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Occupational Health and Safety Risk Assessment in Automobile Industry

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***Abstract*— Identifying and analyzing potential (future) events that may negatively impact individuals, assets, and/or the environment (i.e. hazard analysis) and making judgments "on the tolerability of the risk on the basis of a risk analysis" while considering influencing factors constitutes a risk assessment (i.e. risk evaluation). Occupational Health and Safety is a field in Industrial Engineering which deals with the assessment and eradication of risks or hazards in work place. This study deals with the assessment of risks or hazards that can affect the workers on an industry. A suitable industry will be selected and the risk assessment process will be executed in the industry. All the health and safety aspects will be checked thoroughly and the conclusions will only be drawn after clear examination of each and every aspects.**

***Keywords*— Occupational Health and Safety, Risk assessment, Industrial Engineering, Hazards.**

I. INTRODUCTION

The purpose of occupational health is to safeguard employees' health, safety, and well-being at work by preventing and controlling occupational risks in the first place. But also, through monitoring employees' health as it relates to their jobs, and by supporting healthy habits, workers' physical and emotional well-being. All health professionals benefit greatly from a healthy and safe working environment in terms of their physical, mental, and social well-being. The health and safety of health care employees is also critical for providing high-quality treatment, ensuring patient safety, and preventing infections in hospitals. As defined by the World Health Organization "occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards." Health has been defined as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. “Occupational health is a multidisciplinary discipline of healthcare concerned with helping an individual to do their employment in the healthiest way possible. It is consistent with the promotion of occupational health and safety, which is concerned with preventing injury from working dangers. Risk assessment is the formalized process of identifying hazards (associated with work activities and locations), evaluating risk and then either eliminating or controlling that risk to an acceptable level.

Steps to risk assessment:

1. Identify the hazards.
2. Identify the people who might be harmed and how.
3. Evaluate the risk and decide on precautions.
4. Record the significant findings and implement them.
5. Review and update as necessary.

A. LITERATURE REVIEW

1) Occupational Health and Safety Management Systems Applications and a System Planning Model. (Serenay Calis et al.): Occupational health and safety management systems that can be audited sustainably have been started to be required both in our country and in the world, due to work accidents in recent years. The goal of these management systems are to ensure occupational health and safety activities more simple, understandable and easy to implement in the workplace, to help establish a more effective prevention system and to ensure effective participation of all employees regardless of level difference in the operating system to safety system. As a result of these, work accidents and occupational diseases can be reduced, scientific occupational health and safety studies can be continued and an environment that will help to increase the countries’ development levels. The aim of this study is to show the benefits of occupational health and safety management systems that can provide to employees, enterprises and whole countries and to offer an occupational health and safety management system for Turkey by examining the examples of occupational health and safety management systems of different countries. For this aim, a detailed literature survey is performed and acquired results are evaluated comprehensively.

2) Risk analysis as a basis for safety management system. (Micaela Demichela et al.): The paper shows, with a practical application, how the hazard identification and evaluation phase of the Safety Management System (SMS) in

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a major risk installation (as defined by EC Directive CEE 96/82 (Seveso II) is the sizing criteria for the whole SMS, with its procedures. Probabilistic risk assessment techniques are applied to a foaming agent production plant. The links between quantitative risk analysis steps and results and SMS procedure are explicitly shown. In conclusion, it is shown how a correct and careful risk analysis is necessary to design and implement a SMS able to pursue the policy's objectives allowing an effective revision of the policy itself.

3) 3. Safety management systems: A broad overview of the literature. (Yuling Li et al.) : This paper describes safety management systems (SMSs) on five core aspects: definition, evolution, models, and purpose and common elements of SMSs. A safety management system implements safety management activities, so an overview of definitions of safety and safety management sheds light on the content of an SMS. SMSs emerged from the risk concept and safety defences. The development of SMSs was boosted by research into 'safety', 'management' and 'system' theories, (safety) risk analysis techniques, safety audit tools, and related standards. Consequently, the study of SMSs became a multidisciplinary topic and through modelling SMSs, a generic framework can be established aiding the effectiveness of SMSs.

II. Objectives

A. Broad Objective

Identify the occupational hazards that exists in a specific workplace and to list them out.

B. Specific Objectives

1) The different risks in the work site are identified.

2) The identified risks are classified into different categories.

3) This study deals with the assessment of risks or hazards that can affect the workers on an industry.

4) The risk assessment process will be executed in the industry. All the health and safety aspects will be checked thoroughly and the conclusions will only be drawn after clear examination of each and every aspects.

5) The different methods for elimination of these hazards are also found out and listed.

III. Methodology

The entire project was divided into 3 phases. The phase 1 includes the literature survey undertaken. The basics of risk assessment and all was studied. Sample risk assessments were also taken into consideration during this phase. The second phase includes data collection. In this phase, I personally visited the worksite and all the necessary observations were taken by myself. The hazards were identified in this phase. The third phase includes the analysis of the data collected. After a thorough analysis, the hazards were categorised and control measures for elimination of these hazards were noted.

A. Procedure

1) Study of basic health and safety principles, risk assessments etc.

2) Collection of sample risk assessments done by various companies on their work sites.

3) Physical observation of the industrial site for identification of hazards.

4) Classification of the identified hazards into categories.

5) Finding suitable measures to eliminate the hazard.

6) There are hazards which can't be totally eradicated, the effect of these are minimized by using any of the other methods in the hierarchical order.

B. Data Collection

The data about the hazards where collected directly from KSRTC Central works, Pappanamcode. I personally visited the work site and all the major hazards were clearly identified. The identified hazards are categorized and tabulated. The measures for eliminating these hazards are also tabulated along with them.

C. Categories of Hazard

Hazard categories
Noise; vibration; radiation; mental ill-health; violence at work; substance abuse at work
Work related upper-limb disorders (ergonomics, workstation design etc); manual handling; load handling equipment
Hazardous substances
Health, welfare and work environment; working at height; confined spaces; lone working; slips and trips; movement of people and vehicles in the workplace; work-related driving
Work equipment and machinery
Fire
Electricity

Fig 1: Categories of Hazard

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D. Hierachy for Elimination of Risks

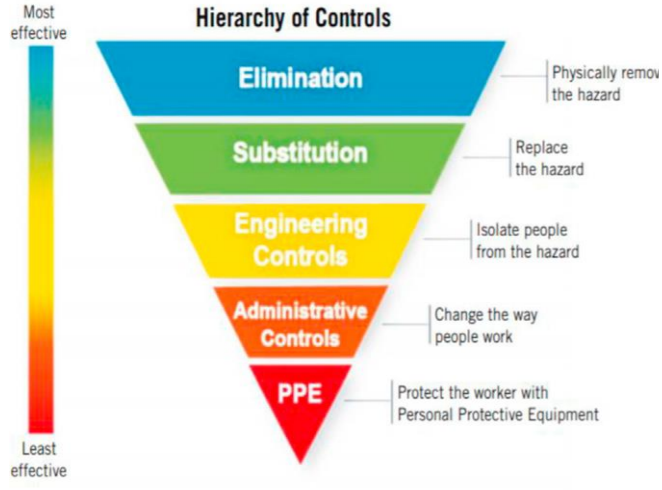

Fig 2: Hierarchy of Controls

1) Elimination
- The optimal risk management solution is to eliminate the risk.
- This is a long-term solution that should be attempted first.
- Once the risk has been eliminated, no more management controls, such as workplace monitoring and surveillance, training, safety auditing, and record keeping, will be required.

2) Substitution
- This process tries to replace a hazard with one that is less dangerous.
- The elimination of one hazard is promptly followed by a shift to another that has a far lower risk.
- In the case of chemicals, rather than replacing the chemical, replacing the same chemical with a safer form, such as powder with pellets, can provide a realistic, safer option.

3) Engineering Controls
- This stage tries to physically restrict the danger by implementing structural modifications in the work environment or work procedures, or by providing a barrier to prevent the line of transmission between employees and hazards.

4) Administrative Controls
- Administrative controls are also operational methods that reduce or eliminate the risk of a hazard by adhering to rules or instructions.
- Improving employees' awareness through measures such as occupational health education may also be an important component of a comprehensive strategy to preventive and protection.

5) Personal protective equipments (PPE)
- When all other control methods have been attempted, PPE should be used only as a last option, either as a short-term precaution during an emergency/maintenance/repair or as an additional safety measure.
- The reliability of this control is dependent on the proper selection of safety equipment, as well as the perfect fit, which must be worn at all times and kept in good condition.

E. Hazard Triangle

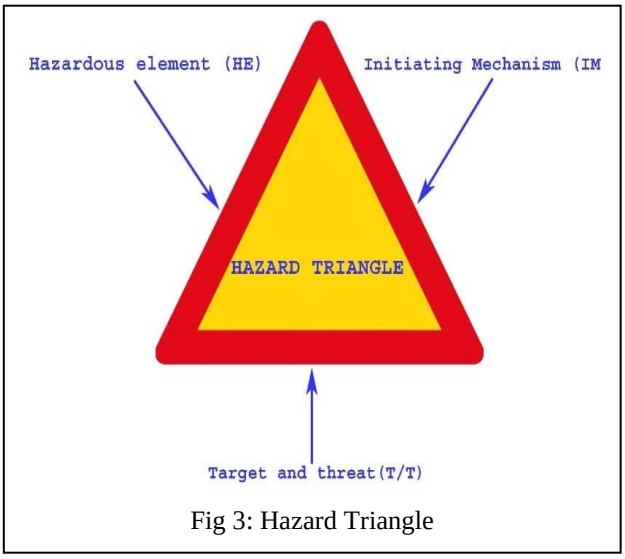

Fig 3: Hazard Triangle

1) Hazardous Element (HE): This is the basic hazardous resource creating the impetus for the hazard, such as a hazardous energy source, such as explosives being used in the system.

2) Initiating Mechanism (IM): This is the trigger or initiator event(s) causing the hazard to occur. The IM causes actualization or transformation of the hazard from a dormant state to an active mishap state.

3) Target and Threat (T/T): This is the person or thing that is vulnerable to injury and/or damage, and it describes the severity of the mishap event. This is the mishap outcome and the expected consequential damage and loss.

The three components of a hazard form what is known in system safety as the hazard triangle.

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IV. About the Industry

A. KSRTC Central Works, Pappanamcode

KSRTC Central Works is a state government-owned automobile manufacturing and assembly company that deals with large scale production of buses, it's overhauling, tyre resoling, assembly, repairing and body painting. It was initiated in the year 1965 and ever since became the sole supplier of transport buses for the state government.

The plant consists of 8 sections namely: Coachbuilding section, Bodypainting booth, Assembly section, Testing and Delivery area, Engine Overhauling section, Brake and Clutch Repair section, Tyre Resoling section and Body Repair section. The process of building a new bus starts when the newly bought bus chassis is brought into the assembly shop. The body of the bus which has already been made from the coach building section and completed its painting job from the body painting shop is mated with the chassis at this section. The completed buses are then sent for testing and are parked in the delivery area. The other sections of the plant are concentrated on repairing and maintenance of the buses. The parts and equipment for repair works are stored in the storage section of the plant.

The over-aged buses are dismantled and the parts are stored in the scrap yard inside the plant. For undergoing all these works various processes such as transportation, welding, grinding, cutting, assembling, painting etc. are done. The equipment for carrying out these processes includes forklifts, hoists, air compressors, diesel generators, spanners, torque wrench etc.

V. Results and Discussion

A. Results

The hazards are identified by physical inspection of the work site. A number of hazards were identified. The identified hazards along with the measures to reduce the risk of these hazards are tabulated below.

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Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
1. Hazardous Substance Exposure to hazardous vapours of paint when performing spray painting of the body of the bus on the spray paint booth.	Workers who work in the paint booth doing painting works. Automotive paints contain polyurethanes and isocyanates which are very toxic chemicals. Inhalation will cause breathing difficulties, headaches, asthma, nausea, dizziness, and fatigue. Long-term exposure can lead to more serious health problems like lung disorders, central nervous system, liver, and kidney damage leading to lung cancer.	1. The work is assigned to a competent worker. 2. PPEs such as helmets, gloves, goggles, safety boots etc. are provided. 3. Space is provided near the paint booth for the workers for keeping PPEs, painting materials etc. 4. The paint booth is well ventilated and illuminated. 5. Selected workers are given refresher training on the First aids. 6. The first aid kit is available in all sections.	1. Purchase Isocyanate free paints which are less toxic for use. 2. Install Local Exhaust Ventilation to discharge away from the generated vapours from the spray paint booth. 3. Periodic rest breaks must be given to workers to reduce the period of exposure to hazardous vapours of paint. 4. Job rotation patterns must be introduced in the working shifts. 5. Safety data sheets of the newly purchased paints must be provided to the workers. 6. The work must be carried out under a competent supervisor. 7. Conduct an induction training to give awareness to the workers about the importance of wearing PPE.

Table 1: Hazardous Substance

Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
2. Manual Handling Lifting, carrying, pushing and pulling of various engine components at the Engine Overhauling section without proper lifting techniques.	Workers working in the Engine overhauling section Engine components are either heavy or irregular shapes which is difficult to transport in the engine overhauling section. Workers tend to carry the loads for various purposes without any lifting techniques. Employees may get shoulder pain, back pain, wrist pain, back injuries, tendons and ligament injuries, and muscular injuries if they handle heavy things beyond their limits and fail to implement proper techniques.	1. For large objects, porters are present to help the manual handlers. 2. Engine Overhauling sections is having adequate spacing for proper working. 3. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 4. The workplace is well illuminated and ventilated. 5. Periodic rest breaks are given to workers. 6. Selected workers are given refresher training on the First aids. 7. The first aid kit is available in all section.	1. Purchase Mobile hoist cranes for carrying and transporting engine components. 2. Provide provisions like industrial platforms for keeping components to reduce the vertical lifting distance. 3. Provide provisions like midway tables to reduce the distance of carrying loads. 4. Job rotation patterns must be introduced in the working shifts. 5. Training must be given to workers on proper manual handling techniques.

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Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
3. Slips and trips Dumping of unusable rubber tyres and other discarded tyres in the walkways of the coach building leading to trip hazards.	All pedestrian workers Workers are prone to tripping over these wastes, resulting in a fall onto a level floor, resulting in knee injury, arm injury, bone fractures, skull fractures, head injuries, and even death.	1. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 2. The workplace is well illuminated and ventilated. 3. Coachbuilding works are done under proper supervision. 4. Selected workers are given refresher training on the First aids. 5. The first aid kit is available in all sections.	1. Introduce a safe system of the workplace such that proper housekeeping is done regularly removing obstruction materials from the walkways. 2. Appropriate warning signs depicting trip hazards must be provided. 3. A competent supervisor must be designated to monitor the housekeeping routines. 4. All workers should be given sufficient information and awareness about trip hazards and the resulting injuries.

Table 3: Slips and Trips

Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
4. Fire hazard Dumping of unusable rubber tyres and other discarded tyres in the walkways and near the coach building section where all the hot works such as welding and cutting activities are taking place.	All workers and visitors of the coachbuilding section. Sparks created during cutting and welding activities can travel distances and can cause a fire hazard. If workers are stuck inside the building, they will be prone to severe burn injuries or various degrees, skin burns, internal burns, and death.	1. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 2. Emergency firefighting equipment (Fire extinguisher, sand buckets etc.) are provided. 3. Proper instructions and awareness are provided to workers on injuries related to fire hazards and their aftermath. 4. Proper training and guidelines must be provided to workers on emergency evacuation procedures. 5. Fire drills on Emergency procedures are conducted periodically (twice a year). 6. Prohibition signs such as No Smoking are displayed. 7. Hot works are carried out under regular supervision	1. Move all flammable rubber tyres to an isolated area, away from the work area. 2. Implement safe working practise such that flammable wastes such as rubber tyres are not dumped around the coachbuilding. 3. Purchase fire-resistant blankets. 4. A fire watcher must be employed. 5. Fire and smoke detectors must be purchased and installed at strategic locations.

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Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
5. Work equipment and machinery (Handheld tools) Workers using torque wrenches improperly for tightening nuts and bolts causing the wrench to slip off the work, sudden break free of the workpiece, breakage of workpiece etc.	All workers working with wrenches and workers nearby. The tool may slip off from the hand causing injuries such as crushed toes crushed finger fracture at the wrist, multiple fractures to the leg and hand. Broken pieces of workpiece striking the nearby workers or the worker using wrench causing cut wounds deep cuts, eye injury, head injury, fractures and in worst-case scenario death due to blood loss.	1. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 2. Work is assigned to a competent worker. 3. The workspace is well illuminated. 4. Workers regularly clean the tools after use. 5. A good storage area is present to store all handheld tools including torque wrenches.	1. Purchase automatic wrench guns to avoid improper use of normal wrenches. 2. Introduce a system such that workers inspect the tool visually before and after use to ensure free from any damages or corrosion. 3. Introduce a safe system of work such that workers handle the tool carefully and appropriately. For example: - Avoid striking wrench with hammers to turn nuts and bolts. 4. Introduce a safe operating procedure such that workers should avoid abuse of tools and use it for jobs that they were not intended for. 5. Regular calibrating of the tool must be done to identify the extent of wear.

Table 5: Work Equipment and Machinery

Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
6. Load handling equipment The obsolete hoist is used for the lifting of various heavy automobile parts such as chassis, engines etc across the assembling unit.	All Workers who work in the assembly line. (Powerlifting operators) Any failure in the pendant stations, pendant cords and power cords of a hoist cause falling of objects leading to fatal injuries such as head injury, broken bones, fractures, amputation and death to the workers working beneath the hoist.	1. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 2. Work is assigned to a competent worker 3. Preventive maintenance is carried out regularly in the assembly unit. 4. An adequate Lifting technique is followed for the lifting of the engines and assembled components using the hoist. 5. The movement of the hoist is slow, to avoid the abrupt, jerky movement of the load.	1. The old and defective hoist must be replaced with a new pneumatic hoist. 2. Purchase a larger hook, for safer loading to avoid slipping and falling of the lifting engine components. 3. Implement a Permit to work system to prevent unauthorised workers to enter the work premises. 4. Provide training to the operators to inspect for any defects or unsafe loads on the load handling equipment before starting the work. 5. Load handling equipment such as the hoist must always be operated under supervision to prevent workers from standing underneath the hoist while carrying loads. 6. A safety check must be done before using the hoist.

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Hazard category and hazard	Who might be harmed and how? (Person Affected by the hazard)	What are they already doing? (Control measures already taken)	What further controls/actions are required? (Control measures needed to be implemented)
7. Working at height Workers working on inappropriate platforms such as faulty step ladders for welding of carriers on the top of the buses.	Welding workers performing the task, workers standing near the bus.	1. PPEs such as helmets, gloves, goggles, safety boots etc are provided. 2. Work is assigned to a competent worker. 3. The workplace is well illuminated and ventilated.	1. Single Scaffoldings must be purchased for working at height. 2. Barricades must be provided around the bus to prevent workers from standing nearby during the welding operation. 3. A Safe system of operation must be introduced such that ladders should not be used as a platform for any kind of works at height. 4. Faulty ladders must be replaced with new ladders and should be used only for low-risk and short-duration tasks. 5. Work must be carried out under a competent supervisor. 6. Implement a system so that the workers inspect the good condition of the scaffoldings before using them.

Table 7: Working at Height

B. Hazard Triangle

Sl No	Hazardous Element (HE)	Initiating Mechanism (IM)	Target and Threat (T/T)
1.	Vapours of paint	Spraying of paint in spray paint booth	Physical illness; death or injury.
2.	Overweighing engine components	Manual Handling of these components	Falling; death or injury.
3.	Discarded tyres in walkways	Tripping on these tyres	Falling; death or injury.
4.	Fire	Sparks from hot works that fall on tyres	Fire; loss of system; death or injury.
5.	Torque wrench	Wrench slipping from hand	Sprains or cuts; death or injury.
6.	Obsolete hoist	Crack in the hoist arm	Breaking of hoist; death or injury.
7.	Inappropriate platforms for working at height	Slipping or falling from these platform	Falling; death or injury.

Table 8: Hazards Triangle Elements

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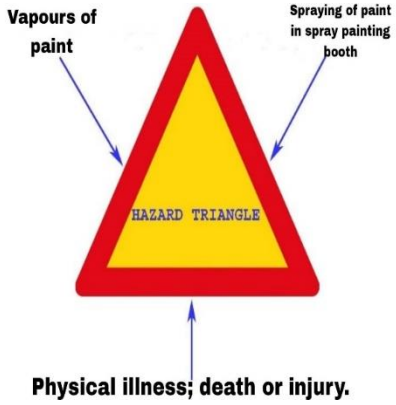
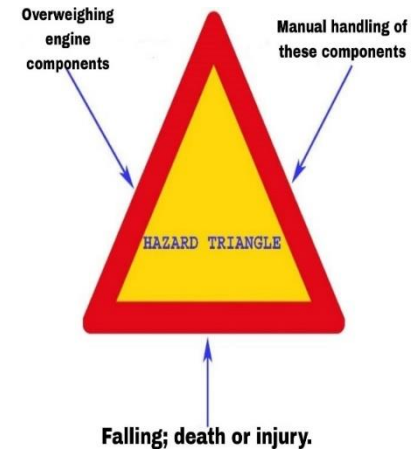
The various identified hazards are shown below in Hazard triangle formats.

1. Hazardous Substance

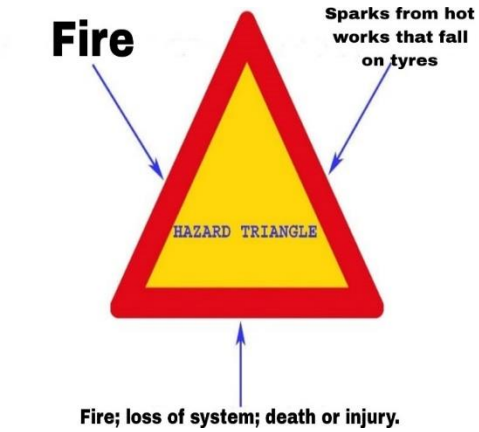


2. Manual Handling

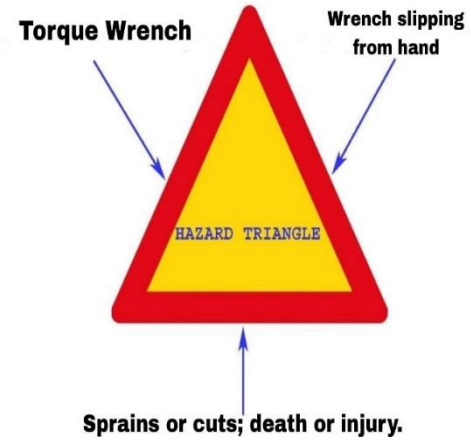


3. Slips and Trips

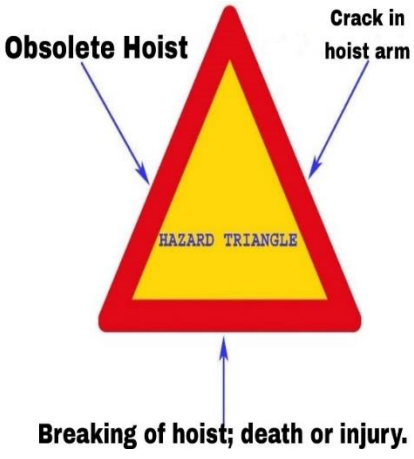
4. Fire Hazard



5. Work Equipment and Machinery



6. Load Handling Equipment



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7. Working at Height

VI. Conclusion

From the previous chapters, we have seen the various hazards that were present in the work site i.e., KSRTC Central Works, Pappanamcode. The collected data was analysed and was categorised according to the categories specified by International Labour Organization. The various measures for eliminating the identified hazards were also discussed.

The following conclusions were drawn after the work:

1) As a result of the physical inspection, 7 hazards were identified in various sections of the work site; namely hazards related with, hazardous substance, manual handling, slips and trips, fire hazard, work equipment and machinery, load handling equipment and working at height.

2) All these hazards are major hazards which can cause the loss of life of the workers exposed to these hazards.

3) Measures for eliminating these hazards are also identified by myself and these are also listed along with the hazards.

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