PalArch's Journal of Archaeology of Egypt / Egyptology

# A RISK ANALYSIS OF OCCUPATIONAL SAFETY LEVELS FOR OPERATORSON COMPANY X USING A HAZOP METHOD WITH AN FTA APPROACH

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**Irfan Ramdani, MuhRikyFirdaus, Ricky YastenFahik, ZidanLazuardi, YaniIriani. A Risk Analysis Of Occupational Safety Levels For Operators On Company X Using A Hazop Method With An Fta Approach-- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(5), 735-745. ISSN 1567-214x**

**Keywords: Occupational Safety And Health; Hazop; Hazard Identification; Fta**

## ABSTRACT

Company X is a manufacturer of airplanes and helicopters that also offers aircraft engines inspection. In an effort to execute its business goals, company X on behalf of its production division owns a lower or an airplane wing process where the division faces extremely high potential risks. The purpose of this study is to identify and analyze the problems faced by Company X. HAZOP and FTA were two methods employed in this research. According to the research findings by means of HAZOP, 8 potential hazards were figured out with 1 low-risk problem, 2 medium-risk problems, 4 high-risk problems, and 1 extreme-risk problem. While, by means of the FTA method, the results revealed 4 problems that are categorized as basic events. The emersion of the troubles is due to the poor lightings. All in all, it is hoped that this study can be a recommendation and offer the company way of betterment in terms of the system.

## INTRODUCTION

Indonesia is continuously growing. The country now develops its national structures and facilities. The factories are rapidly progressing and the flow of globalization brings about significantly huge influences on the international

businesses of today, specifically in Indonesia. The industrial growth is hand in hand with the advancement of technology to consistently supply convenient production processes and also to endure many kinds of other potential risks and hazards. [1]. Competition among companies for resource optimization must be able to result in high-quality productions. Throughout the production time, any kind of job cannot be separated away from the occupational safety and health. [2]. Referring to the International Labor Organization, there are around 1.1 million people die every year because of occupational accidents. The two most reported reasons are illness and occupational accidents [3].

Company X is a pioneer of airplane and helicopter manufacturer in this country. It is not only producing planes butalso providing aircraft engine maintenance services, such as replacing the broken spare parts. This company can compete with other similar business rivalries in the global market by bestowing the best service in every single manufacturing process [4]. Company X has more or less 4000 workers so it must oversee itsproduct manufacturing processes by implementing a K3 program that has already written in article 87 of Indonesia Constitution Number 13 in 2013. The article elucidates that "a company that has more or less 100 workers must implement the K3 management system" [5]. Company X has executed this K3 program, however, cases relating to occupational accidents are still occurring along the way. Therefore, the company has to immediately look for a way to overcome the potential hazard cases by indicating the possible matters. A large number of unfortunate incidents in the workplace arethe result of inconvenient surroundings [6]. This corporation can investigate the working accident cases by means of the HAZOP method that is able to identify the issues and to help to make decisions, ormaking use of the FTA method to investigate the issues.

## LITERATURE REVIEW

Occupational safety is initiated with the intention of preventing any accident in the workplace so that the working performance, especially in the production sector, can be effectively fostered.

Referring to Mangkunegara (2013), job safety and health can unveil someone's mental or physical illness due to the working sphere factor. The too long duration of working that is exceeding one's working-time capacity, such as working overtime, can negatively affect someone's mental and physical state, such as feeling stressed and mad when in the office [7].

Concerning the problem, the HAZOP method can be the problem solver. HAZOP prevents working accidents so the activities in the workplace will remain conducive and smooth (Juliana, 2008) [8]. Moreover, the FTA method can also be utilized to analyze what is being analyzed by HAZOP and to give recommendations of what to do so that employees can make a decision and improvement regarding a previous failure in a company system.

## RESEARCH METHODOLOGY

### *Theories of danger and practicality (HAZOP)*

HAZOP is a problem identifier in which problems will possibly halt the manufacturing process (Juliana, 2008).
Followings are the HAZOP's executing procedures [9]:

1. Process: an executing place
2. Hazard sources: possible dangers that can emerge
3. Deviations:restrictions administered
4. Causes: deviations that will most likely occur
5. To-do Actions: avoid the causes
6. Consequences: an accident will result in a loss
7. Severity: extent of the damage
8. Likelihood: a thing that is possible to happen
9. Risks: a merger between severity and likelihood

Below are tables of criteria for Likelihood, Severity, and Risk Level.

**Table1.** Likelihood

| Likelihood | | | |
|---|---|---|---|
| Level | Probability Scale | Explanations | |
| | | Qualitative | Quantitative |
| 1 | Improbable | Can't be expected in extreme circumstances | Rarely happen within 10 years |
| 2 | Unlikely | Not happening yet, but can appear/occur at any time | Once in 10 years |
| 3 | Equally Likely | Supposed to happen and might happen | Once in 5 years until once in a year |
| 4 | Likely | May occur under any circumstances | More than once per year |
| 5 | Almost Certain | Often expected to appear under the most frequent circumstances | More than once per month |

**Table2.**Severity

| Consequences/Severity | | | |
|---|---|---|---|
| Level | Descriptions | Injury Severity | Working Days |
| 1 | Insignificant | The accident causesno harm or injury to | Does not cause loss of workdays |

| | | | |
|---|---|---|---|
| | | humans | |
| 2 | Minor | The accident causes minor injuries and losses and does not cause any serious impact on business continuity | Can still work on the same day or shift |
| 3 | Moderate | The accident causes injuries and needs hospitalization with moderate financial losses but does not cause any permanent disability | Miss less than 3 workdays |
| 4 | Major | The accident causes serious injuries or permanent disability, huge detriments, and a severe impact on the company's progression | Missing 3 or more workdays |
| 5 | Disastrous | The accident results in death and huge deprivation that can stop the business activity forever | Missing workdays for a lifetime |

**Table3.**
***Risk Level***

Scale

| (Risk Level) | | | | | | |
|---|---|---|---|---|---|---|
| Kemungkinan (Likelihood) | 5 | 5 | 10 | 15 | 20 | 25 |
| | 4 | 4 | 8 | 12 | 16 | 20 |
| | 3 | 3 | 6 | 9 | 12 | 15 |
| | 2 | 2 | 4 | 6 | 8 | 10 |
| | 1 | 1 | 2 | 3 | 4 | 5 |
| Skala Severity/Consequences | | 1 | 2 | 3 | 4 | 5 |
| | | Keseriusan (Severty/Consequences) | | | | |

***Descriptions:***

a. : Low Risk Level
b. : Moderate Risk Level
c. : High Risk Level
d. : Extreme Risk Level

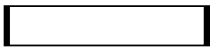
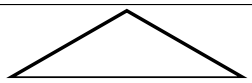
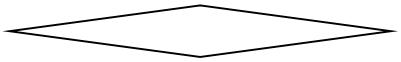
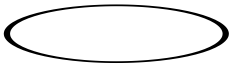
Risk Level Formulation:

Likelihood (L) = 4
Consequences (C) = 4
Conclusion:
L x C = 16 (16 is in the purple box that means it is classified as Extreme Risk)

***Fault tree analysis (FTA)***

FTA was initially found by knowledgeable researcherswhom one of them was Bell Laboratories. FTA is a tree diagram functioning as analysis studies of the management risk that emergesat a particular time (Vesely, 1981) [10].
The FTA's symbols are displayed in the table below [11]:

**Table4.**Symbols Used in FTA Method

| Description Symbol | Keterangan |
|---|---|
|  | Top event |
|  | Logic event OR |
|  | Logic event AND |
|  | Transferred event |
|  | Undeveloved event |
|  | Basic event |

## RESULTS AND DISCUSSIONS

The data employed in this research were primary and secondary. From the observations, the researchers found out the sources of the hazard along with the classifications.

Table of findings of hazard sources can be seen below:

**Table5.**Sources of Hazard Findings

| No | Types of Risks |
|---|---|
| 1 | Hearing impairment |
| 2 | Musculoskeletal disorders |
| 3 | Hand injuries |
| 4 | Head injuries |
| 5 | Visual impairment |
| 6 | Floor installation |
| 7 | Stumbled by JIG |
| 8 | Insufficient lighting |

Here are the descriptions of the 8 observation results;

a. The hearing impairment is caused by the misuse of Ear Plug by some operators violating the SOP that eventually leads to danger. Not using Ear Plugs can bring an impact on hearing loss because of the sound of Rivet installation.

b. Muskuloskeletal disorderis usually riskyfor operators who work at the lower assembly working area. It is caused by the improper working position leading to injury or Muskuloskeletal disorder.

c. Hand injury is caused by the inappropriate use of Safety Gloves as written in the SOP that finally leads to a hazardous source for operators. Not wearing Safety Gloves can cause injuries on operators' hands.

d. The head injury is caused by the misused Safety Hat as explained in the SOP leading to another hazardous source. If an operator does not use a Safety Hat, it can raise the probability to get a head injury as a consequence of being stumbled by equipment at the working place.

e. Visual impairment is the consequence of operators who do not accordingly utilize the Safety Goggles as written in the SOP leading to a source of hazard. Not using the Safety Goggles can lead to visual impairment as the operators deal with relatively small things and tools.

f. Floor installation can pose a danger to the on-duty operators. It can cause tripping because operators are moving.

g. After undertaking observations, stumbled by JIG is one of the possible sources of danger for operators. It can cause injury as the lower assembly area always moves from one side to another

h. Insufficient lighting can be another source of hazard source at the lower assembly working place. It can decrease the operators' ability to see an object that they may unconsciously give defects on the product.

Furthermore, based on the data collection, Risk Leveling is administered to find out the occurring hazards.

The hazard identification and leveling can be seen in the following table [12]:

**Table6.**Risk Assessment Ranking

| | Process | Hazard Findings | | | | |
|---|---|---|---|---|---|---|
| | No. | U ‹ | C* | S* | *Risk Level* | |
| *Lower* | 1 | C Hearing Impairment | 1 | 4 | Seda | Moderate |
| | 2 | Musculoskeletal disorders | 2 | 10 | Ting | High |
| | 3 | l Hand Injury | 3 | 9 | Ting | High |
| | 4 | L Head Injury | 3 | 12 | Ting | High |
| | 5 | Visual Impairment | 3 | 12 | Ting | High |
| *Lower* | 6 | Floor Installation | 2 | 6 | Seda | Moderate |
| | 7 | Stumbled by JIG | 2 | 4 | Renc | Low |
| | 8 | P Insufficient Lighting | 4 | 12 | Eksti | Extreme |

The Risk Leveling of each hazard finding is performed afterward.

**Table7.**Risk Leveling of Hazard Findings

| No. | Sources of Hazard | Risk Level |
|---|---|---|
| 1 | Hearing impairment | Moderate |
| 2 | Musculoskeletal disorders | High |
| 3 | Hand injuries | High |
| 4 | Head injuries | High |
| 5 | Visual impairment | High |
| 6 | Floor installation | Moderate |
| 7 | Stumbled by JIG | Low |
| 8 | Insufficient lighting | Extreme |

**Table 7** depicts a risk leveling generated from the observation data that are classified according to the likelihood, that is the possibility of the hazard occurrence table. It is concluded that stumbled by JIG is classified into the low-risk hazard category, while hearing impairment and floor installation are classified into a moderate-risk hazard category. Muskuloskeletal disorders, hand injury, head injury, and visual impairment are categorized in the high-risk hazard source. The most 'extreme' hazard source is insufficient lighting. The purposes of the hazard sources leveling are to re-identify the Lower working area and to give suggestions to company X to do refinement or improvement of the area.

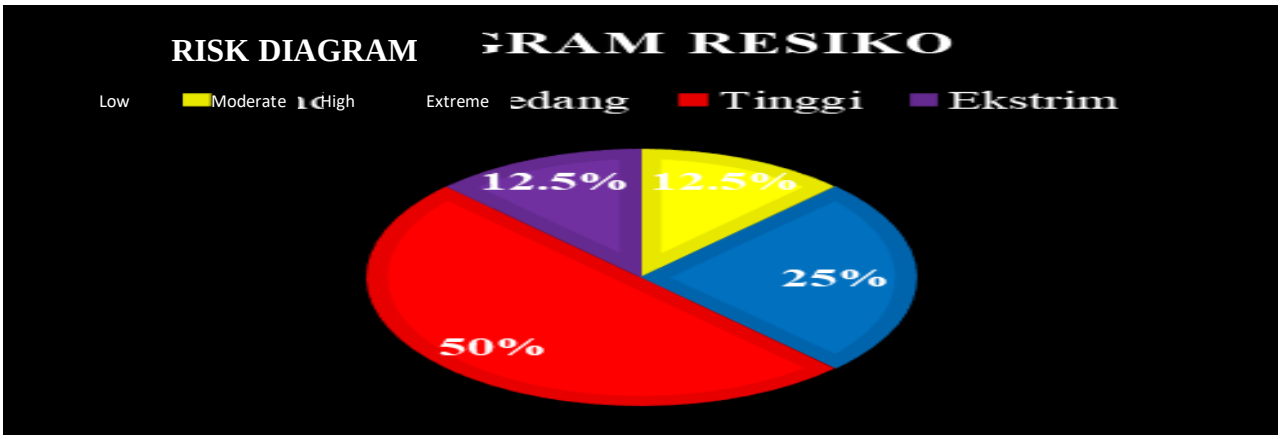



**Figure1.**Risk Diagram of the Hazard Sources at the Lower Assembly Area

The risk diagram in Figure 1 is created to put the readers at ease in understanding the risk leveling results. The diagram depicts that the highest risk percentage (50%) goes to the lower assembly areas, while 25% is for the moderate risk, 12.5% for the low risk, and the rest 12.5% for the extreme risk. These results are acquired from the hazard sources that still emerge in the manufacturing area. Those hazards bring about unfavorable impacts so that refinement and improvement in the lower production sector is very much needed to ensure the manufacturing process will run better than before.

The analysis of the FTA method was undertaken afterward. It ascertains the thing that takes place in a particularly dangerous areathathas been identified. The greatest score in the HAZOP's worksheet goes to the insufficient lighting in which it is also classified into the extreme risk level.

The following figure illustrates the FTA method :

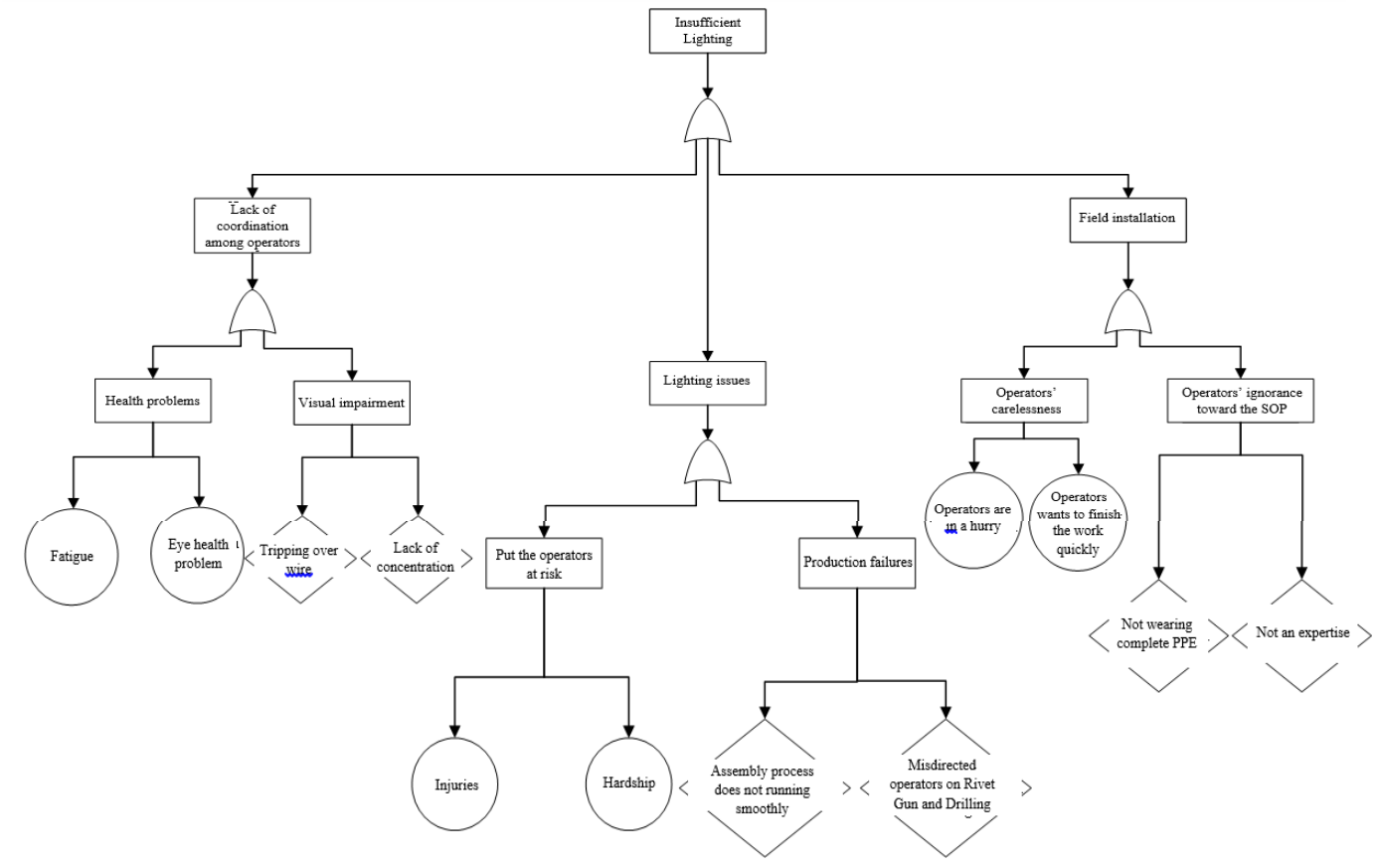



**Figure 2.** Fault Tree Analysis of Lighting

**Figure 2** elucidates the major issue of the investigation results that become the central focus of the whole problems and needs to be solved as soon as possible. Seen from the HAZOP leveling, the highest rank at the top event goes to the "Insufficient lighting". It is classified into an extreme risk level because the lack of lighting fatally can lead to imperfect or defective products. Therefore, perfect lighting is the most essential factor for this company. It can help the company to identify which product should be fixed so a great deprivation can be anticipated. In addition, The FTA tree diagram has a number of symbolic categorization of events.

## CONCLUSION

According to the observations, the researchers conclude that:

1. There were 8 hazard sources in the Lower production area, such as hearing impairment,
Muskuloskeletal disorders, hand injury, head injury, visual health problem and impairment, floor installation, JIG stumbling, and insufficient lighting.
2. The Lower production area was classified as the 'extreme' risk level, the Muskuloskeletal disorders, hand injury, head injury, visual health problem and impairment are in the 'high' risk level; hearing impairment, floor installation are in 'moderate' risk level; and JIG stumbling is the 'low' risk level.
3. All the hazard sources in the workplace have been identified. One source included in the 'extreme' risk category has been analyzed using the FTA method that imparted recommendations to repair and refine the hazard source.

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