Risk Assessment and Analysis in Health, Safety and Environmental (HSE) Hazards of Bitumenous Waterproofing Industry Using HAZID Technique

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Abstract

Today, the use of risk assessment methods in various industries is expanding so that there are currently more than 70 types of different risk assessment methods in the world. These methods are usually used to identify, control and reduce the consequences of risks. The main methods of risk assessment are appropriate methods for risk assessment and their results can be used for management and decision-making to control and reduce its consequences. The purpose of this study is to identify and evaluate the risks to safety, health and the environment and to provide proposed and corrective solutions to reduce or eliminate HSE risks using the HAZID method. This descriptive cross-sectional study was performed for 4 months to identify the risks. For this purpose, a list of possible safety, health and environmental risks was prepared and the risk was evaluated by HAZID technique. In total, 5.15% of the identified risks are unacceptable, 20.62% are undesirable, 50.51% are acceptable, but 23.72% of the need for revision is minor. The results of this research include the implementation of measures such as safety training - professional training - inspection monitoring system - personnel safety management - preventive maintenance system management and forming a safety audit team - establishing regular House Keeping programs, etc. in identifying and Controls identified risks.

1. Introduction

The increasing growth of production, change of technology and application of new materials and machines has caused many injuries and deaths in various industries. Also, increasing losses or losses is the same as reducing profits and incomes, and today this decrease in profits and incomes reduces productivity. Therefore, in order to increase productivity and achieve the goals of organizations, we can identify and assess the risk of hazards in factories by reducing injuries and occupational deaths to reduce losses and losses [1]. One way to prevent workplace accidents is to identify and assess hazards at all stages of the system life. Risk assessment is: identifying the risks in a process, a job or a service, calculating their risk number and providing the best control measures to control them. In fact, risk assessment is a three-step process: identifying total risks - calculating risks - providing control measures that one of the solutions that can be done at different stages of the life of the risk assessment system is the HAZID (Hazard Identification) technique.

Hazid is a systematic method for identifying risks and assessing their risk in different stages, especially the initial stages of product-service formation in order to provide appropriate control measures. In this method, existing and potential risks and threats are examined in two general and partial ways [2]. There are many industries which are endangered by different risk. Like construcion, manufacturing, oil and gas, Coal mine industry and so forth which are recognized as highlyrisk-oriented environment. Integrated resilience engineering can be employed to minimize the damages and hazards caused by sudden changes in such systems [3].

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The main purpose of implementing this technique is to select safe, cost-effective design options and ultimately reduce the cost of damage caused by potential accidents. In fact, the use of Hazid has the following advantages: 1- Recognizing the importance and continuity of all aspects of health, safety, Environmental at the beginning of an operation. 2- An opportunity to consider the implications of HSE in process and development designs. 3- Investigate the potential impact of major design changes in the early stages of forming important financial commitments. 4- Identify threats and risks within each stage of a project life cycle Or Process. 5. Facilitate the process of preparing a list of HSE hazards and threats -6 Identify all potential pollutants from facilities and processes 7- Optimal use of resources

After presenting the results of this research, applying appropriate control measures through the establishment of monitoring and inspection systems, performing engineering measures, establishing regular House Keeping programs - teaching HSE issues to personnel, incentive and punishment program on safety issues to reduce risks to Offers an acceptable level.

2. Literature Review

The following are some of the most important research backgrounds in the field. Dominguez et al., in 2020, in a study entitled "Identification and analysis of risk in areas and production sector of work using the hazid method", concluded that 28 hazards were identified in production, warehousing and office areas. Electrical, mechanical, physical, chemical, biological, ergonomic, psychosocial, environmental, natural and situational. 43% of the risks are moderate, 22% significant, 21% tolerable, 7% trivial and 7% unbearable; It is therefore recommended that you comply with the requirements applicable by the official Mexican standards, practice authorities and compliance measurement indicators [4].

In 2020, Trisiana et al., in a study entitled Assessing Occupational Safety and Health Risks Considering Ohsas Variables Using Hazid-Hazop-Hira Methods, concluded that out of 48 identified risk factors, 47 had potential Medium risk and 1 factor has low risk potential. 12 solutions were proposed for 5 dominant hazards [5].

Imanizadeh et al., in a study entitled Hazard Diagnosis and Risk Assessment of movement and installation of metal molds in tall buildings by Hazid method, concluded that 3% of hazards in the low risk range, 48% in the range the risk is moderate and 49% is in the high risk range [6].

Hesami Arani et al., in a study entitled "Identification evaluation of safety and health hazards in swimming pools using the combination method Hazid - Alarp" concluded that after analyzing the data, 41 types of safety hazards and 35 types of health risks (potential and existing) were identified. A total of 7 work units and 6 jobs in swimming pools were classified and 52 types of health hazards and 69 types of safety hazards were identified, evaluated and classified. After taking corrective measures, according to the ALARP principle, unacceptable risks were classified as acceptable [7].

Davahi et al. in 2020 have conducted research on current applications of system dynamics methodology that address complex healthcare issues. The results indicate that the application of system dynamics has attracted significant attention from healthcare researchers since 2013 [8].

Park (2018) uses a tracking system to collect and use individuals’ location data in the proposed safety framework. A computational and analytical procedure/model was developed to quantify the safety performance of individual workers beyond detection and warning [9].

There many ways to manage pollution in environment and increase safety, regarding what type of pollutants are there it could be chosen a feasible solution. Namely, water pollution with rapid development of economy, heavy application of chemicals and imperfection of water management policies resulted in a series of water problems including water shortage and pollution [10]. Additionally air pollution is another serious environmental issue which had been a headline for many research in recent years. Many feasible solution have been suggested in research. Such as a study by Teimoury et al. in 2017 on new solution approach for air pollution. In this paper a real example is offered as an example of real-world problems and solved by metaheuristic algorithms. More clearly, the core problem consists of assigning producers to distribution centers, vehicle routing and service of distribution centers to clients in a supply chain of natural honey [11]. Another study in this field has been conducted by Daryayehsalameh et al. in 2021 regarding finding a more environment-friendly process for CO2 capture [12].

The aim of HAZID is first to produce a list of all possible hazards and second to evaluate them in order to priorities them. In order to support the evaluating procedure we propose HAZID as a tool the multi criteria decision analysis. The reasonis that the final decision depends on criteria, which correlate the potential hazardous scenarios with different consequences [13].
3. Analysis method

The present study is descriptive-analytical. Data collection was done by field method in 2020. After initial studies; the study area was described. All processes - activities and jobs in the factory; were identified and classified. In this step of research; Using a survey method (field visit and based on methods such as expert interviews; review of records and documents and analysis of processes; to identify safety, health and environmental risks caused by Bitumenous water proofing factory processes. The basis for identifying risks in this research; Based on the methods used; it is based on executive processes. In this study. Hazid method (identification of risk analysis) has been used to identify and evaluate occupational safety and health risks. This method focuses on identifying pre-existing hazards.

3.1. Method technique HAZID

Preparation of HSE checklist includes: 1- Environmental hazards 2- Health hazards 3- Safety hazards.

Risk Identification: At this stage, existing or potentially relevant risks are identified and identified.

Risk Assessment: In order to prioritize risks and control measures at this stage, hazards have been identified and classified. To perform this step, 3 parameters were identified: probability of accident - severity of consequence - Exposure risk.

| Table 1. Three-variable risk matrix |
|------------------------------------|
| L | The probability of an accident | E | Exposure risk | C | Severity of consequence |
|---|--------------------------------|---|---------------|---|------------------------|
| 10 | Very likely | 10 | Continuous or for many days | 100 | Catastrophic: several deaths, permanent and widespread Saddam |
| 6 | Likely: Not unusual, usually 50-50 chance of occurrence. | 6 | Continuous or for many days | 50 | Critical: Mortality, local and permanent injury |
| 3 | Unusual but possible (1 to 10) | 3 | Occasionally: once a week to once a month | 25 | Very serious: permanent illness / disability, abnormal injury |
| 1 | Unlikely (1 in 100) | 2 | Unrepeatable: once a month to once a year | 15 | Serious: Permanent illness or injury, adverse effects |
| 0.5 | Conceivable: Exposure has never happened in years but it can happen (1 in 1000) | 1 | rare | 5 | Important: Need for medical care - Emission of pollutants without harm to the environment |
| 0.1 | Practically impossible (1 - 10,000) | 0.5 | Very rare | 1 | Minor: Minor diseases |

| Table 2. Decision criteria based on risk number |
|-----------------------------------------------|
| Degree of risk | Risk number |
| unacceptable | >600 |
| Undesirable | 301-599 |
| Acceptable on appeal | 91-300 |
| Minor | <90 |

Observation, interview, review of documents and completion of checklists were used to determine the probability of the accident, the severity of the outcome and the amount of contact. The risk number was calculated using the following formula:

\[ \text{Exposure rate} \times \text{Severity of consequence} \times \text{Probability of occurrence} = \text{Risk number} \]

Control measures: Based on the evaluation of risks and their prioritization, control measures are presented and according to the classification of risks, it can be ensured that control measures are applied effectively.
Table 3. Some of the identified risks based on the level of risk obtained

| Risk number | Dangers                                                                 | Risk number | Dangers                                                                                 | Risk number | Dangers                                      |
|-------------|-------------------------------------------------------------------------|-------------|----------------------------------------------------------------------------------------|-------------|----------------------------------------------|
| 270         | Defects in conveyor belts, gears, chains, etc.                          | 135         | The equipment is not connected to the earthing system                                   | 90          | Fire during testing                          |
| 300         | Enclosed space and operation hole                                       | 300         | Wire connection due to faulty wiring                                                    | 540         | Improper handling                            |
| 270         | Inhalation of toxic and dangerous gases (gas fumes)                    | 900         | Overheating of furnaces, mixers, tanks                                                  | 150         | In the spring of maintenance and cutting of tow ropes |
| 540         | Noise pollution caused by equipment and devices                         | 180         | Failure to follow emergency instructions                                                 | 540         | Lack of sufficient staff knowledge           |
| 540         | Air pollution                                                           | 270         | Throw pleats and lava on the face and eyes                                              | 150         | Pressing the on / off button incorrectly without coordination with the relevant administrator |
| 540         | Improper transportation of equipment                                    | 300         | Stuck and crushed between the transmission points and the moving and rotating device    | 450         | People slip and fall                         |
| 150         | Viral risks (corona - hepatitis - rabies - AIDS - warts)                | 270         | Wear, corrosion and leakage of hoses, pipes, tanks, furnaces                           | 180         | Excessive Electric current                   |

4. Findings

The identified environmental safety and health risks are presented in Table 4 and 5.

Table 4. Some examples of occupational health and safety risk assessment and environment with HAZID technique

| Cause of Risk                                                                 | Consequences of risk                   | Probability of occurrence- Severity- Exposure risk | Level of risk |
|------------------------------------------------------------------------------|----------------------------------------|---------------------------------------------------|---------------|
| Power cable defects & hazards of contact with power lines                    | Electric shock - death                 | 6*15*2                                             | 180           |
| Insulation of electrical wires before starting work - Technical and continuous inspection of electrical equipment to ensure their correct operation | Overcurrent capacity in cables, belts and transformers, which causes insulation failure. | 6*15*2                                             | 180           |
| Human error (forgetfulness and carelessness)                                 | Burn - Electric shock - Death          | 6*25*3                                             | 450           |
| The equipment is not connected to earthing system                            | Life and financial risks               | 3*15*3                                             | 135           |
| Wire connection due to faulty wiring                                         | Fire - burns equipment and people       | 6*25*2                                             | 300           |
| Use of FLP lights (anti-spark according to IEC standard) - Inspection and replacement of defective and worn wires and fuses - Selection of fuses and short guards - Execution of wiring in accordance with relevant standards - Complete connection of electrical equipment to the Earthing well. | Equipment wear and tear and its complications - Fire due to equipment corrosion - Bursting of pipes and fittings | 6*25*2                                             | 300           |
### Table 5. Some examples of occupational health and safety risk assessment and environment with HAZID technique

| Cause of Risk                                                                 | Consequences of risk                                                                 | Probability of occurrence - Severity - Exposure risk | Level of risk |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------|---------------|
| Bursting of hoses and pipes                                                  | Fracture, contusion - flooded                                                       | 6*15*2                                               | 180           |
| Risks of opening and closing equipment                                       | Fire - electric shock - fracture                                                     | 6*15*2                                               | 180           |
| Issuance of ptw - Installation of warning signs - Personnel training         | Hand collision with blade and rotating part - Injury - Disability - Stuck hands and clothes on rotating equipment. | 6*3*15                                               | 270           |
| Break the blade and get it off the main axis                                | Throwing a blade at a person - amputation - loss of vision - injury                  | 6*3*15                                               | 270           |
| Selection of suitable and standard blade - Periodic inspection of the blade maintenance axis - Protective cap on top of the blade - Ensuring the correct operation of the blade | Cuts or amputation                                                                  | 6*2*15                                               | 180           |
| The blade stays rotating after turning off                                  |                                                                                      | 6*2*15                                               | 180           |
| Throwing pleats in the eye due to lack of clamps                             | Loss of vision - Retinal damage - Corneal surface abrasion                            | 3*6*25                                               | 180           |
| Improper transportation of equipment                                         | Osteoarthrits of the neck and back - changes in a person's physical condition over time | 6*6*15                                               | 540           |
| Adequate training in ergonomics, job rotation, and rest stations, 3-shift work shifts, transportation of vehicles with conveyors, jacks and forklifts. | Diabetes due to inactivity - osteoarthrits of the neck and back - increased stress | 3*6*15                                               | 270           |
| Standard work space of 12 cubic meters for each person - principled arrangement of raw materials - scheduling for people to rest - job rotation - evaluation of ergonomic detrimental factors.
Table 6 Final results related to occupational safety and health risks and environmental rankings.

| Differential frequency rating of risks according to the level of risk. | Unacceptable | Undesirable | Acceptable on appeal | minor | Total |
|---|---|---|---|---|---|
| total | 5 | 20 | 49 | 23 | 97 |
| Percentage | %5.15 | %20.62 | %50.51 | %23.72 | 100% |

Figure 1. Distribution chart of percentage levels of health, safety and environmental risks using HAZID technique

5. Conclusions

Evaluation results were recorded and presented in HAZID worksheets. In this study, 16 main risks with 97 risk causes were identified and evaluated. Based on the results of the research and based on the evaluation of the risks of the Bitumenous waterproofing industry, which is a large source of flammable and explosive materials, the necessary standard was given to prevent the recurrence, severity and possibility of accidents. Comply with NFPA guidelines and standards. Electrical wires and cables should be installed in accordance with safety principles and valid international standards. Also, the Earthing system, including the connections and ground resistance, should be checked regularly to prevent the reduction of the performance of this system. It is necessary to install an active lightning rod on the building. Due to the high potential of fire and the production of toxic and dangerous gases, it is necessary to develop an emergency response plan and maneuver to assess the readiness of personnel. Also, fire modeling should be done, the results of which can be used to determine the area affected by the fire. It is necessary to identify, design and install automatic fire alarm and extinguishing systems in important places. Springs Belts Chains should be repaired and replaced when needed and have protection. PM-EM-CM repair system should be inspected and implemented. In cargo transportation operations with conveyor belts, cranes, elevator lifts, etc., technical inspection is necessary by observing Safe Working Load (SWL) in loading operations.

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