for identifying and assessing the hazards. One must define the steps for the identification of hazards and a time frame for this identification. The following information should be included:

Who will be responsible for the identification: for example, it may be the work place health and safety committee, or an

individual or individuals appointed by the committee;

The way in which the identification reports are processed: for example, they may be compiled and processed by the committee, or by individuals appointed by the committee:

The identification time frame.

The keeping of a record of the hazards.

After having identified the hazards, one must establish and maintain an identification record, either in print or electronic format.

A time frame for reviewing and, if necessary, revising the methodology The date for the review of the identification: for example, the review of the identification method will be carried out every three years. To complete hazard identification, one can use techniques to identify hazards. Some examples of techniques include, but are not limited to:

- Work place inspections; ii.
- Task safety analysis or job hazard analysis;
- Preliminary investigations;
- Potential accident factors;
- Failure analysis;
- Accident and incident investigations.

It is in your interest to adopt your own process and your own identification techniques so that they match one management procedures and the size of business. In fact, the identification method may vary depending on the size of the work place.

#### **Analyze and estimate risk:**

Risk is the determination of likelihood and severity of the credible accident/event sequences in order to determine magnitude and to priorities identified hazards. It can be done by qualitative, quantitative or semi quantitative method.

#### **Methodologies of risk analysis-**

A qualitative analysis uses words to describe the magnitude of potential severity and the likelihood that those severity will occur. These scales can be adapted or adjusted to suit the circumstances and different descriptions may be used for different risks. This method uses expert knowledge and experience to determine likelihood and severity category.

In semi-quantitative analysis, qualitative scales such as those described above are given values. The objective is to produce a more expanded ranking scale than is usually achieve in qualitative analysis, not to suggest realistic values for risk such as is attempted in quantitative analysis.

Quantitative analysis uses numerical values (rather than the descriptive scales used in qualitative and semi-quantitative analysis) for both severity and likelihood using data from a variety of sources such as past accident experience and from scientific research. Severity may be determined by modeling the outcomes of an event or set of events, or by extrapolation

from experimental studies or past data. Severity may be expressed in terms of monetary, technical or human impact criteria, or any of the other criteria. The way in which severity and likelihood are expressed and the ways in which they are combined to provide a level of risk will vary according to the type of risk and the purpose for which the risk assessment output is to be used. In this guidelines qualitative and semi quantitative method uses as an example.

Likelihood of an occurrence:

This value is based on the likelihood of an event occurring. You may ask the question “How many times has this event happened in the past?” Assessing likelihood is based worker experience, analysis or measurement. Likelihood levels range from “most likely” to “inconceivable.” For example, a small spill of bleach from a container when filling a spray bottle is most likely to occur during every shift. Alternatively, a leak of diesel fuel from a secure holding tank may be less probable.

Table A indicates likelihood using the following values:

LIKELIHOOD (L)	EXAMPLE	RATING
Most likely	The most likely result of the hazard / event being realized	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might be occur at sometime in future	3
Remote	Has not been known to occur after many years	2
Inconceivable	Is practically impossible and has never occurred	1

**Table A**

Severity of hazard:

Severity can be divided into five categories. Severity are based upon an increasing level of severity to an individual's

health, the environment, or to property. Table B indicates severity by using the following table:

SEVERITY (S)	EXAMPLE	RATING
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity	5
Fatal	Approximately one single fatality major property damage if hazard is realized	4
Serious	Non-fatal injury, permanent disability	3
Minor	Disabling but not permanent injury	2
Negligible	Minor abrasions, bruises, cuts, first aid type injury	1

**Table B**

**RISK ASSESSMENT:**

Risk can be presented in variety of ways to communicate the results of analysis to make decision on risk control. For risk analysis that uses likelihood and severity in qualitative method, presenting result in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace.

Risk can be calculated using the following formula:

$L \times S = \text{Relative Risk}$

L = Likelihood

S = Severity

An example of risk matrix (Table C) is shown below:

	Severity (S)				
Likelihood (L)	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Table C

High ■  
 Medium ■  
 Low ■

To use this matrix, first find the severity column that best describes the outcome of risk. Then follow the likelihood row to find the description that best suits the likelihood that the severity will occur. The risk level is given in the box where

the row and column meet.

The relative risk value can be used to prioritize necessary actions to effectively manage work place hazards. Table D determines priority based on the following ranges:

RISK	DESCRIPTION	ACTION
15 - 25	HIGH	A HIGH risk requires <b>immediate</b> action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion.
5 - 12	MEDIUM	A MEDIUM risk requires a planned approach to controlling the hazard and applies temporary measure if required. Actions taken must be documented on the risk assessment form including date for completion.
1 - 4	LOW	A risk identified as LOW may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

Table D

Hazards assessed, as “High Risk” must have immediate actions, to resolve risk to life safety and or the environment. Individuals responsible for required action, including follow up must be clearly identified. A further detail risk assessment method may require such as quantitative risk assessment as means of determine suitable controls measures.

**CONTROL:**

Definition: Control is the elimination or inactivation of a hazard in a manner such that the hazard does not pose a risk to workers who have to enter into an area or work on equipment in the course of scheduled work.

Hazards should be controlled at their source (where the problem is created). The closer a control to the source of the

hazard is the better. This method is often referred to as applying engineering controls. If this does not work, hazards can often be controlled along the path to the worker, between the source and the worker. This method can be referred to as applying administrative controls. If this is not possible, hazards must be controlled at the level of the worker through the use of personal protective equipment (PPE), although this is the least desirable control.

### **Selecting a suitable control:**

#### ***Selecting a control often involves:***

Evaluating and selecting short and long term controls;

Implementing short-term measures to protect workers until permanent controls can be put in place; and

Implementing long term controls when reasonably practicable.

For example, suppose a noise hazard is identified. Short-term controls might require workers to use hearing protection. Long term, permanent controls might remove or isolate the noise source.

#### ***Types of Control:***

At the source of the hazard

Elimination - Getting rid of a hazardous job, tool, process, machine or substance is perhaps the best way of protecting workers. For example, a salvage firm might decide to stop buying and cutting up scrapped bulk fuel tanks due to explosion hazards.

Substitution - Sometimes doing the same work in a less hazardous way is possible. For example, a hazardous chemical can be replaced with a less hazardous one. Controls must protect workers from any new hazards that are created.

#### ***Engineering control:***

Redesign - Jobs and processes can be reworked to make them safer. For example, containers can be made easier to hold and lift.

Isolation - If a hazard cannot be eliminated or replaced, it can sometimes be isolated, contained or otherwise kept away from workers. For example, an insulated and air-conditioned control room can protect operators from a toxic chemical.

Automation - Dangerous processes can be automated or mechanized. For example, computer-controlled robots can handle spot welding operations in car plants. Care must be taken to protect workers from robotic hazards.

Barriers - A hazard can be blocked before it reaches workers. For example, special curtains can prevent eye injuries from welding arc radiation. Proper equipment guarding will protect workers from contacting moving parts.

Absorption - Baffles can block or absorb noise. Lockout systems can isolate energy sources during repair and

maintenance. Usually, the further a control keeps a hazard away from workers, the more effective it is.

Dilution - Some hazards can be diluted or dissipated. For example, ventilation systems can dilute toxic gasses before they reach operators.

### **Administrative controls:**

Safe work procedures - Workers can be required to use standardized safety practices. The employer is expected to ensure that workers follow these practices. Work procedures must be periodically reviewed with workers and updated.

Supervision and training – Initial training on safe work procedures and refresher training should be offered. Appropriate supervision to assist workers in identifying possible hazards and evaluating work procedures.

Job rotations and other procedures can reduce the time that workers are exposed to a hazard. For example, workers can be rotated through jobs requiring repetitive tendon and muscle movements to prevent cumulative trauma injuries. Noisy processes can be scheduled when no one is in the workplace.

Housekeeping, repair and maintenance programs - Housekeeping includes cleaning, waste disposal and spill cleanup. Tools, equipment and machinery are less likely to cause injury if they are kept clean and well maintained.

Hygiene - Hygiene practices can reduce the risk of toxic materials being absorbed by workers or carried home to their families. Street clothing should be kept in separate lockers to avoid being contaminated by work clothing. Eating areas must be segregated from toxic hazards. Eating should be forbidden in toxic work areas. Where applicable, workers should be required to shower and change clothes at the end of the shift.

### **Personal Protective Equipment:**

Personal protective equipment (PPE):

Personal protective equipment means any equipment which is intended to be worn or held by a person at work and which protects him against one or more risks to his health or safety and any additional accessory designed to meet that objective;

PPE is usually chosen to provide protection appropriate to each of type of hazard present. There are specifications for the types of PPE used for protecting an individual's head, eyes, footwear, limb and body, fire retardant clothing, respiratory, hearing, and personal flotation devices.

It may also include required apparel for example when traffic hazards are present high visible and distinguishable "vests must be worn"

Personal Protective Equipment (PPE) and clothing is used when other controls measures are not feasible and where additional protection is needed. Workers must be trained to use and maintain equipment properly. The employer and workers must understand the limitations of the personal protective equipment. The employer is expected to require

workers to use their equipment whenever it is needed. Care must be taken to ensure that equipment is working properly. Otherwise, PPE may endanger a workers health by providing an illusion of protection.

### **SAFE WORK PROCEDURES:**

Through the completion of a Job Hazard Analysis, sometimes hazards are identified and cannot be eliminated or engineered out of a particular task. Safe Work Procedures are step by step instructions that allow workers to conduct their work safely when hazards are present. A Safe Work Procedure identifies the materials and equipment needed, and how and when to use them safely.

Safe Work Procedures are generally prepared for –

Critical high risk jobs where accidents have or could result in severe injuries; Hazardous work where accidents occur frequently. New or altered tasks have been introduced. New equipment has been added to a process; A job that requires many detailed tasks; Where two or more workers required for a job, and each must perform specific tasks simultaneously; and Specific tasks are done infrequently; Safe Work Procedures must include: Regulatory requirements; Necessary personal protective equipment; Required training; Worker responsibilities; Specific sequence of steps to follow to complete the work safely; Required permits; and Emergency procedures.

An example of a task that requires the development of a safe work procedure is confined space entry. Individuals who must work within confined spaces must ensure that safe work procedures are developed and followed to maximize life safety.

### **DOCUMENTING HIRA:**

Responsibility and accountability

Proper management of hazards sporadically identified in the workplace can be done through effective process. Ultimately, the individual or team who identified the hazard must ensure proper communication of the hazard to the appropriate workplace authority (manager, department head, or designated person). Each HIRA must be fully documented. The HIRA form must be completed by the HIRA team and signed by the in charge personnel of the area. Departments responsible for the hazards and their control are required to maintain all records of assessments for at least 3 years. (In some cases, legislative requirements will determine the minimum time to retain records).

The appropriate authority is responsible for ensuring that effective and timely controls are applied to the hazard and communicating the results back to the originator. Management or employer must endorse and approve the HIRA results. Employer must communicate all HIRA to employees, monitor the follow up action and keep the records. The HIRA Form (Link below the page) is an example to document the HIRA process.

Documenting process:

Instructions to team leader and persons conducting HIRA:

Complete HIRA Form. It is recommended to use a single form for each work process;

Record the names and designation of HIRAC team members;

Outline the process workflow and indicate in the form under 'process/ location column;

List all activities (routine and non-routine) for each work process under the "Work Activity" column;

Identify the hazards associated with each activity and record in "Hazard" column;

Determine the effect of each hazard identified and record in "Effect" column;

Record any existing hazard control measures;

Determine likelihood (L) from Table A and severity (S) from Table B for each hazard. Assign P and C rating in respectively column. The existing control measures should be take into consideration while determine (L) and (S);

By using Risk Matrix (Table C and D) assign one risk and record in "Risk" column;

Based on the risk assigned, recommend appropriate risk control measures (see Table D);

Assign a suitable person to implement the recommended risk control and indicate the follow up action date and status;

Repeat the HIRA for other activities and process;

Conduct another round of HIRA after control measures have been implemented; and

Review HIRA for every three years or whenever there are changes in process or

Examples of Workplace Hazards:

The Hazard Identification listed is to assist in the identification of hazards in the work place. This table provides some additional explanation of the meaning of the hazard classifications.

<b>WORK ENVIRONMENT</b>	
Adequate Access	Refers to adequate access to, from and within the workplace
Air Conditioning	Refers to uncontaminated air in the work space
Confined Spaces	Means enclosed work space where people do not normally work (defined in standards)
Temperature Extremes:	
a) Heat	This includes contact with hot objects, hyperthermia, fire (Not explosions)
b) Cold	This includes contact with cold objects and hypothermia
Lighting	Refers to adequate illumination for the particular work being done
Mental Stress	Includes bullying, workplace violence, shift work, excessive work loads
Dehydration	Adequate water supply for the individuals while working
<b>ENERGY</b>	
Electrical	Includes contact with exposed wires and contact with high voltage
Gravity	Includes falls, trips and slips of persons as well as objects falling, working at heights
Kinetic Energy:	
a) The body hitting objects	Hitting objects with part of the body
b) Hit by moving objects	Being hit by moving objects but excluding falling objects
c) Explosion	An explosion may also include heat as a hazard
d) Penetrating objects	This includes all objects that can penetrate including needles
Vibration	Includes vibration to parts or to the whole body
Acoustic/Noise	Includes exposure to single, sudden sound or long term exposure
Pressure	Pressure in hydraulic and pneumatic systems
<b>MECHANICAL</b>	
Vehicles	Being caught between, struck by or against vehicles (includes fork lifts)
Mobile and Fixed Plant	Being caught between, struck by or against plant (defined in legislation)

Powered Equipment	Includes electrical or fuel powered equipment, tools and appliances
Non-Powered Equipment	Includes non-powered hand tools, appliances and equipment
<b>MANUAL HANDLING</b>	
Muscular Stress	
a) Lifting, carrying	Refers to muscular stress while lifting, carrying, or putting down objects
b) Other handling	Refers to muscular stress while handling objects other than above
c) Without handling	Refers to muscular stress with no objects being handled
d) Repetitive movement	Refers to repetitive movement and low muscular loading
Ergonomics	Includes fatigue, stress or errors due to workplace design
<b>ANIMAL / INSECT</b>	
Bites/ Stings	Includes bites and stings from animals and/or insects
<b>BIOLOGICAL</b>	
Biological /Microbiological	Includes bacterial, fungal, viral, parasitic or human/animal tissue/fluids blood products
<b>CHEMICAL</b>	
	Refers to single or long term contact with chemicals
Flammable	Refers to chemicals which burn
Corrosive	Refers to chemicals which will corrode tissue or metals
Toxic	Refers to chemicals which will poison a worker
Oxidizers	Refers to chemicals which will provide oxygen to a fire, or react readily
Compressed Gases	Refers to gases which under high pressure
<b>IONIZING RADIATION</b>	
	Refers to radioactive substances and radiation producing equipment like X-rays
<b>OTHER RADIATION</b>	
Laser	Refers to coherent low divergent electromagnetic radiation. the Helium-Neon lasers used in the undergraduate Physics labs, or the laser pointers
Ultraviolet	Refers to electromagnetic radiation from 180 nm to 400 nm
Infrared	Refers to electromagnetic radiation from 700 nm to 1 mm
Radiofrequency	Refers to electromagnetic radiation from 100 kHz to 300 MHz

Microwave	Refers to electromagnetic radiation from 0.3GHz to 300 GHz
Electromagnetic Field	Includes static magnetic fields and low frequencies from 0 to 100kHz. The NMR magnets used in research laboratories. ELF magnetic fields induce electric fields in the body which result in current flows and heating in biological tissue.
<b>ENVIRONMENTAL</b>	
Release Contamination	Atmosphere, sanitary sewer, storm sewer Ground water, fresh water, soil
<b>MAJOR EVENT/ACTIVITY</b>	
<b>OTHER EVENT/ACTIVITY</b>	
	Includes events such as sporting or public events on or off campus
<b>NATURAL EVENT/ ACTIVITY</b>	
Rain/Storm/Lightning/ Flooding	Preparation is the key to being able to address these issues
<b>OTHER EVENT/ACTIVITY</b>	
Working Alone	Loss of personal security, unable to communicate with emergency services
<b>PROPERTY EVENT/ACTIVITY</b>	
Structure Collapse	Loss of building
Structure Damage	Wall crumbling
System Component	Loss of monitoring system or suppression system
Water Damage	Plumbing leak,
Utility Disruption	Loss of essential services - gas, electricity, water

## RISK ASSESSEMENT PROCEDURES

### Hazard and Operability Analysis (HAZOP)

A HAZOP is an organized examination of all possibilities to identify and processes that can malfunction or be improperly operated.

HAZOP analyses are planned to identify potential process hazards resulting from system interactions or exceptional operating conditions.

Features of HAZOP study are:

- It gives an idea of priorities basis for thorough risk analysis,
- It provides main information on the potential hazards, their causes and consequences,
- It indicates some ways to mitigate the hazards,
- It can be executed at the design stage as well as the

operational stage,

It provides a foundation for subsequent steps in the total risk management program.

#### Advantages:

- Offers a creative approach for identifying hazards, predominantly those involving reactive chemicals.
- Thoroughly evaluates potential consequences of process failure to follow procedures.
- Recognizes engineering and administrative controls, and consequences of their failures.
- Provides a decent understanding of the system to team members.

### **Disadvantages**

Requires a distinct system of engineering documentation and procedures.

HAZOP is time consuming.

Requires trained engineers to conduct the study.

HAZOP emphasizes on one event causes of deviations or failures.

### **List possible causes of deviation**

Select a process or operating step

Repeat for all guide words

Apply guide word to process variable or task to develop meaningful deviation

Repeat for all process variables or tasks

Repeat for all process sections or operating steps

Select a process variable or task

Examine consequences associated with deviation

Explain design intention of the process section or operating step

Develop action items

Identify existing safeguards to prevent deviation

Access acceptability of risk based on consequences, cause and protection

### **Failure Mode and Effect Analysis (FMEA)**

An FMEA is a systematic method for examining the impacts of component failures on system performance. Basically FMEA focuses on failures of systems and individual components and examines how those failures can impact facility and processes. FMEA is most effective when a system is well defined and includes the followings key steps:

#### **Listing of all system components;**

Identification of failure modes (and mechanisms) of these components;

Description of the effects of each component failure mode;

Identification of controls (i.e., safeguards, preventive) to protect against the causes and/or consequence of each component failure mode;

If the risks are high or the single failure criterion is not met.

### **Fault Tree Analysis (FTA)**

A fault tree is a detailed analysis using a deductive logic model in describing the combinations of failures that can produce a specific system failure or an undesirable event. An

FTA can model the failure of a single event or multiple failures that lead to a single system failure.

FTA is often used to generate:

Qualitative description of potential problems

Quantitative estimates of failure frequencies/ likelihoods and relative importance of various failure sequences/contributing events

Suggested actions to reduce risks

Quantitative evaluations of recommendation effectiveness

The FTA is a top-down analysis versus the bottom-up approach for the event tree analysis. The method identifies an undesirable event and the contributing elements (faults/conditions) that would initiate it.

The following basic steps are used to conduct a fault tree analysis:

Define the system of interest.

Define the top event/system failure of interest.

Define the physical and analytical boundaries.

Define the tree-top structure.

Develop the path of failures for every branch to the logical initiating failure.

Perform quantitative analysis.

Use the results in decision making.

Once the fault tree has been developed to the desired degree of detail, the various paths can be evaluated to arrive at a probability of occurrence.

### **Advantages**

It directs the analyst to ferret out failures deductively;

It points out the aspects of the system which is appropriate for an understanding of the mechanism of likely failure; define the system or operation identify the initiating events identify controls and physical phenomena define accident scenarios analyze accident sequence outcome summarize results use result in decision making

It provides a graphical assistance enabling those responsible for system management to visualize the hazard; such persons are otherwise not associated with system design changes;

Providing a line of approach for system reliability analysis (qualitative, quantitative);

Allowing the analyst to give attention to one particular system failure at a time;

Providing the analyst with genuine understandings into system behavior.

### **Disadvantages**

Requires a skilled analyst. It is an art and also a science

Focuses only on one particular type of problem in a system, and multiple fault trees are required to address the multiple modes of failure

Graphical model can get complex in multiple failures

### **Event Tree Analysis (ETA)**

An ETA is an inductive analysis that graphically models, with the help of decision trees, the possible outcomes of an initiating event capable of producing a consequence.

#### **Procedure of Event Tree Analysis**

An analyst can develop the event tree by inductively reasoning chronologically forward from an initiating event through intermediate controls and conditions to the ultimate consequences.

An ETA can identify range of potential outcomes for specific initiating event and allows an analyst to account for timing, dependence, and domino effects that are cumbersome to model in fault trees. 49

An ETA is applicable for almost any type of analysis application but most effectively is used to address possible outcomes of initiating events for which multiple controls are in place as protective features.

### **Advantages**

Accounts for timing of events

Models domino effects that are cumbersome to model in fault trees analysis

Events can be quantified in terms of consequences (success and failure)

Initiating event, line of assurance, branch point, and accident sequence can be graphically traced

### **Disadvantages**

Limited to one initiating event

Requires special treatment to account for system dependencies

Quality of the evaluation depends on good documentations

Requires a skilled and experienced analyst

The above techniques provide appropriate methods for performing analyses of a wide range of hazards during the design phase of the process and during routine operation. A combination of two or three methods is more useful than individual methods as each method has some advantages and disadvantages.

### **Failure Mode Effect and Critical Analysis (FMECA)**

The FMECA is composed of two separate investigations, the FMEA and the Criticality Analysis (CA). The FMEA must be completed prior to performing the CA. It will provide the

added benefit of showing the analysts a quantitative ranking of system and/or subsystem failure modes. The Criticality Analysis allows the analysts to identify reliability and severity related concerns with particular components or systems.

## **DISCUSSION AND CONCLUSION**

### **Discussion**

Construction is a high hazard industry that comprises a wide range of activities involving construction, alteration or repair. Examples include residential construction, bridge erection, excavations, demolitions and large scale painting jobs. Hazard identification and risk analysis is carried for identification of undesirable events that can leads to a hazard. The analysis of hazard mechanism by which this undesirable event could occur and usually the estimation of extent, magnitude and likelihood of harmful effects.

As the part of the work work, hazard identification and risk analysis was carried out for construction and the hazards were identified and risk analysis was carried out. The different activities were divided into high, medium, and low depending upon their likelihood and consequences. These have been presented in chapter 5. The high risk activities have been marked in red color are un-acceptance and must be reduced. The risk which are marked in yellow color are tolerable but efforts must be made to reduce risk without expenditure that is grossly disproportionate to the benefit gained. The risk which are marked in green color have the risk level so low that it is not required for taking actions to reduce its magnitude any further. The risk rating calculations were carried out by a qualitative, semi-qualitative, quantitative method.

In Indian Industry construction industry the high risk activities which were related to falling from rooftops, unguarded machinery, being struck by heavy construction equipment, electrocutions, silica dust, asbestos. Falls from height have been viewed as the one of the most frequent killers of the workers on construction site. Common construction site falls include roof related falls, crane falls, scaffolding falls, elevator shaft falls, falling objects. These may occur as a result of inadequate edge protection. This type of condition turn out because improper use of PPE and improper supervision. In this construction industry it was observed that the use of PPE was proper and proper arrangements were there to check the person is wearing a PPE or not. The PPE includes helmet, non-skid safety boots, safety glasses, ear-muffs etc. The required PPE should be provided and used in a manner that protects the individuals from injury. Few minor injury which can be prevented are slips, trip, collapse of unstable rocks, atmosphere containing toxic or combustible gases, protects from chemical and hazardous material etc.

## **CONCLUSION**

The first step for emergency preparedness and maintaining a safe workplace is defining and analyzing hazards. Although all hazards should be addressed, resource limitations usually do not allow this to happen at one time. Hazard identification

and risk assessment can be used to establish priorities so that the most dangerous situations are addressed first and those least likely to occur and least likely to cause major problems can be considered later.

The study also revealed that systematic methods were used and risk was assessed by brainstorming, checklist and health and safety regulations. Working at height, and manual handling observed to be most critical hazards in Indian Industry construction site.

Based on methods used to communicate risk at construction sites, it was revealed that toolbox meetings, site meetings, posters and informal verbal communication are used to communicate risk. It was also revealed that safety committees and gang supervisors play a major role in communicating health and safety risks. However the issue of power relations and conflicts was observed when there is a clear separation between health and safety communication and quality and productivity. The study also reveals that PPE is the main item used for risk control. However, there was enough PPE on the sites. Based on factors influencing risk management, the study reveals that legal system plays a major role in risk assessment, communication and control. The regulations provide for some hazards such as falling from a height and control mechanisms. They also require that health and safety risk to be communicated to workers and that PPE be provided for worker.

Regular inspections, penalties and compliance certificates issued by regulatory institutions influence risk management more. Furthermore, the organizational culture of safety is another factor influencing risk management. It is observed that construction firms with a safety culture considered health and safety when employing the site manager, the safety coordinator and safety officer. Knowledge of health and safety is a criterion for employment. Meanwhile firms with a safety culture provide resources for site workers, such as PPE and training. Additionally, individual characteristics such as experience of those working on construction sites, their educational background and knowledge of health and safety matters also influence health and safety risk management. It was observed that risks were assessed based on experience and educational background. Furthermore, the study revealed that the work environment such as site layout and location, the nature and the size of the work, working methods and working team influence health and safety risk management.

The study also provides factors hindering health and safety risk management in construction sites. The factors include the low level of public awareness of regulations, lack of resources such as personnel and funds, coverage of the regulations, complexity of design, the procurement system, and the low level of education, site configuration, and location. Thus the main 'mantra' is that every job on the construction site must be carried out with at-most activity.

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