RESEARCH ARTICLE

SAMRIDDHI Volume 16, Issue 2, 2024 Print ISSN: 2229-7111 Online ISSN: 2454-5767

Strategic Perspectives on Holistic Hazard Identification and Risk Assessment in Smart Manufacturing

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Abstract

The primary objective of defining objectives and scope is to establish the purpose and goals of the risk assessment. This involves clearly articulating what the organization hopes to achieve through the assessment, such as identifying potential hazards, evaluating associated risks, and implementing effective risk mitigation measures. By defining clear objectives, the organizations provide direction and focus for the hazard & risk assessment effort, ensuring that it serves a specific purpose and delivers tangible outcomes. In addition to objectives, defining the scope of the hazard &risk assessment is crucial. Scope delineates the boundaries and parameters within which the assessment will be conducted. This includes specifying the geographic location, organizational units, processes, and activities that will be included in the assessment, as well as any exclusions or limitations. Establishing the scope upfront, organizations ensure that the assessment is comprehensive yet manageable, focusing on areas of highest priority and relevance. Furthermore, defining objectives and scope facilitates stakeholder engagement and communication it provides clarity, direction, and focus to the assessment process, ensuring that it delivers meaningful insights and actionable recommendations to enhance safety, minimize risks, and protect organizational assets and personnel.

Keywords: Hazard Identification, Risk Assessment, Workplace Ergonomics, Unsafe condition, Unsafe act Reporting, Site Walkthrough, Electrical safety.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2024); DOI: 10.18090/samriddhi.v16i02.03

Introduction

Proper Safety Measures: For avoiding accidents at the work place there should be proper safety measures. Guidelines are issued by the government from time to time in relation to enacting measures for checking accidents which should be strictly followed. These measures should include that machinery should be properly guarded; danger areas should be fenced etc. Proper Selection. The selection of the employees should be done on the basis of properly devised tests so that the suitability of the job is determined. Because the wrong selection will create problems as some employees are accident prone and not suitable for the job. Incentives: For motivating the workers for adhering safety measures, incentives should be provided to them for maintaining safety. Monetary and non-monetary incentives should be provided to the workers who adhere to the safety measures in too. Safety Training: The training should be provided to the workers for providing them information regarding the safety measures. The workers should be provided with the knowledge regarding the hazards of the machines, areas of accident proneness, and the precautions in case of some accidents.[1] This training should be provided to both workers and supervisors. Proper Maintenance of Machines and Equipment's: One of the main reasons for the accidents is the fault in the machines or equipment's. So, there should be proper maintenance of machines and equipment's and these should be properly greased and should be frequently inspected by the personnel of engineering department. There ought to be a Wellbeing Chief in each modern endeavour to plan and work the security program. The fundamental target of the wellbeing project ought to be 55 wellbeing and security of the lives, wellbeing and government assistance of the specialists utilized in Intern. The accompanying prudent advances might be taken on to forestall mishaps in the ventures. Security board might be comprised in each plant.

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How to cite this article: Masilamani, G., Maharajan, K. (2024). Strategic Perspectives on Holistic Hazard Identification and Risk Assessment in Smart Manufacturing. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 16(2), 63-75.

Source of support: Nil

Conflict of interest: None

It ought to comprise of the agents of both the administration and the laborers. All the security projects ought to be carried out through the wellbeing panel. Security Preparing – The managers ought to prepare the new representatives in wellbeing techniques. The potential reasons for mishaps ought to be cleared up for the new workers and they ought to be shown propensities and movements that will keep them out of risk. Preparing projects ought to likewise be intended for the managers.

Material dealing with hardware ought to be introduced to convey massive materials starting with one spot then onto the next. No specialist might be expected to lift or convey weighty burdens which might cause injury. Watching of Machines - Security gatekeepers ought to be planned, built and used to give positive assurance, forestall admittance to the risk zones during tasks, stay away from bother in activity and give insurance against unanticipated possibilities.[2] These are as hard protected covers gave to the moving or pivoting portions of machines. Support of Plant - The plant ought to be kept up with looking great. All articles liable to deter the sections implied for development by laborers ought to be eliminated. Entries ought not be utilized to store merchandise or materials. Dry, perfect and ventilated store rooms with reasonable racks, racks, and so on ought to be accommodated keeping electrical and other unsafe gear.

Customary Investigation - There ought to be standard examination of machines and hardware and power links to really take a look at any spillage

Materials & Methods

Hazard Identification Process

Hazard identification is a critical process in bearing manufacturing industries to ensure the safety of workers and the prevention of accidents. Below is a step-by-step guide for hazard identification in the context of bearing manufacturing.

- Conduct a Site Walkthrough: Begin by conducting a comprehensive walkthrough of the entire manufacturing facility, including production areas, storage spaces, and maintenance areas. Observe work processes, equipment, machinery, and workstations.[3]
- Review Work Processes and Procedures: Examine the step-by-step processes involved in bearing manufacturing. Identify tasks that may involve manual handling, machinery operation, or exposure to hazardous substances.
- Consult Workers and Supervisors: Engage with workers and supervisors to gather insights into their daily tasks and any concerns they may have about safety. Use their experience and knowledge to identify potential hazards that might not be immediately apparent.
- Examine Machinery and Equipment: Inspect all machinery and equipment used in bearing manufacturing for safety features and potential hazards. Check for proper machine guarding, emergency stop mechanisms, and any signs of wear or malfunction.[4]
- Assess Chemical and Material Hazards: Identify any hazardous substances used in the manufacturing process, such as lubricants, cleaning agents, or materials used in bearing production. Ensure proper labelling, storage, and handling procedures are in place.
- Evaluate Ergonomic Factors: Assess workstations and tasks for ergonomic factors that may contribute to musculoskeletal disorders or repetitive strain injuries. Look for opportunities to improve workstation design and reduce physical stress on workers.
- Consider Environmental Factors: Evaluate environmental factors such as noise levels, ventilation, and temperature in different areas of the facility. Identify potential sources of environmental hazards and assess their impact on worker health shown in the figure 1.
- Review Electrical Safety: Inspect electrical systems, wiring, and equipment for compliance with safety standards. Identify any exposed wires, potential electrical faults, or areas where electrical shocks could occur.
- Examine Fire and Emergency Preparedness: Ensure that fire safety measures, including fire exits, extinguishers, and alarms, are in place and regularly maintained. Review emergency response procedures and assess the readiness of workers to respond to different types of emergencies.
- Document and Prioritize Hazards: Document all identified hazards, including their location and potential consequences. Prioritize hazards based on the level of risk they pose, considering the likelihood and severity of potential incidents.
- Implement Control Measures: Develop and implement control measures to mitigate or eliminate identified hazards. This may include engineering controls, administrative controls, and the use of personal protective equipment.
- Regularly Review and Update: Conduct regular reviews of hazard identification processes to account for changes in equipment, processes, or personnel. Update safety procedures and training programs accordingly.

Experimental Methodology

Integrating hazard identification and risk management processes is crucial for maintaining a safe and productive environment in bearing manufacturing industries.[5,6]

The following is a step-by-step guide that combines both processes:

- Form a Cross-Functional Team.
- Define Objectives and Scope.
- Conduct a Site Walkthrough.
- Review Work Processes and Procedures.
- Consult Workers and Supervisors.
- Examine Machinery and Equipment.
- Assess Chemical and Material Hazards.
- Evaluate Ergonomic Factors.

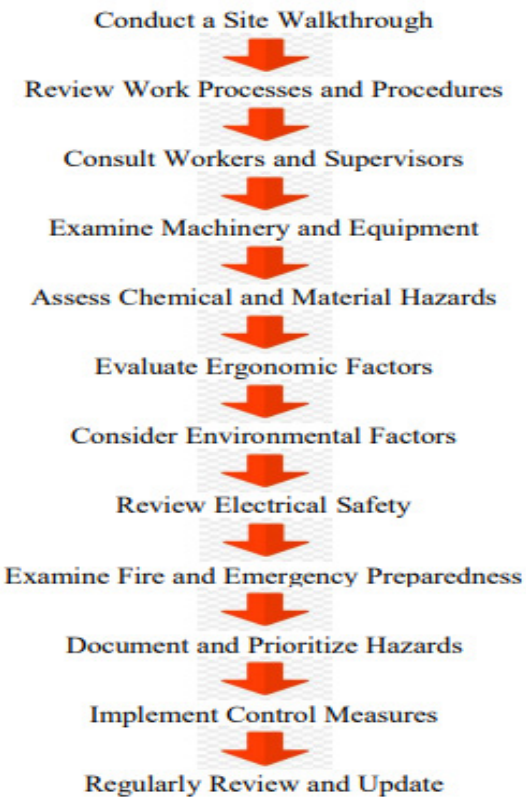

Figure 1: Hazard identification process

- Consider Environmental Factors.
- Review Electrical Safety.
- Categorize and Prioritize Risks.
- Quantitative Risk Assessment
- Develop Mitigation Strategies.
- Implement Control Measures.
- Monitor and Review.
- Communication and Training.
- Incident Reporting and Analysis.
- Continuous Improvement.
- Document and Record.

Results & Discussion

Form a Cross-Functional Team

Forming a cross-functional team is a pivotal step in hazard identification and risk assessment (HIRA) within the manufacturing sector. This collaborative approach brings together individuals with diverse backgrounds, expertise, and perspectives from various departments or disciplines within the organization. The purpose is to conduct a comprehensive evaluation of potential hazards and associated risks inherent in the manufacturing processes. The formation of a cross functional team ensures representation from key stakeholders across different functional areas such as engineering, operations, maintenance, safety, environmental health, quality assurance, and management. Each team member contributes unique insights and knowledge relevant to their respective domains, enabling a thorough examination of hazards and risks from multiple angles. Collaboration within a cross-functional team facilitates the sharing of information, experiences, and best practices across departments.[7] It fosters open communication channels and breaks down organizational silos, leading to a more holistic understanding of risks and their implications.

Through dialogue and exchange, team members can identify and prioritize risks based on their severity, likelihood of occurrence, and potential impact on the organization's objectives. Moreover, involving employees from different departments in the HIRA process promotes a sense of ownership and accountability for risk management outcomes. By actively engaging frontline workers, supervisors, and managers in hazard identification and risk assessment activities, organizations empower their workforce to contribute to safety initiatives and take proactive measures to mitigate risks.

A cross-functional team also ensures that diverse perspectives are considered when developing risk mitigation strategies. By bringing together individuals with varying backgrounds and areas of expertise, the team can identify creative solutions and innovative approaches to address complex risks effectively. Overall, forming a cross-functional team is essential for conducting a robust hazard identification and risk assessment process in the manufacturing industry.[8] By leveraging the collective knowledge, skills, and experiences of team members, organizations can proactively identify, assess, and mitigate risks to create safer work environments, protect assets, and enhance operational resilience shown Table 1.

Forming a cross-functional team is an essential step in various processes, including hazard identification and risk management. A cross-functional team typically consists of individuals from different functional areas or departments within an organization, each bringing their unique expertise and perspectives.

Here's a guide on how to form a cross-functional team:

- Identify Team Objectives: Clearly define the objectives and goals of the cross-functional team. This could include hazard identification, risk management, process improvement, or any specific project.
- Determine Team Size: Assess the complexity and scope of the task to determine the appropriate size of the team. Aim for a balance that ensures representation from key functional areas without becoming too large.
- Select Team Members: Identify individuals from different departments or functional areas who possess the necessary skills, knowledge, and experience related to the team's objectives. Consider including representatives from production, safety, maintenance, quality control, and management.
- Ensure Diversity of Skills and Perspectives: Strive for diversity in skills, expertise, and perspectives within

Table 1: Cross functional team

CROSS-FUNCTIONAL TEAM			
1	Identify Team Objectives	1. …… 2……..	Date:
2	Team Size	No of Persons :	Department:
3	Select Team Member	1. Mr…… 2. Mr…… 3. Mrs……..	
4	Ensure Diversity of Skills and Perspectives		
5	Secure Leadership Support		Any External Support required:
6	Roles and Responsibilities		
7	Establish Communication Channels		
8	Promote Team Building		
9	Provide Training if Necessary		For all the workers
10	Create a Project Plan		Modern Thinking
11	Encourage Open Communication		Knowledge shearing
12	Monitor Progress		
13	Celebrate Achievements		Zero Hazards, Awards and Recognition
14	Evaluate and Iterate		

the team. Include members with technical expertise, operational knowledge, and those familiar with safety regulations and procedures.

- Secure Leadership Support: Obtain support and endorsement from organizational leadership to ensure the team's authority and access to necessary resources. Leadership support is crucial for overcoming obstacles and implementing recommendations.
- Define Roles and Responsibilities: Clearly define the roles and responsibilities of each team member. Ensure that each member understands their contribution to the team's objectives.
- Establish Communication Channels: Set up effective communication channels to facilitate collaboration among team members. Regular team meetings, updates, and open communication contribute to the success of the team.
- Promote Team Building: Conduct team-building activities to foster a positive working environment. Building strong interpersonal relationships contributes to effective collaboration and problem-solving.
- Provide Training if Necessary: If team members lack specific skills or knowledge needed for the task, provide training or resources to bridge the gap. Training ensures that all team members are equipped to contribute effectively.
- Create a Project Plan: Develop a project plan outlining the team's objectives, milestones, timelines, and deliverables. Having a clear plan helps the team stay focused and organized.
- Encourage Open Communication: Foster an environment where team members feel comfortable expressing their opinions, concerns, and ideas. Open communication is crucial for identifying and addressing challenges effectively.
- Monitor Progress: Implement a system for monitoring the team's progress against established milestones. Regularly review achievements, address challenges, and adjust the plan as necessary.
- Celebrate Achievements: Acknowledge and celebrate the team's achievements and milestones. Recognition boosts morale and encourages continued dedication to the team's objectives.
- Evaluate and Iterate: After completing the assigned task or project, conduct a thorough evaluation. Identify lessons learned, areas for improvement, and opportunities for future collaboration.

Conduct a Site Walkthrough

Conducting a site walkthrough is a pivotal step in hazard identification and risk assessment (HIRA) within the manufacturing industry. This hands-on approach involves physically inspecting the workplace environment to identify potential hazards, assess existing controls, and gather relevant information for risk assessment. A site walkthrough provides valuable insights into the actual working conditions, operational practices, and potential sources of risk within the facility. During a site walkthrough, trained personnel, including safety professionals, supervisors, and employees familiar with the work processes. Systematically inspect various areas of the facility, including production floors, storage areas, equipment rooms, maintenance areas, and common spaces.[9,10]

They observe work practices, equipment operations, storage arrangements, and environmental conditions to identify any hazards that may pose risks to workers, property, or the environment.

The site walkthrough involves a comprehensive examination of physical hazards such as trip hazards, slip hazards, machinery hazards, electrical hazards, chemical hazards, ergonomic hazards, and fire hazards. Furthermore, the site walkthrough serves as an opportunity to verify the effectiveness of existing control measures and safety protocols. By inspecting safety signage, emergency response equipment, personal protective equipment (PPE) usage, and adherence to safety procedures, personnel can assess whether controls are adequate or require enhancement to mitigate identified risks. Overall, conducting a site walkthrough is essential for identifying hazards, assessing risks, and prioritizing control measures to enhance workplace safety.[11] It provides a first-hand understanding of the working environment, fosters collaboration among stakeholders, and enables proactive risk management strategies to protect employees, assets, and the organization's reputation shown Table 2.

Preparatory Steps

- Review Existing Documentation: Familiarize yourself with any existing safety manuals, procedures, and relevant documentation related to the site. Understand the layout, key processes, and potential hazards mentioned in existing records.
- Identify Key Personnel: Determine key personnel who can provide insights during the walkthrough, such as

Table 2: Site walk through

Preparatory Steps	Conducting the Site Walkthrough	Post-Walkthrough Actions
1. Review Existing Documentation 2. Identify Key Personnel	1. Wear Personal Protective Equipment (PPE) 2. Follow Safety Procedures 3. Start with the Perimeter 4. Observe Work Areas 5. Check for Housekeeping 6. Inspect Equipment and Machinery 7. Evaluate Material Handling 8. Examine Emergency Exits and Evacuation Routes 9. Check for Environmental Factors 10. Assess Chemical Storage and Handling 11. Engage with Workers 12. Document Findings 13. Review Emergency Response Equipment 14. Conduct a Closing Meeting	1. Compile and Analyze Data 2. Generate a Hazard Report 3. Prioritize Hazards 4. Develop Corrective Action Plans 5. Implement Corrective Actions 6. Monitor and Review

supervisors, safety officers, or experienced workers. Conducting the Site Walkthrough

- Wear Personal Protective Equipment (PPE): Ensure you are wearing appropriate PPE based on the nature of the site. This may include safety glasses, hard hat, gloves, and steel-toed boots.
- Follow Safety Procedures: Adhere to site-specific safety procedures and guidelines. Observe all posted safety signs and follow designated walking paths.
- Start with the Perimeter: Begin the walkthrough by inspecting the perimeter of the site. Note any potential external hazards, such as nearby roads, bodies of water, or other structures.
- Observe Work Areas: Enter work areas systematically, observing ongoing activities, equipment, and work processes. Take note of machinery in operation, material storage, and the layout of workstations.
- Check for Housekeeping: Assess the general housekeeping and cleanliness of the site. Identify any clutter, debris, or spills that may pose a hazard.
- Inspect Equipment and Machinery: Inspect machinery and equipment for proper operation and maintenance. Look for signs of wear, damage, or inadequate guarding.
- Evaluate Material Handling: Assess how materials are handled, stored, and transported. Identify any manual handling tasks and evaluate ergonomic considerations.
- Examine Emergency Exits and Evacuation Routes: Verify the locations of emergency exits, fire extinguishers, and first aid stations. Ensure evacuation routes are clear and well-marked.
- Check for Environmental Factors: Evaluate environmental conditions, such as temperature, lighting, and ventilation. Identify any factors that may impact worker comfort and safety.
- Assess Chemical Storage and Handling: If applicable, inspect areas where chemicals are stored and handled. Ensure proper labelling, storage practices, and availability of safety data sheets (SDS).
- Engage with Workers: Talk to workers on-site to gather insights into their tasks and any safety concerns they may have. Encourage open communication and observations from those directly involved in the work.
- Document Findings: Take photographs and detailed notes of any observed hazards or potential risks. Document the location, nature, and severity of each identified concern.
- Review Emergency Response Equipment: Verify the condition and accessibility of emergency response equipment, such as eye wash stations, showers, and spill kits.
- Conduct a Closing Meeting: If appropriate, hold a closing meeting with key personnel to discuss preliminary findings. Provide an opportunity for additional input or clarification. Post-Walkthrough Actions:
- Compile and Analyze Data: Organize the collected information, photographs, and notes. Analyze the data to identify trends, patterns, and common hazards.
- Generate a Hazard Report: Prepare a comprehensive hazard report that includes a list of identified hazards, their locations, and suggested corrective actions.
- Prioritize Hazards: Prioritize hazards based on their severity, likelihood, and potential impact. Focus on addressing high-priority hazards promptly.
- Develop Corrective Action Plans: Collaborate with relevant stakeholders to develop corrective action plans for each identified hazard. Ensure the plans are feasible, actionable, and aligned with safety regulations.

Consult Workers and Supervisors

The worker-supervisor relationship is a critical component of effective operations in the manufacturing industry. In this setting, the dynamics between workers and their immediate supervisors can have a significant impact on productivity, morale, and overall business performance.[12]

Traditionally, the manufacturing industry has followed a hierarchical structure, with a clear delineation of authority and responsibility. Supervisors are tasked with overseeing the work of their team members, ensuring that production goals are met, quality standards are maintained, and safety protocols are followed. This top-down approach emphasizes the need for clear communication, well-defined procedures, and a strong sense of accountability. However, in recent years, there has been a shift towards more collaborative and participative management styles in manufacturing.[13] Supervisors are increasingly expected to serve as mentors, coaches, and facilitators, rather than just issuing directives. They must be able to foster a culture of trust, open communication, and continuous improvement, where workers feel empowered to share their ideas and contribute to the decision-making process.[14]

Effective worker-supervisor relationships in manufacturing are built on mutual respect, clear expectations, and a shared understanding of the organization's goals. Supervisors need to provide regular feedback, both positive and constructive, to help workers understand their strengths, identify areas for improvement, and feel valued for their contributions.[15,16] They should also be responsive to workers' concerns, whether related to safety, training, or work-life balance. At the same

time, workers are expected to take ownership of their tasks, follow instructions, and actively participate in continuous improvement initiatives. They should feel comfortable raising issues or concerns with their supervisors, and be willing to collaborate on solutions that benefit the entire team., and sustained business success in an increasingly dynamic and challenging industry landscape

Consulting workers and supervisors is a crucial step in the review and improvement of work processes and procedures.[17] Involving those directly engaged in the day-to-day activities provides valuable insights, enhances buy-in, and contributes to the success of process enhancements. Here's a guide on how to effectively consult workers and supervisors during this process:

- Establish a Communication Plan: Clearly define how communication will be conducted. Consider using a combination of group meetings, one-on-one discussions, surveys, and written communication to ensure information reaches all relevant parties shown in the Figure 2.
- Schedule Meetings: Arrange meetings with workers and supervisors to discuss the purpose of the process review, the importance of their input, and the overall goals of the improvement initiative.
- Explain the Objectives: Clearly communicate the objectives of the process review. Explain why it's necessary, what the organization aims to achieve, and how their input is vital to the success of the initiative.
- Encourage Open Communication: Create an environment that encourages open communication. Stress the importance of honest feedback and assure workers and supervisors that their opinions are valued.
- Ask for Input on Current Processes: Gather insights on the strengths and weaknesses of the current processes. Ask workers and supervisors about pain points, bottlenecks, and areas where improvements can be made.[18]
- Discuss Resource Allocation: Inquire about resource allocation and workload. Understand if there are any resource constraints, and whether additional support or adjustments are needed to enhance efficiency.
- Seek Suggestions for Improvement: Encourage workers and supervisors to provide suggestions for improvement. They often have valuable practical knowledge and can propose realistic solutions to enhance processes.
- Discuss Training Needs: Assess training needs by discussing whether additional training or skill development is required to execute processes effectively. Identify gaps in knowledge and skills.
- Clarify Roles and Responsibilities
- Address Safety Concerns
- Provide Feedback on Proposed Changes
- Acknowledge and Appreciate Contribution.
- Ensure Two-Way Communication
- Summarize Findings
- Incorporate Feedback into Plans
- Communicate Changes
- Provide Follow-Up Opportunities
- Celebrate Successes

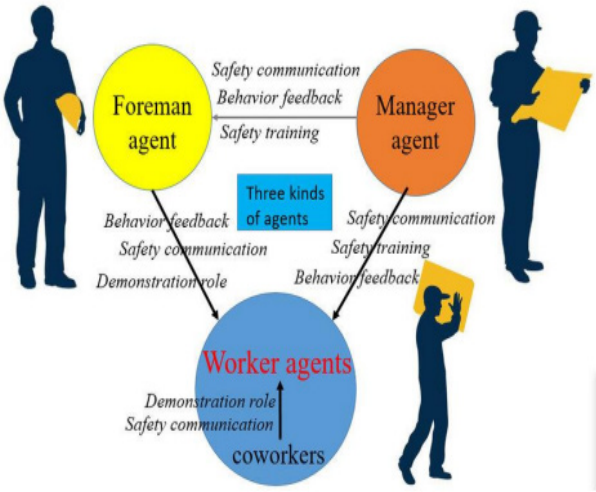

Figure 2: Worker supervisor relationship

Examine Machinery and Equipment

A comprehensive checklist for machinery and equipment is essential in any manufacturing or industrial setting. It helps ensure the safe, reliable, and efficient operation of critical assets.[19] The checklist should cover a range of areas, including general inspection, electrical systems, mechanical systems, safety features, maintenance records, operational procedures, and environmental considerations.[20] By thoroughly inspecting the equipment, verifying safety mechanisms, reviewing maintenance histories, and confirming proper usage, organizations can identify and address potential issues before they lead to downtime, accidents, or compliance violations.[21]

Regularly completing this checklist can help extend the lifespan of equipment, improve productivity, and maintain a safe working environment for all personnel. Examining machinery and equipment is a critical aspect of ensuring workplace safety, operational efficiency, and compliance with regulations. Regular inspections and assessments help identify potential issues, prevent breakdowns, and promote the overall well-being of the workforce.[22]

Here's a guide on how to effectively examine machinery and equipment

Define inspection objectives

Clearly define the objectives of the machinery and equipment examination. Identify specific aspects to be assessed, such as safety, functionality, and compliance with standards.[23]

- Establish a Schedule: Develop a regular inspection schedule based on the type of machinery and equipment, industry standards, and manufacturer recommendations. Consider both routine and more comprehensive inspections.
- Review Documentation: Gather and review documentation related to the machinery and equipment, including

manuals, maintenance records, and any manufacturer specifications. Ensure that all documentation is up-to-date.

- Engage Qualified Inspectors: Assign qualified inspectors to conduct examinations. Inspectors should have the necessary expertise, training, and knowledge to assess the specific machinery and equipment.
- Check for Compliance: Ensure that machinery and equipment comply with relevant safety standards, regulations, and industry best practices. Address any identified non-compliance issues promptly.
- Inspect for Safety: Prioritize safety inspections to identify potential hazards, malfunctions, or wear and tear that could compromise the safety of operators and other personnel Shown in the Table 3.
- Evaluate Functional Performance: Assess the functional performance of machinery and equipment. Verify that they operate as intended and meet performance specifications. Identify any signs of abnormal operation.
- Examine Wear and Tear: Inspect machinery and equipment for signs of wear and tear, corrosion, or degradation. Pay attention to critical components, moving parts, and areas prone to deterioration.
- Check Lubrication and Fluid Levels: Verify that machinery and equipment are properly lubricated, and fluid levels are within the recommended ranges. Inadequate lubrication can lead to increased friction and premature wear.
- Inspect Electrical Systems: If applicable, inspect electrical systems for wear, damage, or potential electrical hazards. Ensure that electrical components are secure and meet safety standards.
- Review Control Systems: Examine control systems to ensure they are functioning correctly. Check for proper calibration, responsiveness, and accuracy in controlling machinery and equipment.
- Assess Environmental Conditions: Consider environmental factors that could impact machinery and equipment, such as temperature, humidity, and exposure to corrosive substances. Implement measures to protect against environmental damage.
- Evaluate Emergency Stop Systems: Verify the functionality of emergency stop systems. Ensure that emergency stop buttons and safety interlocks are operational and easily accessible.
- Inspect Guarding and Safety Features: Check safety features, such as guards, barriers, and warning signs. Confirm that these features are in place and effectively prevent access to hazardous areas.
- Document Findings: Document the findings of the examination, including identified issues, recommended corrective actions, and any necessary repairs or replacements.
- Implement Corrective Actions: Based on the examination findings, implement corrective actions promptly. Prioritize and address critical issues that could impact safety or operational integrity.
- Monitor and Update Records: Establish a system to monitor and update records of machinery and equipment inspections. Keep a comprehensive log of inspection results, maintenance activities, and any modifications made.
- Provide Training and Awareness: Ensure that operators and maintenance personnel are adequately trained on

Table 3: Machinery equipment check sheet.

GENERAL MACHINE SHOP SAFETY CHECKLIST

Room_____ Building_____ Date_____

Supervisor_____ Inspected by_____

EMERGENCY	YES	NO	N/A	COMMENTS
Emergency Phone Numbers posted near a phone				
Exits and exit paths are free of obstruction				
First aid kit(s) available and stocked				
Fire extinguishers accessible and inspected monthly				
GENERAL SAFETY	**YES**	**NO**	**N/A**	**COMMENTS**
Administrative responsibility for shop safety has been clearly defined.				
Machine users have completed "Basic Machine Shop Safety" and specific training on individual tools and training is documented.				
Where necessary, lock-out/tag-out procedures are documented for each piece of equipment, and training has been provided & documented				
Protective (ANSI Z87.1 approved) eyewear worn at all times in areas where equipment is operating				
Safety training documented and posted or maintained in a central location				
Student access limited to regular hours of operation				
After-hours access is prohibited, unless prior, written approval obtained.				
Mandatory student "buddy system" enforced at all times				
Long, loose hair must be contained in a scarf, cap or other appropriate fashion; long facial hair properly restrained				
Loose clothing, loose neck wear and jewelry not being worn while operating, or in proximity to, machinery				
Acceptable shoes are worn by equipment users				
Long shirt sleeves must be rolled up snugly above the elbows				
Compressed air reduced to 30 psi and not used to clean person or clothes				
Personal listening devices are prohibited.				

GENERAL MACHINE SAFETY	YES	NO	NA	COMMENTS
Machinery installed/mounted to prevent unintentional movement or tipping				
A brush is available to remove stock shavings and chips				
Materials, scrap, and debris properly contained				
Machinery located so that operators do not stand in an aisle or interfere with the operation of other equipment				
Powered electrical equipment has an on-off switch				
Actuating controls are guarded or located to prevent accidental actuation, and precautions have been taken to prevent a machine from automatically restarting upon the restoration of power after a power failure				
A red emergency stop device is provided where the machine workstation is remotely located from the machine controls				
GENERAL MACHINE SAFETY	**YES**	**NO**	**NA**	**COMMENTS**
Actuation of the controls requires continuous depressions during the hazardous portion of the machine cycle where the machine workstation is remotely located from the machine controls				
ELECTRICAL SAFETY	**YES**	**NO**	**NA**	**COMMENTS**
All electrical service cords are in good condition				
Electrically powered machines are grounded				
All electrical receptacles within 6-feet of water source have working GFCI protection				
Extension cords are not used as a permanent source of electricity				
HOUSEKEEPING/HAZARD COMMUNICATION	**YES**	**NO**	**NA**	**COMMENTS**
Storage areas are free of accumulations of materials that constitute a hazard from fire, explosion or pest harborage				
Working dust collection system to minimize materials & debris around cutting, drilling & milling equipment				
All safety cans are red in color				
All emergency stop devices on machines (except cables) are red in color				
Physical hazards are marked with yellow or yellow with black stripes				
Unobstructed 3-foot aisle maintained between machines				
Chemicals are properly labeled, and stored in designated area(s)				
Appropriate safety signs, labels, tags & other postings are displayed in applicable areas				

the proper use, care, and maintenance of machinery and equipment. Promote awareness of safety protocols.

- Continuous Improvement: Foster a culture of continuous improvement. Encourage feedback from operators and maintenance personnel, and use insights gained from inspections to enhance preventive maintenance programs.

Evaluate ergonomic factors

Workplace ergonomics is a critical aspect of creating a safe and productive work environment. Ergonomics focuses on designing and arranging workspaces, tools, and equipment to minimize physical stress and strain on workers, ultimately enhancing their comfort, health, and overall performance.

In an industrial or manufacturing setting, ergonomic considerations are particularly important due to the physical nature of many job tasks. Workers may be required to perform repetitive motions, lift heavy objects, or maintain awkward postures for extended periods, all of which can lead to musculoskeletal disorders (MSDs) such as back pain, tendinitis, or carpal tunnel syndrome.

Effective workplace ergonomics aims to address these risks by optimizing the fit between the worker and their work environment. This can involve adjusting the height, angle, or layout of workstations, providing ergonomic seating and tools, and implementing material handling procedures to reduce the physical demands on workers shown in the figure 3.

For example, in an assembly line, workers may need to repeatedly reach for parts or components. By positioning these items within easy reach and at the appropriate height, employers can minimize the strain on the worker's shoulders, neck, and back. Similarly, providing adjustable desks or workbenches allows employees to customize their work surface to their individual needs, promoting better posture and reducing the risk of MSDs.

Assess chemical and material hazards

Here is a list of common chemical hazards that can be found in industrial settings shown Table 4:

Table 4: Chemical and material hazards.

CHEMICAL HAZARDS	MATERIAL HAZARDS
✓ Flammable and Explosive Chemicals	✓ Flammable and Combustible Materials
✓ Corrosive Chemicals	✓ Compressed Gases
✓ Toxic Chemicals	✓ Explosives and Reactive Materials
✓ Reactive Chemicals	✓ Corrosive Materials
✓ Asphyxiants	✓ Toxic and Hazardous Materials
✓ Carcinogenic Chemicals	✓ Radioactive Materials
✓ Sensitizers	✓ Biological Hazards
✓ Particulates	✓ Nano materials
✓ Biological Hazards	

Flammable and explosive chemicals

Gasoline, propane, acetylene, hydrogen, etc.

Corrosive chemicals

Acids (e.g., sulfuric acid, hydrochloric acid, nitric acid) Bases (e.g., sodium hydroxide, ammonia)

Toxic chemicals

- Heavy metals (e.g., lead, mercury, cadmium)
- Solvents (e.g., benzene, toluene, xylene)
- Pesticides and herbicides
- Cyanides

Reactive chemicals

- Oxidizers (e.g., hydrogen peroxide, chlorine)
- Pyrophoric chemicals (e.g., metal hydrides, organolithium compounds)
- Water-reactive chemicals (e.g., sodium, potassium)

Asphyxiants

- Nitrogen, carbon dioxide, methane

Carcinogenic chemicals

Benzene, asbestos, vinyl chloride, formaldehyde

Sensitizers

- Isocyanates, epoxy resins, latex

Particulates

- Silica dust, wood dust, metal fumes

Biological hazards

- Infectious agents (e.g., bacteria, viruses, fungi)

Nano materials

- Carbon nanotubes, nanoparticles, quantum dots

These chemical hazards can pose a wide range of

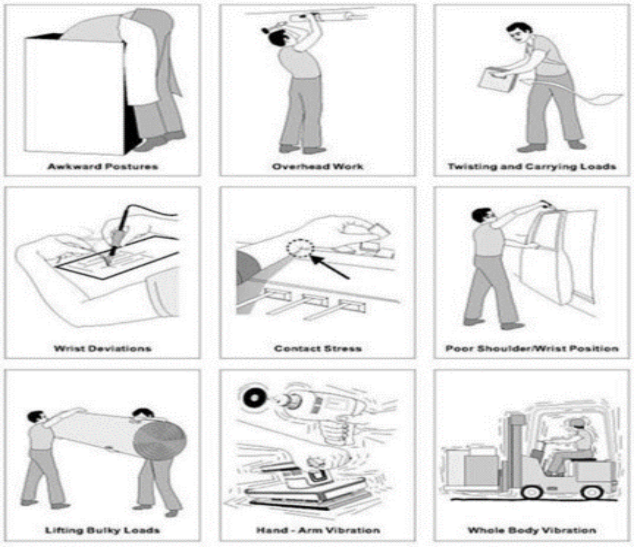

Figure 3: Workplace ergonomics

health and safety risks, including fire, explosion, corrosion, poisoning, and long-term health effects.[24] Proper handling, storage, and disposal of these chemicals, as well as the use of appropriate personal protective equipment, are essential to mitigate these risks in industrial settings.

Here are some common material hazards that can be found in industrial settings

Flammable and Combustible Materials

- Gasoline, diesel fuel, propane, natural gas
- Solvents, paints, varnishes, adhesives
- Wood, paper, plastics, textiles

Compressed gases

- Oxygen, nitrogen, argon, helium
- Acetylene, hydrogen, propane

Explosives and reactive materials

- Gunpowder, dynamite, fireworks
- Peroxides, nitrates, chlorates

Corrosive materials

- Acids (e.g., sulfuric acid, hydrochloric acid)
- Bases (e.g., sodium hydroxide, ammonia)

Toxic and hazardous materials

- Heavy metals (e.g., lead, mercury, cadmium)
- Pesticides, herbicides, and insecticides
- Asbestos, silica dust, wood dust

Radioactive materials

Uranium, radium, thorium

Biological hazards

Infectious agents (e.g., bacteria, viruses, fungi)
Toxins produced by microorganisms

Nanomaterials

- Carbon nanotubes, nanoparticles, quantum dots These material hazards can pose a variety of risks, including fire, explosion, corrosion, poisoning, and exposure to radiation or infectious agents. Proper handling, storage, and disposal of these materials, as well as the use of appropriate personal protective equipment, are essential to mitigate these risks in industrial settings.
- Assessing chemical and material hazards is a critical component of ensuring workplace safety and compliance with health and safety regulations. This assessment helps identify potential risks associated with the use, handling, storage, and disposal of chemicals and materials in a facility[25] Here's a guide on how to effectively assess chemical and material hazards.
- Compile an Inventory: Create a comprehensive inventory of all chemicals and materials used or stored in the workplace. Include information such as names, quantities, locations, and intended uses.
- Review Safety Data Sheets (SDS): Obtain and review Safety Data Sheets for each chemical. SDS provides crucial information about the properties, hazards, safe handling, and emergency procedures for each substance.
- Classify Chemicals: Classify chemicals based on their hazards, such as flammability, toxicity, reactivity, and health effects. Use established classification systems and hazard symbols
- Identify Potential Hazards: Assess potential hazards associated with each chemical and material. Consider factors such as exposure routes (inhalation, ingestion, skin contact), physical hazards, and the compatibility of substances.
- Evaluate Exposure Levels: Evaluate potential exposure levels to chemicals during various activities. Consider factors like duration, frequency, and concentration to determine the risk of exposure.
- Assess Storage and Handling Practices: Review storage and handling practices for chemicals and materials. Ensure that proper storage conditions are maintained to prevent accidents, spills, or reactions.
- Consider Process Changes: Assess the impact of any planned process changes on chemical and material hazards. Evaluate how modifications may affect the overall risk profile and whether additional safety measures are needed.
- Implement Engineering Controls: Implement engineering controls to minimize exposure, such as ventilation systems, fume hoods, or containment systems. Ensure that these controls are properly maintained.
- Personal Protective Equipment (PPE): Identify and recommend appropriate personal protective equipment (PPE) based on the hazards associated with each chemical. Ensure that workers are trained in the correct use and maintenance of PPE.
- Emergency Response Planning: Develop or review emergency response plans for chemical spills, releases, or accidents. Ensure that employees are trained in emergency procedures and evacuation routes.
- Chemical Compatibility evaluate the compatibility of different chemicals stored or used in proximity. Ensure that incompatible substances are properly separated to prevent reactions.
- Waste Disposal Procedures: Assess waste disposal procedures for chemicals and materials. Ensure compliance with regulations and implement proper disposal methods to minimize environmental impact.
- Training and Awareness: Provide comprehensive training for employees on the safe handling, storage, and disposal of chemicals and materials. Foster awareness of potential hazards and the importance of following safety protocols.
- Regular Inspections: Conduct regular inspections of chemical storage areas, laboratories, and other relevant areas. Look for signs of leaks, spills, or improper storage practices.

- Evaluate Chemical Reaction Hazards: Assess potential chemical reaction hazards, especially when multiple chemicals are used or stored in close proximity. Identify any conditions that could lead to reactions or explosions.
- Review Regulatory Compliance: Ensure compliance with relevant regulatory requirements, including OSHA (Occupational Safety and Health Administration) standards, environmental regulations, and any other applicable laws.
- Recordkeeping: Maintain accurate records of chemical inventories, hazard assessments, training sessions, and emergency response drills. These records are essential for audits and regulatory compliance.
- Continuous Monitoring and Improvement: Establish a system for continuous monitoring of chemical and material hazards. Regularly review and update hazard assessments based on changes in processes, chemicals, or regulations. By systematically assessing chemical and material hazards and implementing appropriate control measures, organizations can create a safer work environment, protect the health of employees, and reduce the risk of accidents or incidents related to hazardous substances.

Quantitative risk assessment

Quantitative risk assessment is a crucial process in the manufacturing industry, as it helps organizations identify, analyze, and mitigate various risks that can impact their operations, finances, and overall performance. Hazard Identification and Risk Assessment (HIRA) is a crucial process in various industries to ensure the safety and well-being of employees, assets, and the environment. The primary objective of HIRA is to systematically identify potential hazards, evaluate the associated risks, and implement appropriate control measures to mitigate or eliminate these risks.

The HIRA process typically involves the following steps:

- Hazard Identification: This step involves the thorough examination of the work environment, processes, equipment, and activities to identify potential sources of harm, such as physical, chemical, biological, or ergonomic hazards.
- Risk Assessment: Once the hazards are identified, the next step is to assess the likelihood of the hazard occurring and the potential severity of its consequences. This assessment helps prioritize the risks and determine the appropriate control measures.
- Risk Control: Based on the risk assessment, control measures are implemented to eliminate, reduce, or mitigate the identified risks. These measures may include engineering controls, administrative controls, or the use of personal protective equipment (PPE).
- Monitoring and Review: The HIRA process is an ongoing activity that requires regular monitoring and review to ensure the effectiveness of the implemented control measures and to identify any new or emerging hazards. By conducting a comprehensive HIRA, organizations can proactively address potential safety concerns, minimize the likelihood of accidents or incidents, and ensure a safer work environment for all stakeholders.

Implement control measures

In the manufacturing industry, safety control measures are essential for protecting workers, minimizing operational

Table 5: Hazard Identification and risk assessment

OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM																			Doc Ref:No:01	
Hazard Identification and Risk Assessment																			Rev No:0	
																			Date: 11.03.2024	
Process : Office																				
Area / Location	Activity	R/NR	Sub activity	D / ID	Hazard	Risk	N/A/E	Causes	Existing control (1/2/3/4/5)	Legal ?	IPC	Evaluation of Risk					Risk (UR / AR)	Criteria for unacceptable risk	Required Control Methods (1/2/3/4/5/6/7/8/9 /10)	Reference
												SCL	SEV	POC	PC	RPN				
Admin Office	Document Work & Office work	R	Document Prepared and storage work	D	Continuous Sitting infront of computer and doing work	Body Pain	N	Wrong Body Posture	4	No	No	1	2	3	1	6	AR	_	1,7	
		R		D	Leg hit on cabin furniture while moving the	Leg Injury	A	No focus Safety measure while movement	4,5	No	No	1	1	2	1	2	AR	_	1,7	
		R	Cleaning 5S Activity	D	Cleaning solvent contect with skin	Skin Irritation	A	Instruction and training	4,5	No	No	1	2	2	1		AR	_	1,7	
		R		D	Access of sharp edges in rack , door cleaning time	Small cut in hand	A	Not use in PPE	4,5	No	No	1	2	2	1	4	AR	_	5,6	
						Prepared By				Reviewed By									Approved By	
Signature																				
Name																				
Designation																				
Date																				

Type of Activity : R - Routine and NR - Non Routine, Condition : N - Normal, A - Abnormal and E - Emergency, IPC - Interested Party Concern,O- Operational concern, A - Administractive control, Evaluation of Impacts : SCL - Scale, SEV - Severity, POC - Probability of Occurrence, PC - Present/ Existing Control and RPN - Risk Potential Number, AR - Acceptable risk , UR - Un acceptable risk.
Existing control : 1)Elimination 2)Substitution 3)Engineering control 4)Administrative control 5)PPE-Personal Protective equipment
Required Control Methods: 1 -EHS Management Program / 2-Operational Control* / 3-Emergency Manual /4-Measurement monitoring Program /5-Personnel Protective Equipment / 6-Training Plan/7-Health Plan/8-Legal compliance register /9- MSDS/ 10- Competent Person
Operational control includes *
1.Engineering control

disruptions, and ensuring compliance with regulatory standards. These control measures encompass a range of strategies and practices that work together to create a comprehensive safety management system.[26]

One of the primary safety control measures in manufacturing is the implementation of engineering controls. This includes the design and installation of physical barriers, guarding systems, and automated safety mechanisms that minimize the risk of accidents and injuries. For example, machine guarding can prevent workers from coming into contact with moving parts, while emergency stop systems can quickly shut down equipment in the event of an emergency shown Table 5.

Administrative controls are another important aspect of safety in manufacturing. These refer to the policies, procedures, and training programs that govern safe work practices and ensure workers are prepared to identify and mitigate risks. This may include lockout/tagout protocols for servicing equipment, permit-to- work systems for high-risk tasks, and comprehensive safety training for all personnel. Personal protective equipment (PPE) is also a critical safety control measure in manufacturing environments. Providing workers with appropriate PPE, such as hard hats, safety glasses, gloves, and respirators, can protect them from hazards like falling objects, chemical exposures, and airborne particles.[27]

Effective monitoring and auditing are essential to ensure the continued effectiveness of these safety control measures. Manufacturers should conduct regular inspections, safety audits, and incident investigations to identify and address any gaps or deficiencies in their safety systems. This data-driven approach allows organizations to continuously improve their safety performance and make informed decisions about future investments in safety infrastructure and training.

Furthermore, a strong safety culture, fostered through effective communication, employee engagement, and a commitment to continuous improvement, is a vital control measure in its own right. When workers are empowered to identify and report safety concerns, and management is responsive to their feedback, the entire organization becomes more vigilant and proactive in maintaining a safe work environment. By implementing a comprehensive suite of safety control measures, manufacturers can protect their most valuable asset – their workforce – while also enhancing operational efficiency, reducing liability, and demonstrating their commitment to social responsibility and sustainability.

Incident reporting and analysis

Incident reporting is a critical component of an effective safety management system in the manufacturing industry. Proper incident reporting enables organizations to identify and address safety issues, mitigate risks, and continuously improve their operational practices.

In the manufacturing context, an incident can be defined as any unplanned event that results in, or has the potential to result in, injury, illness, damage to property, or disruption to operations. This can include accidents, near-misses, equipment failures, spills, or any other occurrence that

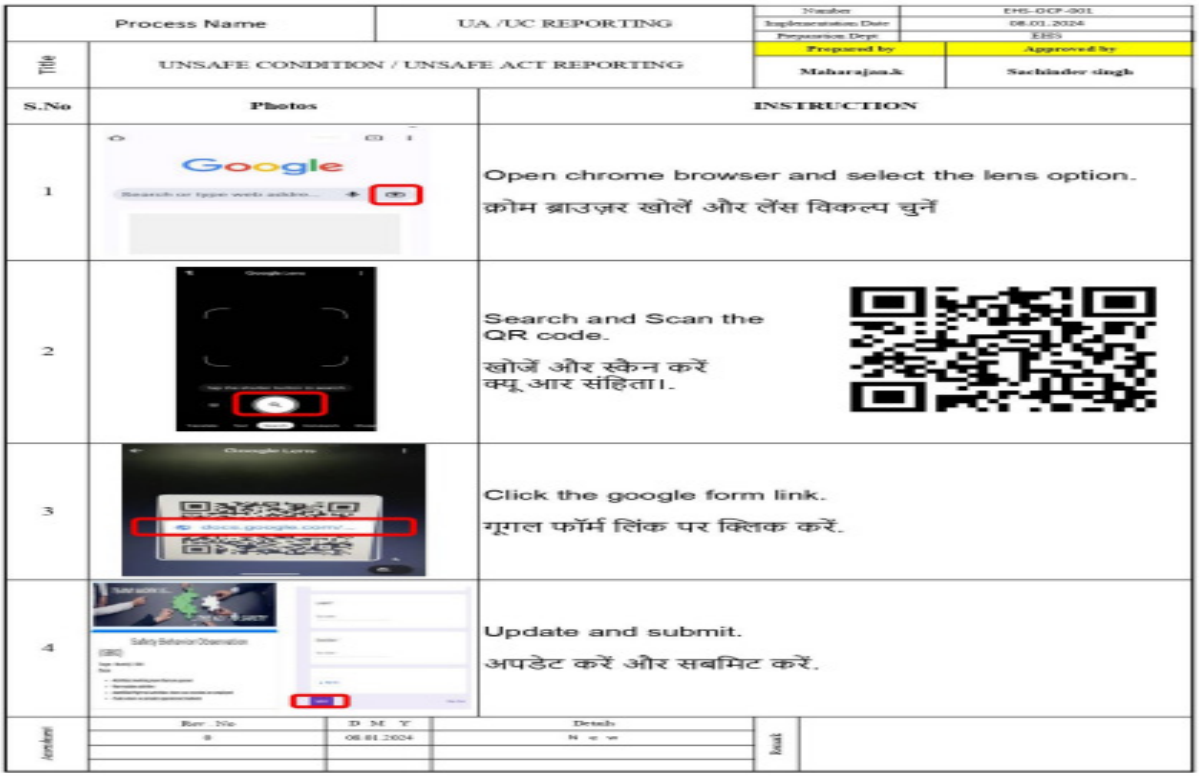

Figure 4: Unsafe act/ unsafe condition reporting procedure

deviates from standard, safe operating procedures. Effective incident reporting in manufacturing requires a well-defined and consistently applied process. This typically begins with the immediate reporting of any incident by the worker or supervisor who witnessed or was involved in the event. This initial report should capture key details, such as the time and location of the incident, a description of what occurred, the individuals or equipment affected, and any immediate actions taken.

The incident investigation process typically begins with the initial incident report, which provides the basic details of the event. The investigation team, which may include safety managers, subject matter experts, and relevant personnel, then conducts a thorough analysis to determine the underlying factors that led to the incident.

This analysis may involve reviewing relevant procedures, inspecting equipment and work areas, interviewing witnesses, and analysing any available data or records. The investigation team may also use various investigation techniques, such as root cause analysis, fault tree analysis, or the "5 Whys" method, to systematically uncover the contributing factors.

Once the root causes have been identified, the investigation team develops and implements appropriate corrective actions. These actions may include modifying procedures, upgrading equipment, providing additional training, or enhancing safety controls. The team also identifies preventive measures to address any systemic issues and reduce the likelihood of similar incidents occurring in the future.

Effective incident investigation not only helps to prevent recurrence but also provides valuable insights that can be used to improve overall safety and operational performance within the manufacturing organization shown figure 4.

- Establish Incident Reporting Policy
- Educate Employees
- Implement Reporting System
- Define Incident Categories
- Complete Incident Report Forms
- Report Incidents Promptly
- Investigate Incidents
- Document Investigation Findings
- Implement Corrective Actions
- Communicate Findings and Actions
- Monitor and Review

Conclusion

Hazard Identification and Risk Assessment (HIRA) is a critical process in the manufacturing industry, as it helps organizations systematically identify, evaluate, and control potential hazards that could harm workers, assets, or the environment. By conducting a thorough HIRA, manufacturing companies can significantly improve their overall safety performance and reduce the likelihood of accidents, injuries, and property damage.

The HIRA process allows manufacturers to take a proactive approach to safety by first identifying all possible hazards, and then assessing the associated risks based on the likelihood of occurrence and the potential severity of consequences. This information can then be used to implement appropriate control measures, such as engineering controls, administrative controls, or the use of personal protective equipment (PPE), to mitigate or eliminate the identified risks.

Continuous monitoring and review of the HIRA process is essential to ensure the effectiveness of the implemented control measures and to identify any new or emerging hazards that may arise due to changes in the manufacturing process, equipment, or work environment. By maintaining a robust HIRA program, manufacturers can foster a strong safety culture, protect their workforce, safeguard their assets, and ensure compliance with relevant safety regulations and industry standards. Overall, the successful implementation of a comprehensive HIRA program in the manufacturing sector can lead to significant improvements in workplace safety, increased productivity, and a positive impact on the bottom line through the prevention of costly accidents and incidents.

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