PLANT SAFETY INSPECTION STUDIES IN AUTOMOBILE INDUSTRIES

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ABSTRACT

A plant safety inspection is a kind of self-checking system. Its aims are to identify potential hazards, look for facility failure, confirm the existing safety measures are effective, ensure safety tools availability and conformity, check safety protection devices functionally, seek unsatisfactory safety programs, check documents and check current safety conditions of the workplaces. Workplace inspections help prevent injuries and illness. Through critical examination of the workplace, inspections identify and record hazards for corrective action. Joint occupational health and safety committees can help plan, conduct, report, and monitor inspections. Regular workplace inspections are an important part of the overall occupational health and safety program.

Keyword: - *Hazards in automobile industries, safety training, HIRA, RFMEA, FMEA, Safety equipment, Findings & recommendations*

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1. INTRODUCTION

The strong link between OSH and public health was recognized with the recommendation to strengthen and promote ILO and World Health Organization (WHO) programs aimed at reducing occupational deaths, injuries, and illnesses, and enhancing the integration of occupational health and public health to increase synergies and improve overall health levels. The Labor Inspection Convention, 1947 (No.81) – a priority convention- has attracted significant ratification. The Protection of Workers Health Recommendation, 1953 (No.97), the Welfare Facilities recommendations, 1956 (No. 102), the working environment (Air pollution, Noise, and Vibration) Recommendation, 1977 (No. 156), the Occupational Safety and Health recommendation, 1981 (No. 164).

1.1 Purpose and need of inspection

Identify conditions and unsafe acts with the potential to cause injury or disease. Determine necessary corrective measures. Prevent unsafe work conditions from developing. To establish uniform procedures to coordinate management involvement at every location in the event of plant inspection. Maintain a safe work environment, Control unsafe acts and conditions and ensure operational efficiency. Workplace inspections help to identify existing hazards so that appropriate corrective action can be taken. Monitor hazard controls (Personal protection equipment, engineering control policies, and procedures)

1.2 Objective

To establish a system to verify compliance with the relevant regulatory requirements, in-house safety rules, regulations, and safe work practices. To find out hazards, accident causes (unsafe conditions and actions) losses, and appropriate remedial measures for their prevention control.

To maintain a safe work environment, operational profitability, and control unsafe actions of people. To check statutory provisions of the factories, act, and similar other safety statutes

To check the effectiveness of the existing systems and to find improvement if required for total loss control. To gain workers organized human activity and factory life. The objective of this inspection is to demonstrate the need for the process of plant in our workplaces.

2. CONCEPTUAL FRAMEWORK

2.1 Plant safety inspection

A plant safety inspection is a kind of self-checking system. It aims to identify potential hazards, look for facility failure, confirm the existing safety measures are effective, ensure safety tools availability and conformity, check safety-protection devices functionally, seek unsatisfactory safety programs, check documents, and check current safety conditions of the workplaces. The organization and administration of every safety program require that management makes a complete and competent effort to provide a safe workplace. Physical concepts to be considered include the topics described in the following section.

- Assignment of Responsibility
- Emergency Preparedness
- Employee Awareness, Acceptance of Responsibility, and Participation
- Identification, Control, and Monitoring of Potential Hazards
- Management Leadership
- Maintenance of Safe working conditions
- Medical and First Aid Systems
- Safety, Health, and Environmental Record Keeping and Statistics
- Safety Organization and Administration
- Safety Policy, Program, and Activities
- Safety Rules, Regulations, and Procedures
- Safety Training and Education
- Compliance
- Identification of Exposures
- Safeguarding Exposures
- Protection and guarding, Safety Organization, Environmental controls

2.2 Inspection procedures

Inspection procedures vary considerably. The group that makes inspections should give equal consideration to accident, fire, and environmental health exposures; storage of incompatibles; explosives; and other hazardous situations. Cut paperwork for the inspection team to a minimum. Checklists are useful for helping the inspection team cover details. Because checklists have limited scope, do not solely rely on them in general inspections. Refer to section 3, Safety inspection checklist, for a detailed discussion on areas to include.

2.3 Safety inspection

A safety inspection is defined as a monitoring function conducted in an organization to locate and report existing and potential hazards which can cause accidents in the workplace. Safety and health inspection ensures that working conditions/environment) conform to legal or safety requirements and combine efforts of employers, employees, safety experts, and inspectors to create a safe working environment.

Inspection - An organized method of identifying hazards and eliminating or controlling them.

Hazard - A condition that has the potential to injure you

Physical hazard - Physical hazards are often thought to be less important than chemicals but this is not so. They can and do cause severe problems, injuries, or, even death. The nature of physical agents is wide and should not be underrated as the main ones capable of causing occupational disorders.

Unsafe Act – Unsafe acts are specific actions or lack of actions by an individual that is under the individual’s control, such as knowingly not following established rules and safe work procedures, disregarding hazards, choosing not to wear PPE, ignoring safety rules, or abusing equipment.

Unsafe condition – Unsafe conditions include poor housekeeping, congested areas, deficient equipment, equipment lacking safeguarding, poor visibility and weather conditions, and lack of PPE. Inadequate training and inadequate supervision should also be considered unsafe conditions, whereas deficiency in skill or ability is a “personal factor”.

2.4 Worker’s safety inspection

A person who provides physical and/ or mental Labour and/ or expertise to an employer or other person. This includes the concept of an employee, which implies a formal employment contract, and also informal workers who provide Labour and/or expertise outside of a form of contractual act relationship. In a larger enterprise or organization, it includes managers and supervisors who may be considered part of management but are also workers. It also includes those who perform unpaid work, either in terms of forced Labour or domestic work and those who are self-employed.

Workplace – Any place where physical and/or mental Labour occurs, whether paid or unpaid. This includes formal work sites, private homes, vehicles, or outdoor locations on public or private property.

Risk – A combination of the probability of exposure to a hazard, plus the severity of the impact from exposure to that hazard.

Safety – The state of being protected against physical, social, spiritual, financial, psychological, or other types or consequences of failure, error, accidents, or harm. This can take the form of being protected from the event or from exposure to something that causes health or economic losses. It can include the protection of people or possessions.

2.5 Walk-around inspection

The main purpose of the walk-around inspection is to identify potential safety and/or health hazards in the workplace. The CSHO shall inspect in such a manner as to eliminate unnecessary personal exposure to hazards and minimize unavoidable personal exposure to the extent possible.

Incident – An undesired event that results in injury to people, damage to the environment, or loss of assets and/or production. An incident leading to a loss is most often the result of contact with a substance or source of energy (mechanical, electrical, thermal, etc.) above the threshold limit of the body or structure involved or the environment.

Accident – An undesired event that results in harm to people, damage to property or loss to process, or a combination of these.

2.6 Hazard identification

Recognizing that a hazard exists and defining its characteristics. An incident that could have resulted in a loss, but did not. Absence from work for more than one work day.

Medical Aid Injury – An injury that is attended to by a medical doctor but is minor enough to allow the injured person to return to the job on the day of injury.

Personal protective equipment – Any device worn by a worker to protect against hazards; for example, dust mask, gloves, ear plugs, hard hand hats, and safety goggles.

2.7 Preventive maintenance

A system for preventing the failure of machinery and equipment by knowing the reliability of parts maintaining service records scheduling parts replacement maintaining inventories of the least reliable parts and parts scheduled for replacement.

Human error – Human error, which accounts for the majority of incidents, includes not only errors by workers but also errors such as engineering deficiencies and lack of adequate organizational control, and poor management systems.

Housekeeping – A way of controlling hazards along the path between the source and the worker. Good housekeeping means having no unnecessary items in the workplace and keeping all necessary in their proper places. It includes proper cleaning, disposal of wastes, clean-up of spills, and maintaining clear aisles, exits, and work areas.

2.8 Ergonomics

The science of fitting jobs to people encompasses the body of knowledge about physical abilities and limitations as well as other human characteristics that are relevant to job design.

Engineering controls – Physical changes to a job that eliminate or reduce the presence of ergonomic hazards. Examples of engineering controls may include changing, modifying, or redesigning workstations, tools, facilities, equipment, materials, or processes.

Ergonomic risk factors – Aspect of a job that posts biomechanical stress to the employee, such as forceful exertion, repetition, awkward or static postures, contact stress, and vibration.

2.9 Ergonomic injuries and illnesses

Injuries and illnesses of the muscles, nerves, tendons, ligaments, joints, cartilage, and spinal discs. It does not include injuries caused by slips, trips, falls, or other similar accidents. Examples of ergonomic injuries and illnesses include; Carpal Tunnel Syndrome, De Quervain's disease, Sciatica, Epicondylitis, Tendonitis, herniated spinal disc, and low back pain.

Signs and symptoms – Objective physical findings or physical indications that an employee may be developing an ergonomic injury or illness.

Contamination – The presence of a hazardous substance that is capable of causing serious physical harm or death.

Decontamination – The removal and disposal of a hazardous substance from personnel, equipment, and vehicle.

Incident – An incident is defined as an exposure occurrence

Occupational disease or illness – Occupational disease or illness is defined as acute/chronic serious physical harm produced by exposure related to the work environment.

2.10 SWI

A Safe Work Instruction (SWI) is a document that records the process to be followed to conduct an activity safely (may have alternative names such as; Safe Operating Procedure or Safe Work Method Statement). The document should have the steps to be followed to complete the activity safely recorded in a logical progression along with any controls/safety measures that need to be used.

Injury frequency rate – Frequency rate = Number of injuries * 200000 hours / total exposure hours

Injury severity rate – Severity rate = Number of lost work days * 200000 hours / Total exposure hours

3. REVIEW OF LITERATURE

1. **Plant maintenance management practices in automobile industries:** A retrospective and literature review Mahesh Pophaley1, Ram Krishna Vyas2, et.al, JIEM (2010). This paper endeavors to present a classification, review, and analysis of the literature on Plant Maintenance Management Practices (PMMP) employed in Automobile Industries. There is a considerable amount of published research available concerning plant maintenance during the last few decades. Similarly, many research articles are available that focus on various aspects of the automobile industry. However, very few studies focus on the critical examination of maintenance practices in Automobile Industries in particular. Hence considering the slump in automobile industries in recent times, a wide-ranging and focused review is attempted here and only those researches have been examined that mainly concentrate on this core aspect. Thus, one of the objectives of this literature review is to investigate the present state of Plant Maintenance Management Practices, based on studies conducted in different countries and published in a variety of journals over the past two decades. An examination of 55 pertinent research studies has shown that the publications can be grouped into two categories namely Conceptual and Empirical Research. An analysis of these research articles published between 1990 and 2008, revealed that current maintenance practices range from conventional to the latest techniques for optimizing maintenance functions like TPM, RCM, and Proactive Maintenance. These studies focused more on maintenance problem solving and the main difficulties are reported along with probable solutions. Another goal of the paper is to analyze the articles by year and type of journal they were published in, to determine the trends in maintenance management studies, and to recommend future direction for research.

2. **Material flow optimization – a case study in the automotive industry jolanta b. Krolczyk, et.al. (1)** Today, most contemporary organizations are facing many dilemmas, the essence of which is the determination of the ways of acquisition or maintenance of their position in the competitive environment. Companies have to continuously increase their economy. One of the ways to get competitive prevalence is the analysis and optimization of material flow which contributes to the reduction of the company costs. Material flow in a production organization tells us a lot about how well the system is organized. The paper presents an analysis of the current state of material flow in a production company of the automotive branch. A project for material flow optimization has also been proposed; the project consists of the creation of a program of internal transport and optimization of the location of the working stands. The paper describes the current problems of company internal transport and indicates solutions to those problems.

3. **Introducing automotive E/E safety engineering: Challenges and solutions Dr. Christof Ebert, et. al, (2)** This paper explains that Functions such as adaptive cruise control, crash protection systems, active body control, and ESP are increasing in complexity and taking an ever more active role in controlling the car. These functions are realized by systems of sensors, actuators, and interconnected electronic control units. The systems must be designed to function under a variety of operating conditions and must adhere to several mechanical, hardware, and, software constraints. To be able to manage the emerging product liability risks associated with such systems as well as ensure the high level of quality required of automotive systems, significant improvements to engineering processes are necessary. In this article, we

describe our experiences in adapting companies' development processes to conform to safety standards and to cope with the challenges mentioned above. We detail key success factors in overcoming these challenges and provide practical examples from working with global OEMs and tier-one suppliers on implementing safety standards in E/E development.

4. **A Structured and Model-Based Hazard Analysis and Risk Assessment Method for Automotive Systems, Kristian Bickers et.al. (1)** The released ISO 26262 standard requires a hazard analysis and risk assessment for automotive systems to determine the necessary safety measures to be implemented for a certain feature. In this paper, we present a structured and model-based hazard analysis and risk assessment method for automotive systems. The hazard analysis and risk assessment are based on a requirements engineering process using problem frames. Their elements are represented by a UML notation extended with stereotypes.

5. **Risk Assessment for Machinery Shop in Automobile Industry, P.Suresh Kumar, et.al.** The automotive industry occupies a significant place in the Indian economy. The well-developed industry acts as a catalyst and gives energy to the economic growth of the country also increased accidents among the workers due to workplace hazard manufacturing of auto components carry with them workplace hazards, the hazards and risks connected with welding operations, assembly operation by machine or manual in shock absorber manufacturing industry was identified and controlled using risk matrix techniques. The findings reveal that major tasks were associated with the events of material handling, machine operation, maintenance of any machinery, packing, and housekeeping. Hazards of varying degrees were identified and the associated risk was classified was trivalent risk, Low risk, medium risk, High risk, and very high risk. The tasks carried out with those hazards and risks are suggested with control measures and recommendations.

6. **Risk assessment of India automotive enterprises using Bayesian networks, et.al.** Today's enterprises are facing increased level of risks. Companies must assess risk continually. Risks modeling is a complex task because of risks events dependencies and hard task of relevant data. The purpose of this paper is to provide an enterprise risk assessment model that is updated continually. Enterprise risk assessment model is provided using Bayesian network methodology for assessing enterprise risks. The networks are used to assess business, economic and external risks and assess its impact on net income of the company. Data for enterprise risk assessment was collected from five automotive companies operating in India.

7. **Hazard Identification and Risk Assessment in Automotive Industry, Ramesh et.al,** Hazard Identification and Risk Assessment or HIRA system can act as a risk assessment tool which will assist users in identifying hazard and estimating risk involved in each identified hazard. This risk assessment tool will identify possible hazard involved in each task in departments. Once the hazard has been identified, risks involved will be estimated and categorized. If the estimated risk falls in a category, which is higher than the low-risk category, then possible control measures will be recommended. At the same time, the user can add new work plan, task, and control measures into the system to update existing information system.

4. INTRODUCTION TO HIRA

4.1 Hazard Identification and Risk Assessment

The following steps are involved for Hazard Identification and Risk Analysis. The steps are shown in the figure

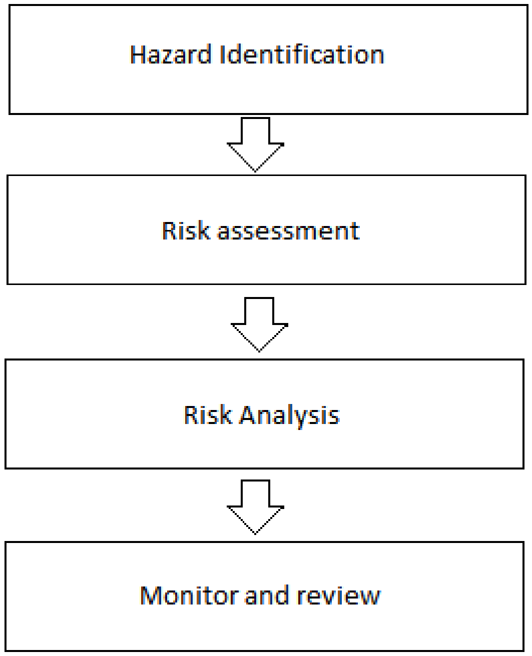

Fig 4.1: Steps for Hazard Identification and Risk Analysis

A major problem faced by the emergency team is how to identify, prepare, mitigate, eliminate, respond and recover from hazards. Several questions arise when faced with this challenge: What hazards exist in my area? How frequently do they occur? How severe can their impact be on the employees, equipment, property, and the environment? Which hazards have the greatest threat to the work environment? A Hazard Identification and Risk Assessment (HIRA) assists emergency managers in answering these issues. It is a systematic tool for risk assessment that can be used to assess the risks of several hazards. There are three reasons why a HIRA technique is useful to the emergency management profession.

4.2 Risk Assessment

Risk assessment is the process used to determine the likelihood that people may be exposed to an injury, illness, or disease in the workplace arising from any situation identified during the hazard identification process before consideration or implementation of control measures. Risk occurs when a person is exposed to a hazardous situation. Risk is the likelihood that exposure to a hazard will lead to an injury or a health issue. It is a measure of the probability and potential severity of harm or loss. Risk assessment forms a crucial early phase in the disaster management planning cycle and is essential in determining what disaster mitigation measures should be taken to reduce future losses. Any attempt to reduce the impact of disaster requires an analysis that indicates what threats exist, their expected severity, who or what they may affect, and why. Knowledge of what makes a person or a community more vulnerable than another added to the resources and capacities available determines the steps we can take to reduce their risk. Risk assessment is carried out in a series of related activities which build up a picture of the hazards and vulnerabilities which explain disaster events.

4.3 Different Terminologies Associated with Risk Assessment

Following are some of the important terminologies involved in hazard identification and risk analysis:
Harm: Physical injury or damage to the health of people either directly or indirectly as a result of damage to property or the environment.

Hazard: Hazard is a situation that poses a level of threat to life, health, property, or environment. Most hazards are dormant with only a theoretical risk of harm however once a hazard becomes active it can create an emergency.
Hazardous situation: A circumstance in which a person is exposed to a hazard
Hazardous event: A hazardous situation that results in harm
Accident: An accident is a specific, unidentifiable, unexpected, unusual, and unintended external action that occurs in a particular time and place with no apparent and deliberate cause but with marked effect.
Risk: Risk concerns the deviation of one or more results of one or more future events from their expected value.

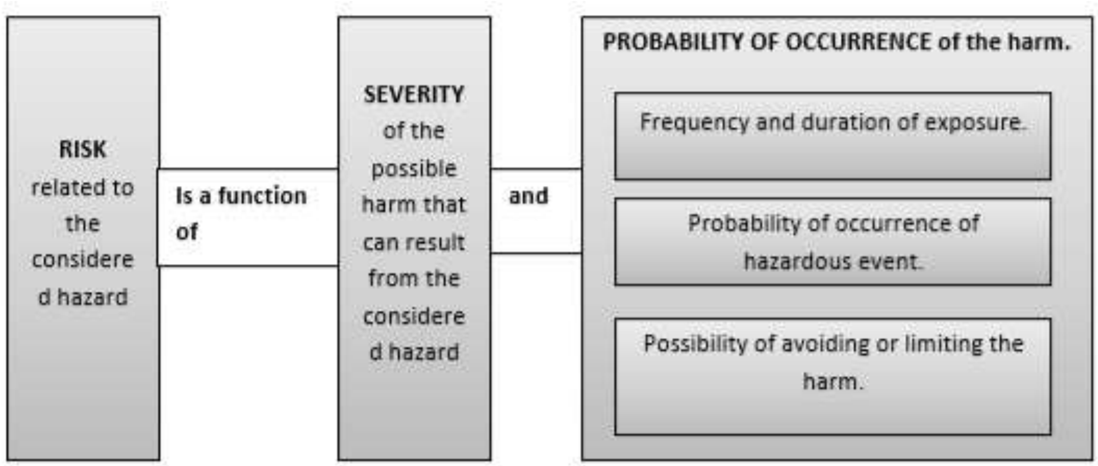

Fig 4.2: The European Community's Definition of Tolerable Risk.

Tolerable risk: Risk which is accepted in a given context based on the current values of society
Protective measure: The combination of risk reduction strategies taken to achieve at least the tolerable risk. Protective measures include risk reduction by inherent safety, protective devices, personal protective equipment, information for use, installation, and training.
Severity: Severity is used for the degree of something undesirable.

Different Forms of Injury

- Serious Bodily Injury means any injury which involves the permanent loss of any part or section of the body or the permanent loss of sight or hearing or any permanent physical incapability or the facture of any bone or one or more joints or bone of any phalanges of hand or foot.
- Reportable Injury means any injury other than any serious bodily injury, which involves the enforced absence of an injured person from work for a period of 72 hours or more.

Risk Analysis: A systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences.
Risk Assessment: The process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels, or other criteria.
Risk Treatment: Selection and implementation of appropriate options for dealing with risk.

4.4 Types of Hazard Identification and Risk Analysis

There are three types of hazard identification and risk assessments:

- Baseline Hazard Identification and Risk Analysis;
- Issue-based Hazard Identification and Risk Analysis; and
- Continuous Hazard Identification and Risk Analysis.

They are all inter-related and form an integral part of a management system. A brief description of each of the three types of Hazard Identification and Risk Analysis is given below:

Baseline Hazard Identification and Risk Analysis

The purpose of conducting a baseline HIRA is to establish a risk profile or set off risk profiles. It is used to prioritize action programs for issue-based risk assessments.

Issue-based Hazard Identification and Risk Analysis

The purpose of conducting an issue-based HIRA is to conduct a detailed assessment study that will result in the development of action plans for the treatment of significant risks.

Continuous Hazard Identification and Risk Analysis

The purpose of conducting continuous Hazard Identification and Risk Analysis is to:

- Identify Operational health and safety hazards to immediately treat significant risks.
- Gather information to feed back to issue-based Hazard Identification and Risk Analysis.
- Gather information to feed back to baseline Hazard Identification and Risk Analysis.

4.5 The Inter-relationship between types of HIRA

The relationship between the different types of HIRA is illustrated in Figure 4.3. The figure illustrates

- 1. Risk profiles are used for planning the issue-based HIRA action program.
- 2. Provides clear guiding principles for compatibility so that the issue-based HIRA and continuous HIRA are more effective enabling continuous improvement.
- 3. Codes of practice, standard procedures and management instructions, and new information from issue-based HIRA can be used to improve the continuous HIRA and update the baseline HIRA so that it remains comprehensive.
- 4. The issue-based HIRA and baseline HIRA draw from the data captured by the continuous HIRA process to be effective. 5. The risk management process serves management.

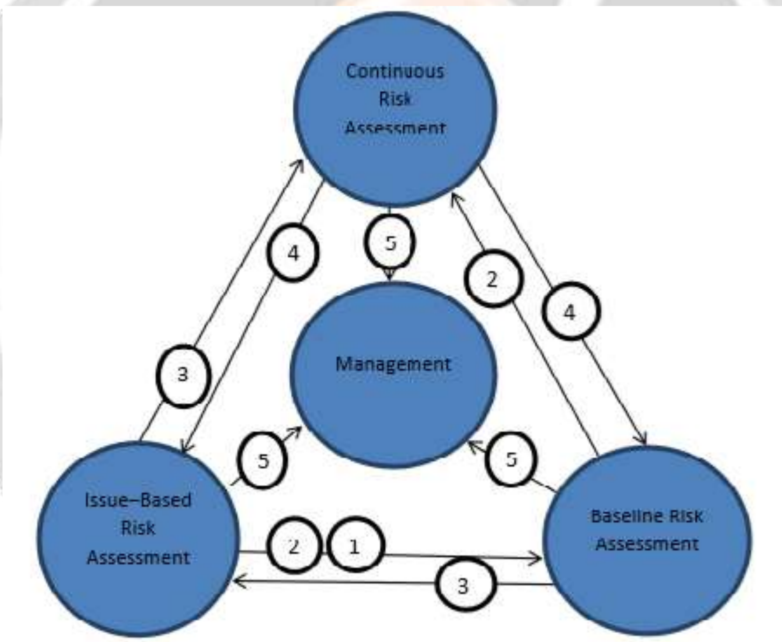

Fig4.3: The Inter-relationship between Different Types of HIRA.

The different steps of the risk assessment procedure are as given below (Figure 4.4)

Fig 4.4: different steps of the risk assessment procedure

4.6 Noise Level Measurements

A sound level meter is used to measure the noise level in the work environment. Sound level meters are rated in the following categories, based on the accuracy of the meter: (a) type 1, precision; (b) type 2, general-purpose; (c) type 3, survey; and (d) special-purpose sound level meters. Type 1 or type 2 sound level meters are required for OSHA noise surveys and are specified in most community noise ordinances. There are two general types of calibrators for sound level meters: the loudspeaker type and the piston phone type.

The elements in a measuring system are:

- The Transducer; that is, the microphone.
- The Electronic amplifier and calibrated attenuator for gain control.
- The Frequency weighting or analyzing possibilities.
- The Data storage facilities.
- The Display.

The two main characteristics are:

1. The frequency response: the deviation between the frequency function of the true value and the measured value. The human ear is capable of hearing sounds between 20 Hz and 20 kHz, the frequency response of the sound level meter should be good, over the range with variations smaller than 1 db.

2. The dynamic range: that is, the range in dB over which the measured value is proportional to the true value, at a given frequency (usually 1000 Hz). This range is limited at low levels by the electrical background noise of the instrument and high levels by the signal distortion caused by overloading the microphone or amplifiers.

Characteristics of A & C weighting network: Frequency A weighting - The characteristic is similar to the Human Ear Listening response. Generally, A frequency weighting network is selected if making Weighting Network the environmental sound level measurement.

4.7 Automobile machineries

1) Hydraulic press

Fig 4.5: Hydraulic press

2) Bending machine

Fig 4.6: Bending machine

3) Lathe

Fig 4.7: lathe machine

4) CNC machine

Fig 4.8: CNC machine

5) Drilling

Fig 4.9: Drilling machine

4.8 Manufacturing Process of Automobile Parts

Manufacturing is the production of merchandise for use or sale using labour and machines, tools, chemical and biological processing, or formulation. The term may refer to a range of human activities, from handicrafts to high tech, but is most commonly applied to industrial production, in which raw materials are transformed into finished goods on a large scale. Such finished goods may be used for manufacturing other, more complex products, such as aircraft, household appliances, or automobiles, or sold to wholesalers, who in turn sell them to retailers, who then sell them to end users and consumers. Manufacturing takes turns under all types of economic systems. In a free market economy, manufacturing is usually directed toward the mass production of products for sale to consumers at a profit.

In a collectivist economy, the state frequently directs manufacturing to supply a centrally planned economy. In mixed market economies, manufacturing occurs under some degree of government regulation.

The following are the characteristics of the assembly line in which the problem arises and assumptions,

- The raw material moves on a conveyor at a constant speed
- In each step of the process team worker's work. The members of the worker's team continuously perform different manufacturing processes on the same product and workstation.
- Respective products are launched on the line from the first station at a constant time interval.
- In each working process the products will enter in the same sequence.
- All the machining process has different upstream and downstream boundaries.
- The operator returns to the next product or to the upstream boundary of the station, whatever is reached first, in zero time after finishing the workload on the current product due to the fact that the speed of the conveyor is much slower than the walking speed of the workers.
- Hazard analysis is the most important step in risk controls because, it is used to identify the hazards, consequence rating and probability rating reduction cannot be calculated. In the context of safety at work processes and practices usually mean that a process hazard analysis must be conducted. Hazard

identification is the most important part of any risk control elimination of hazards is almost always the best way of reducing risk, and it is the only way in which risk can be reduced.

Step 1: Identifying Hazard
Step 2: Assessing the Risk
- Assess the probability & hazard consequence rating
- Hazard Consequence Rating Table
- Probability Rating Table

Step 3: Control the Risks
- Risk Control Hierarchy

Step 4: Review the Control Measures

Elimination: Eliminate the hazard by removal from the workplace.
Substitution: Replace the most hazardous process or substance and practices with a less hazardous one.
Engineering: Isolate the hazard from employees with mechanical aids.
Administration: Implement safe work practices and methods.
Personal Protective Equipment: Provide suitable PPE to cover and protect an employee.

The hierarchy of risk control is useful in determining appropriate risk control measures. The best method of controlling a risk is to eliminate the hazard-it is not always possible to do this immediately. The aim of implementing controls is to get as many controls in place so the risk is reduced to as low as possible.

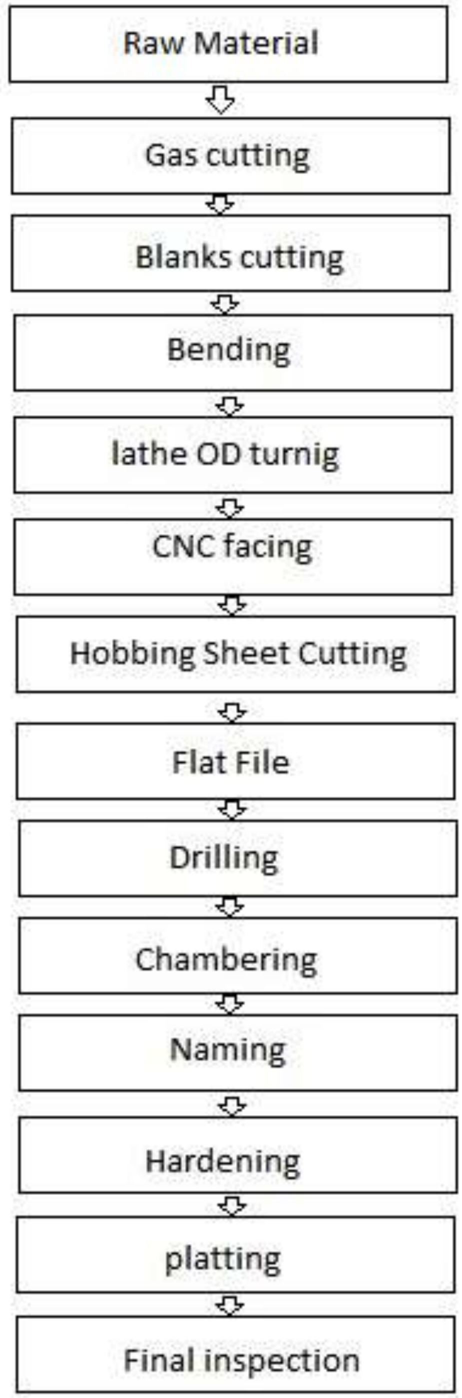

Fig 4.10: Common Segments of automobile parts manufacturing

4.9 Methodology

The following methodology has been adopted for the preparation of this project report.

- Visited the entire plant area in **MAHALAKSHMI ENGINEERING** and studied the various operations, work methods, practices, working conditions, handling procedures for hazardous substances, and housekeeping and made the observations through a walk-through survey.
- Inspecting each section activity, process parameter, and sop.
- Referred to various literature regarding standards and statutes in connection with plant safety inspection.
- Unsafe Act and unsafe condition method hazard notification
- Study each raw materials handling method and observe safety precaution
- Each machine CLTI checklist notification
- Operating and Maintenance records are inspected.
- Discuss with the concerned operators, safety pillar members, and maintenance team.
- A listing of recommendations is developed specifying the need for additional action or study.
- Plant safety inspection of the plant was carried out to study the current practice with an inspection methodical focus of a prepared checklist.

PLANT SAFETY INSPECTION						
A	**NO**	**Housekeeping**	**Yes**	**No**	**N/A**	**Correction date**
	1	Trash picked up and trash cans empty?				
	2	Are walkways clear?				
	3	Exist visible and unobstructed?				
	4	Equipment, hoses, etc. that aren't in use, are they properly stored?				
B		**Machinery**	**Yes**	**No**	**N/A**	**Correction date**
	1	Is preventive maintenance of machinery regularly carried out?				
	2	Are machine guards properly installed and maintained?				
	3	Have the workers been trained in machinery operation?				
	4	Are there enough safety signs around these machines?				
	5	Guarding of transmission machinery				
C		**Lighting**	**Yes**	**No**	**N/A**	**Correction date**
	1	Is lighting for every workplace and workstation enough according to the regulation and working requirements?				
	2	Is lighting regularly checked and monitored and is the record kept?				
	3	Is emergency lighting available and reliable?				

Table4.1 Plant safety inspection

5. DATA COLLECTION AND ANALYSIS

To methodically identify, evaluate and control hazards in the process of a factory. The process of hazard analysis shall be documented and shall include measures over a serious scenario that can occur in a factory and the necessary corrective or control measures that can be incorporated to mitigate the frequency or severity of the risk associated with the scenario event.

5.1 Worksite analysis

Evaluate all workplace activities and processes for hazards.

Reevaluate workplace activities when there are changes in; processes, materials& machinery.

Conduct onsite inspections, identify hazards, and take corrective actions.

Provide a hazard reporting system for employees to report unsafe and unhealthful conditions.

Investigate all accidents and near misses to determine their root causes.

5.2 Hazard prevention and control

Eliminate and control workplace hazards (e.g., engineering controls, workstation design, and work practices).

Establish a preventive maintenance program.

Keep employees informed of safety and health activities and conditions.

Plan for emergencies (e.g., create an evacuation plan, train employees and conduct fire drills).

Record and analyze occupational injuries and illnesses.

5.3 Safety inspection checklist

I. Walkways

Are aisles and passageways kept clear and at least 22 inches wide? Yes

Are aisles and walkways appropriately marked? Yes

Are wet surfaces covered with non-slip materials? Matt provided

Are openings or holes in the floors or other walking surfaces repaired or otherwise made safe? Yes

Is there safe clearance for walking in aisles in which vehicles operate? Yes

Are materials and equipment stored so sharp objects do not obstruct the walkway? Sharp edges removed

Are changes of direction or elevation easily identified? Yes

Do aisles or walkways near moving operating machinery, welding, and similar operations

Keep employees away from hazards? Welding work in the workshop

Is there a floor-to-headroom height of at least 6.5 feet provided for the entire length of any walkways? Yes

Are bridges provided over conveyors and similar hazards? No conveyor

II Work environment: general

Are all work areas clean and orderly? Yes

Are walking surfaces dry or slip-resistant? Yes

Are spilled materials or liquids cleaned up immediately? Regular cleaning system maintains

Is combustible scrap, debris, and waste safely contained and removed from the site promptly? Daily two people doing

Are covered metal waste cans used for oily and paint-soaked waste? Move to scrap yard

Is the appropriate number of toilets and washing facilities provided? Yes

Are toilets and washing facilities sanitary? Yes

Are work areas adequately lighted? Yes

III. Transportation: employees and materials

Do employees who operate vehicles on public thoroughfares have operator licenses? No

Are motor vehicle drivers trained in defensive driving and proper use of the vehicle? Yes

Are employees required to use a seatbelt? Yes

Does each van, bus, or truck used to transport employees have an adequate number of seats? Checklist maintained

When employees are transported by truck, are safeguards provided to prevent them from falling from the vehicle? Each truck has one guard available

Are vehicles equipped with lamps, brakes horns, mirrors, windshields, and turn signals that are in good repair? Checklist

Are transport vehicles equipped with handrails, steps, stirrups, or similar devices so employees can safely mount or dismount? Checklist

Is a fully charged fire extinguisher, in good condition, with at least a 4 B: ratings maintained in each employee transport vehicle? Yes

When sharp-edged cutting tools are carried in passenger compartments of employee transport vehicles, are they placed in closed boxes or containers that are secured in place? Yes

Are employees prohibited from riding on top of any load that can shift, topple, or otherwise becomes unstable? No

Are materials that could shift and enter the cab secured or barricaded? Yes

5.4 Checklist for Arc welding machine

S. No	Description	Yes	No	Remarks
1	ON/OFF knob is provided	Yes	-	-
2	A regulator with an indicator is provided	Yes	-	-
3	Welding cables connected to the welding machine with lugs at the joints	Yes	-	-
4	No damage to the insulation of the welding cables		No	Earth wire open
5	The electrode rod holder and earthing holder are without damage	Yes	-	-
6	Industrial type plug for power tapping cable of welding machine	Yes	-	-
7	No internal live electrical parts of the welding machine exposed	Yes	-	-
8	Trolley without damaged wheels		No	One wheel damage

Table 5.1 Checklist for Arc welding machine

5.5 Checklist for cutting machine

S. No	Description	Yes	No	Remarks
1	Crack &damage to the cutting plate	-	No	-
2	Presence of a cutting plate guard	Yes	-	-
3	Presence of a locking system for the plate & guard	Yes	-	-
4	Presence of the job clamp and its condition	Yes	-	-
5	Presence of the handle and its condition	Yes	-	-
6	Cable condition (Any cut, wear, etc.) Improper insulation and presence of wire top plug	-	No	Plug to be changed
7	Presence-cutting dust guard	-	No	Dust not removed

Table5.2 Checklist for cutting machine

5.6 Checklist for drilling machine

S. No	Description	Yes	No	Remarks
1	Equipment should be double insulated (written in the machine body)	Yes	-	-
2	Equipment should be free from any defect like broken handles, broken parts, etc.,	Yes	-	-
3	The wire should be free from any defects and improper joints.	Yes	-	-
4	The wire top plug should be present in good condition	-	No	The switch cover is to be replaced
5	The drilling bit should be in good condition		No	Drill bit to be changed
6	Presence of a drilling bit holder	Yes		
7	Condition and presence of the switch	Yes		

Table 5.3 Checklist for Drilling machine

5.7 Checklist for Personal Protective Equipment

S. No	Description	Yes	No	N/A
1	Have you assessed workplace hazards that might require PPE and reviewed related injuries?	Yes	-	
2	Has the assessment been documented?	-	No	-
3	Does the documentation identify the workplace evaluated?	Yes	No	-
4	Has training been provided to each employee who is required to wear PPE?	Yes	-	-
5	Has the training been documented?	Yes	-	-
6	Are protective goggles or face shields provided to employees and worn when there may be danger of flying material or caustic or corrosive materials?	Yes	-	-
7	Are ANSI-approved safety glasses worn at all times in areas where there is a risk of eye injury?	Yes	-	-
8	Are protective gloves, aprons, or shields provided to employees for protection against cuts, corrosive liquids, and chemicals?	Yes	-	-

9	Are hard hats provided and worn where there is a danger of falling objects?	Yes	-	-
10	Are hardhats inspected periodically for damage to the shell and the suspension system?	Yes	-	-
11	Do employees expose to vehicular traffic wear high-visibility garments that make them stand out from their surroundings?	Yes	No	-
12	Do workers wear reflective garments at night?	-	No	-

S. No	Description	Yes	No	N/A
13	Are appropriate provided for regular or emergency use where they are necessary?	Yes	-	-
14	Is there a written respirator program?	-	No	-
15	Are the respirators inspected before and after each use?	Yes	-	-
16	Is a written record kept of all inspection dates and findings?	-	No	-
17	Have all employees been trained in work procedures, and proper use and maintenance of protective clothing equipment for cleaning up spilled toxic or other hazardous materials or liquid?	Yes	-	-
18	Is a spill kit available for employees to clean up spilled toxic or hazardous materials?	-	No	-
19	Are employees required to wear safety shoes when they are exposed to conditions that could cause foot injuries?	Yes	-	-
20	Is all protective equipment sanitary and ready to use?	Yes	-	-
21	Is there an eyewash facility and a quick drench shower in each work area where employees are exposed to caustic or corrosive materials?	Yes	-	-
22	Do employees have lunch areas in areas where there is no exposure to toxic materials?	Yes	-	-
23	Is protection from occupational noise provided when sound levels exceed those of the OSHA hearing conservation standard – 1910.95?	Yes	-	-

Table 5.4 Checklist for Personal Protective Equipment

5.8 Plant Safety Inspection checklist

PLANT SAFETY INSPECTION						
A	NO	Housekeeping	Yes	No	N/A	Correction date
	1	Trash picked up and trash cans empty?	Yes	-	-	-
	2	Are walkways clear?	Yes	-	-	-
	3	Exist visible and unobstructed?	Yes	-	-	-
	4	Equipment, hoses, etc. that aren't in use, are they properly stored?	Yes	-	-	-
B		Machinery	Yes	No	N/A	Correction date
	1	Is preventive maintenance of machinery regularly carried out?	Yes	-	-	-
	2	Are machine guards properly installed and maintained?	Yes	-	-	-
	3	Have the workers been trained in machinery operation?	Yes	-	-	-
	4	Are there enough safety signs around these machines?	-	No	-	9.11.2022
	5	Guarding of transmission machinery	Yes	-	-	-
C		Lighting	Yes	No	N/A	Correction date
	1	Is lighting for every workplace and workstation enough according to the regulation and working requirements?	Yes	-	-	-
	2	Is lighting regularly checked and monitored and is the record kept?	Yes	-	-	-
	3	Is emergency lighting available and reliable?	Yes	-	-	-

D		Personal Protection	Yes	No	N/A	Correction date
	1	Safety glasses?	-	-	N/A	-
	2	Hearing protection?	-	-	N/A	-
	3	Work shoes?	-	-	N/A	-
	4	Double eye protection, face shields when grinding?	Yes	-	-	-
	5	Chemical eye wash station inspected?	Yes	-	-	-
	6	Apron	Yes	-	-	-
	7	Safety gloves?	Yes	-	-	-
E		Fire extinguishers	Yes	No	N/A	Correction date
	1	Visible, accessible, has been serviced?	Yes	-	-	-
	2	Inspection tag Present?	Yes	-	-	-
	3	Does the gauge show charge?	Yes	-	-	-
F		Electrical	Yes	No	N/A	Correction date
	1	Are all boxes closed?	Yes	-	-	-
	2	No bare exposed wires?	Yes	-	-	-
	3	Trip guards on the column?	Yes	-	-	-
	4	Three-foot clearance in front of panels?	Yes	-	-	-
	5	Are extension cords free from damage?	-	No		19.11.2022
	6	Properly grounded?	Yes	-	-	-
G		First Aid	Yes	No	N/A	Correction date
	1	Is the area clean?	Yes	-	-	-

	2	Is it properly stocked?	-	No	-	20.11.2022
	3	Rescue basket present?	-	No	-	-
H		Training	Yes	No	N/A	Correction date
	1	Safety training and inspections held for new employees regularly	Yes	-	-	-
	2	First Aid-trained individuals available for medical emergencies	Yes	-	-	-
	3	Fire extinguisher familiarization provided	Yes	-	-	-
	4	Personnel is trained in the proper selection, use, and maintenance of personnel protective equipment.	Yes	-	-	-
	5	Is sufficient clearance provided around and between machines to allow for safe operation, setup, servicing, material handling, and waste removal?	Yes	-	-	-
I		General	Yes	No	N/A	Correction date
	1	Are hazardous materials stored and labeled properly?	Yes	-	-	-
	2	Is MSDS available in working place?	-	No	-	27.11.2022
	3	Are restrooms clean?	Yes	-	-	-
	4	Lighting, O.K.?	Yes	-	-	-
	5	Are areas free from fluid spills, hoses, and trip hazards?	Yes	-	-	-
	6	Are proper signs posted for the area?	Yes	-	-	-
	7	Where are applicable-are respirators being worn?	Yes	-	-	-
	8	Cleaned and stored properly?	Yes	-	-	-

	9	Forklifts – horns working?	-	-	N/A	-
	10	Are shop phones working?	-	-	N/A	-
	11	Are roof fans working?	Yes	-	-	-
	12	Stripping in the shop visible?	Yes	-	-	-
	13	LOTO system maintained?	Yes	-	-	-

Date: - 27.11.2022

Section: - CNC & VMC Inspectors: -

Table 5.5 Plant safety inspection checklist

6. FINDINGS AND RECOMMENDATIONS

6.1 Findings

- Trolley movement area floor damage
- Stacking machine bottom sharp edge observed
- Smoke fumes came into the wax-melting tank
- Sawdust particles flying on the road near the furnace area
- Observed helmet not worn in the PV process area
- Noticed gloves not available in the box in the circle machine area
- One tube light is not available near the monorail’s movement area
- Noticed one fire bucket missing in the near lacquering area
- Dry room entrance area air hose lying in the pathway
- Excess length bolt found in dry room 2 entrance point
- Safety guard not fully covered in end cutting machine
- Two roof ventilators not working in the CNC machining section
- Conveyor movement area guard not available
- Unused wire hanging near supervisor’s table
- Tools are wrongly kept in the press machine top
- Noticed some checking tables are different heights in the packing area
- Unwanted used water bottles kept in the working area
- Aluminum ladder does not properly move up and down

6.2 Recommendations

- Floor to be corrected in trolley movement area within 10 days
- Yellow shade transparent sheet to be replaced in working line II and store area
- Rubber sheet to be provided in stacking machine bottom area
- Exhaust fan to be provided in a wax melting tank area
- Damage filter bags to be replaced with a new ones in the saw dust collection unit
- Compulsory helmet should wear in the PV process area and a supervisor regular monitoring system is required
- Compulsory gloves are to be kept in the circle machine area
- One tube light to be provided in the monorail’s movement area
- Do not take the fire bucket for other use, display to be provided
- Excess length bolt to be removed near dry room entrance point
- Safety guard to be covered fully in end cutting machine
- Housekeeping to be improved and the suction line to be corrected

- Movement trolley to be kept in the yellow marking area
- Unwanted drums to be removed and daily checklist maintain
- Damage gloves do not use while handling the crucible
- Two roof ventilators are to be repaired in the CNC machining area
- Safety guard is to be provided in the conveyor movement area
- Unused wire to be removed near supervisor table
- Proper insulation is required in the impregnation machine
- Tools to be kept in the toolbox
- Unwanted used water bottles to be removed
- Aluminum ladder rope to be corrected

7. FMEA AND RFMEA ANALYSIS

7.1 FMEA

FMEA is an analytic technique based on pre-occurrence prevention which is used for using failure mode and effects analysis. The focus of this technique is increasingthe safety coefficient and consequently, customer satisfaction through prevention before failure. FMEA is a tool that isused with minimum risk to predict problems and defections during the stages of designing or developing processesand services in the organization. One of the factors in the success of FMEA is its execution time. When we face a problem in many cases, corrective measures might be defined and executed to eliminate that problem. These measures are a reaction to what has happened. In such cases, permanent elimination is difficult and requires enormous costs and resources, because moving from the current situation toward optimal conditions will have high inertia. However, during the implementation of FMEA and by predicting potential problems and calculating their risks,measures will be defined and executed to eliminate them or reduce their occurrence rate. There are two types of FMEA,one is PFMEA which is potential failure modes and effects analysis, and the other is DFMEA which is design failure modes and effects analysis. Here, we define RFMEA, which is project risks failure modes and effects analysis.

7.2 RFMEA Preparation

RFMEA preparation requires teamwork. The number of team members depends on the project's complexity. However, more than six people are not recommended. If the project is complicated, it is better to form multiple committees with each sub-team taking on a part of the work. Teams consist of experts who have the most knowledgeof the project. People such as engineers and design specialists, construction and assembly, quality, after-sales service, marketing, and logistics. From the initial stages of work to the implementation of the proposed measures and review of their results and eventually completing the RFMEA, these teams are responsible for all the related activities. One of theadvantages of this team approach is that any activity that is defined will always be agreed upon by all units of the organization, and therefore their implementation will not cause any problems or resistance. In this method, project risksare first identified, and values of risk indicators including risk intensity, I, occurrence probability, P, and risk identification are extracted from the related tables, and then the risk score, R, and RPN are calculated. The risk score is risk intensity multiplied by the probability of its occurrence, and RPN is a risk score multiplied by the recognition number, N.

$$R = I \times P$$

$$RPN = R \times N$$

Then, the Pareto chart for risk score and RPN are separately prepared, and the critical risk score and critical RPN are determined based on the results of previous projects or the experience of experts. In the next step, the RPN graph is drawn based on the risk score for all the risks, and lines of critical risk score and critical RPN are specified. After that, risks that lie both in the range of critical risk score and critical RPN are specified, and proper measures will be defined to reduce their risk score and RPN. Then in the next stage, given the defined measures, values of intensity, occurrence, extraction recognition, risk score, and RPN are determined again. This operation continues until all the risks have a riskscore and an RPN score lower than the critical values.

Nine executive steps of RFMEA are:

1. Risk identification
2. Determining the values of indicators of occurrence, intensity, and recognition from Tables 1, 2, and 3
3. Calculating risk score and RPN value
4. Drawing the Pareto chart of the risk score
5. Drawing RPN Pareto chart
6. Determining RPN values and critical risk score
7. Drawing the Pareto chart based on the risk score
8. Repairing an action plan for critical risks
9. Recalculating RPN and risk score

Table 7.1. Suggested criteria to assess the occurrence

Occurrence Probability	Occurrence number
It is definitely going to happen	10
It is very likely to happen	9
The chance of occurrence is medium	8
It might happen	7
The possibility of occurrence exists	6
The probability of happening and not happening is the same	5
The probability of occurrence is low	4
It is unlikely to happen	3
It is extremely unlikely to happen	2
It will not happen	1

Table 7.2. Suggested indicators to evaluate recognition

Recognition Probability	Recognition no.
The risk is unrecognizable	10
The probability of risk recognition is relatively unlikely	9
Risk recognition is unlikely	8
The probability of risk recognition is relatively	7

low	
The probability of risk recognition is low	6
The probability of risk recognition is relatively medium	5
The probability of risk recognition is medium	4
The probability of risk recognition is relatively high	3
The probability of risk recognition is high	2
Risk recognition is definite, and there is enough time to act	1

Definition of recognition: recognition is a method or technique to discover risk when there is enough time to take necessary action.

After completing the RFMEA table, Pareto charts for risk score and RPN are provided as the following:

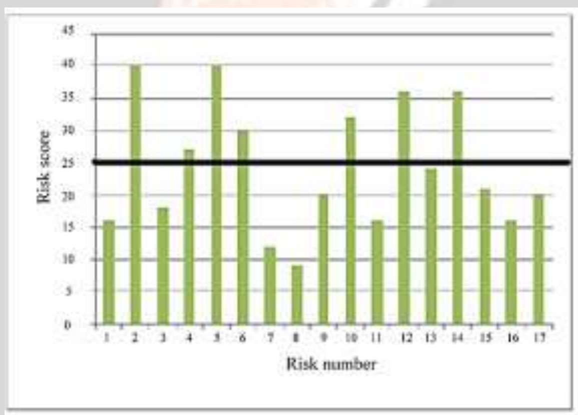

Figure 7.1. Pareto chart for risk score

Critical RPN and critical risk score should be selected according to the data so that we can identify the risks that are in critical condition. In this project and given the previous experiences of project team members, a critical risk score of25 and a critical RPN of 100 are selected.

Based on the risk score and by placing the risk score and critical RPN, the RPNgraph is as follows.

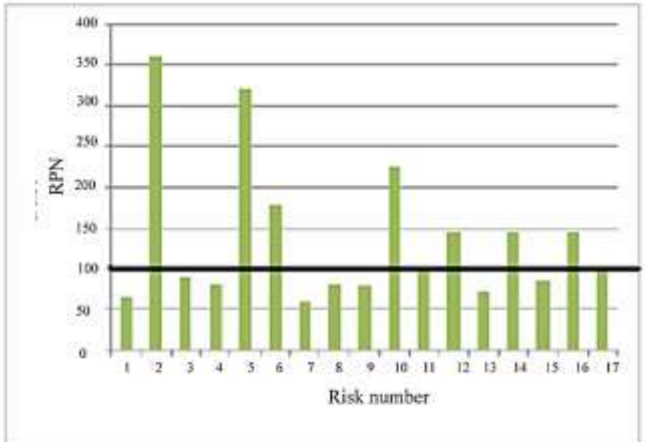

Figure 7.2. Pareto chart for RPN

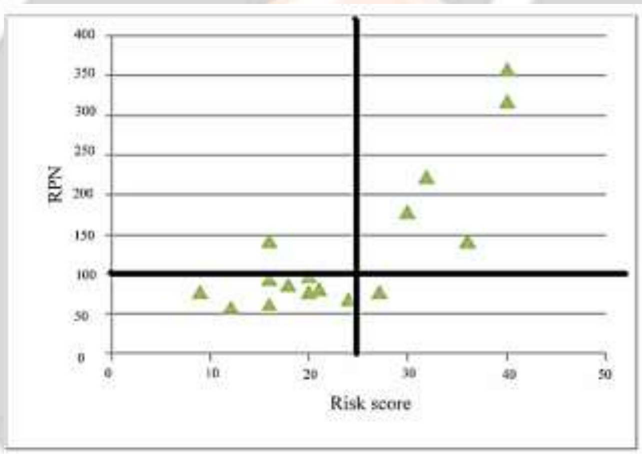

Figure 7.3. RPN graph based on risk score

8. CONCLUSION

Using RFMEA in risk management is a relatively simple and practical method. Given that the FMEA method is wholly known in automotive companies thus using it is more effective for project risk management. This method defines two indicators of risk score and RPN for all the risks, and in other words, it introduces project risks in quantitative terms. With this method, we can quickly identify critical risks and take proper actions to deal with them. Then, the values of numerical risk indicators are calculated, and we ensure that the risks are lower than the critical condition. Employing this method in automotive companies has had good results and has led to improvements in project management indicators such as time, deviation from the determined cost, and technical quality of projects. During this term, work has gone through work plant inspection standards and statutes. This term work used to understand the basic idea of safety and the importance of the work plant inspection method, through this safety manual. The structure of the plant is quite satisfactory and is under constant surveillance. Training is one of the best tools for a safe work environment in the automobile parts manufacturing process. So, the plant has to conduct various levels of safety training activity for the employees to generate a common awareness about safety and health. The company must put it into practice as safety is a culture to develop. A continuous approach oh behaviorbased safety training will create a good working environment. Through hazard identification and unsafe action, unsafe conditions were observed in the plant. To identify, evaluate and control occupational health hazards to protect all personnel from diseases or illnesses arising from their exposure and programs to protect all workers from specific occupational health hazards.

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