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Occupational Health and Safety

Analysis of Potential Work Accidents at PT. XYZ Using The Hazard and Operability Study Method

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A B S T R A C T

Electricity is a major economic factor in Indonesia. Providing electric power is divided into three processes, namely generation, transmission and distribution. PLN is one of the electrical energy providers in Indonesia which plays an important role in providing sufficient electricity for daily activities, industry and other sectors. K3 is an important factor that must be applied to PLN because it is related to electricity. The Transmission and Substation Service Unit (ULTG) carried out time-based maintenance, condition-based maintenance and emergency maintenance and it was found that one of the workers was not using complete Personal Protective Equipment (PPE) when checking the Lightning Arrester (LA). So research is needed with the aim of analyzing K3 in the activity process to determine potential hazards and hazard risk levels. Descriptive research methods are used to analyze the risk of work accidents that may occur during maintenance. This research uses the Hazard and Operability Study (HAZOP) method to determine the value of possibilities and consequences by distributing questionnaires to K3 supervisors. PT. A B C. The results show six hazards with a high risk level, one hazard with a medium risk level, and six hazards with a low risk level. High risk caused by material, electrical voltage and work attitude. Risk controls include testing equipment and PPE several times a year, refilling PPE, complying with SOPs, and providing drinking water. Hazard control efforts at PT. ABC includes the use of the HAZOP method, implementation of clear SOPs, provision of appropriate PPE, routine equipment checks, and emergency response plans in emergency situations.

1. INTRODUCTION

Occupational safety and health or commonly abbreviated as K3 is important and cannot be separated from a labor system and human resources in an industry. A qualified, productive, and competitive workforce will increase work productivity. Health conditions are the main capital of workers in carrying out their duties, unhealthy work environment factors are also an additional burden for workers beyond the tasks given to them by the company. Management of worker health and the work environment is expected to create work synergies that can increase work productivity [1].

Given the important role of labor in a company, the safety and health conditions of the workforce need to be of particular concern so that workers can carry out their duties properly. In addition, occupational safety and health is the human right of every worker. A safe and healthy work environment is an important element in supporting the safety and health of the workforce. The implementation of occupational safety and health (K3) is an effort to create a workplace that is safe, healthy, and free from environmental pollution, so as to reduce or free from work accidents and occupational diseases [2].

Activities related to electricity will be very dangerous if not equipped with personal protective equipment, both for field employees and office employees. Power generation companies must have a competent workforce in accordance with their role. The company is required to be able to pay more attention to the safety and health of employees, so that they can be able to realize the goals of the company.

PT. ABC is engaged in transmission services which has the main function of managing distribution installation assets (transmission and substations) and maintaining installation assets to maintain the continuity of high-voltage electricity distribution efficiently, reliably and environmentally friendly. When carrying out routine 2-year maintenance work at PT. ABC, there is one worker who does not wear complete Personal Protective Equipment (PPE), during the process of checking the Lighting Arrester (LA) this is the cause of a work accident.

Figure 1. Maintenance of MTU Bay jepara 2

Several previous studies related to work accident prevention measures have been carried out, with the results found that the highest potential hazards occur in the classification of work procedures, namely as much as 50% [4]. Next, another study obtained results, namely the existence of 5 sources of danger (hazard) [5]. Then the highest level of risk is found in the source of danger (hazard) conveyor schingga can be considered to get the most important improvements. Then another study found 50 types of potential hazards with 3 risk categories that have the potential for work accidents to occur [6]. With the following details: one source of danger in the high risk category, 6 sources of danger in the medium risk category. Then improvements are also made such as K3 training, supervising work, and carrying out maintenance on machines and other equipment.

Based on these existing problems, this research was prepared with the aim of conducting a risk analysis of occupational safety and health at PT ABC so that it can take control and prevention measures against hazards that have the potential to appear in the workplace.

2. LITERATURE REVIEW

2.1. Occupational Safety Health (OSH)

The general understanding of safety is aimed at ensuring that work is carried out without occupational diseases and accidents. Therefore, all workers in the workplace must create safety in the work environment so that it is not dangerous in order to achieve the goal of optimal work results. [7].

From a philosophical point of view, Occupational Safety and Health (OSH) can be interpreted as a form of effort that ensures labor is given protection, perfection of worker integrity and work culture, as a whole providing welfare to workers (both physical and spiritual). While from a scientific point of view, Occupational Safety and Health (OSH) is determined from knowledge and its application to accidents, explosions, fires, pollution, diseases and other events. [8].

2.2. Hazard and operability study (HAZOP)

HAZOP can be defined as a standardized procedure whose use aims to establish safety in new or modified systems for possible risks or potential hazards [9].

The likelihood criteria are used to calculate the probability of an accident risk occurring based on the frequency per unit of time (day, month, year). Meanwhile, the consequences criteria refer to the impact of risk, which is classified based on the severity of the impact from potential risk events [10].

In conducting hazard analysis using HAZOP, the likelihood criteria are required. These criteria can be seen in Table 1. Meanwhile, the consequences criteria for risk assessment can be found in Table 2.

Table 1. The Likelihood Criteria [10]

Level	Criteria	Description	
		Qualitative	Semi-Qualitative
1	Rarely happens	Can be imagined, but only in extreme cases	Happens less than once in 10 years
2	Unlikely to happen	Hasn't happened yet, but may occur at some point	Happens once within a 10-year span
3	Likely to happen	Should happen and may have occurred here or elsewhere	Happens once in 5 years to once every year
4	Very likely to happen	Can easily happen, may occur in the most frequent situations	Happens more than once a year to once a month
5	Almost certain to happen	Happens frequently, expected in most frequent situations	Happens every month or more than once a month

Table 2. Consequences Criteria [11]

Level	Criteria	Description	
		Injury Severity	Work Day
1	Insignificant	The event does not cause injuries and does not result in material losses	No lost workdays
2	Minor	The event causes minor injuries treatable with first aid and results in material losses	Lost workday on the same day
3	Moderate	The event causes serious injuries requiring hospital treatment and results in moderate material losses	Lost workdays below 3 days
4	Major	The event causes severe injuries leading to permanent disability and results in significant material losses	Lost workdays more than 3 days
5	Catastrophic	The event results in fatalities and causes extensive material losses	Permanent loss of workdays

In the risk severity assessment process using the risk matrix table, the likelihood and consequences values obtained are processed using the risk matrix table to determine the severity of the risk. Each color means a different score or risk value or risk level.

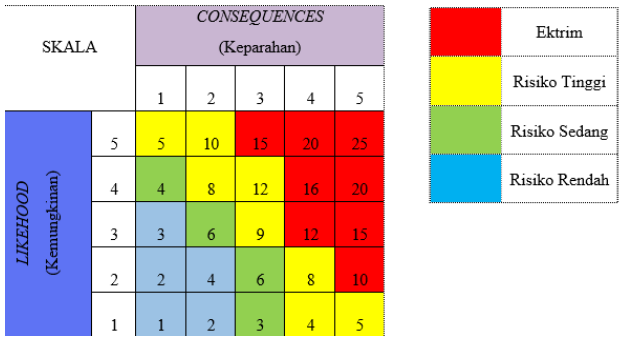

Figure 2. *Risk matrix* [12]

3. METHODOLOGY

The method chosen for this research is the descriptive method because it aligns with the research objective of providing an objective overview of risk analysis for potential workplace accidents during the biennial maintenance process at PT. ABC. The research process is divided into 5 stages, namely:

a. Stage 1, observation in the K3 section at ULTG kudus to find problems and conduct literature studies from scientific articles.
b. Stage 2, interviews and documentation to obtain data on potential hazards and their sources.
c. Stage 3, data on potential hazards and their sources are obtained to determine the level of hazard risk based on the risk matrix with reference to AS / NZS: 2004.
d. Stage 4, discussion is conducted to determine improvement efforts
e. Stage 5, conclusions and suggestions from the research

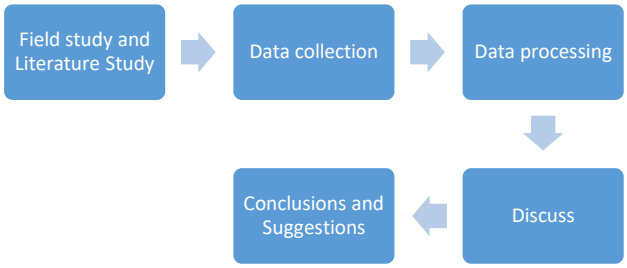

Figure 3. Research Stages

4. RESULTS AND DISCUSSION

4.1. Data Collection

a. Hazard and Risk Identification Data

Table 3. Hazard and Risk Identification

Process	Hazard Findings	Risk
Making work records	Recording errors	Work delay
Moving equipment into the truck	Equipment falling and hitting the worker	Bruises, damaged equipment
Installing hazard signs at the work site	High temperature	Dehydration
Workers wearing PPE	Harness entanglement	Bruises
Conducting safety briefing	High temperature	Dehydration
Groundman preparing work equipment & lifting it onto the scaffold	Equipment falling and hitting the groundman, incorrect positioning while lifting	Bruises, damaged equipment, sprains, muscle injuries
Testing all MTUs at Bay Jepara 2 and cleaning isolators with the help of the PDKB team, as some parts are still live (under voltage)	High temperature, vehicle noise, bad weather, slipping from ladder, equipment (tools) contacting network and grounding, PPE leakage	Respiratory issues, fatigue, dehydration, heat stroke, hearing impairment and loss of concentration, work delay/failure, falling from height, equipment damage, cuts/fractures, burns/ disability
Testing LA (Lightning Arrester) including tan delta testing, insulation testing, contact resistance testing, and LA counter testing	High temperature, vehicle noise, bad weather, slipping from ladder, equipment (tools) contacting network and grounding, PPE leakage	Respiratory issues, fatigue, dehydration, heat stroke, hearing impairment & loss of concentration, work delay/failure, falling from height, equipment damage, cuts/fractures/skin bruises, electrical shock, burns/disability
Testing CVT (Capacitive Voltage Transformer) including tan delta testing, insulation testing, and contact resistance testing	Bad weather, slipping from ladder, equipment (tools) contacting network and grounding, PPE leakage	Respiratory issues, fatigue, dehydration, heat stroke, hearing impairment and loss of concentration, work delay/failure, falling from height, equipment damage, cuts/fractures, burns/disability
Testing of PMS Line (DS/Disconnection Switch) includes insulation testing and contact resistance testing.	High temperatures, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage.	Fatigue, dehydration, heat stroke, loss of concentration, delayed/failed work, damaged equipment, skin tears/bruises, electric shocks, burns/disabilities.
CT (Current Transformer) testing in the form of tan delta testing, insulation testing, and contact resistance testing	high temperature, bad weather slipping from stairs, equipment (keys) exposed to the network and ground leakage PPE	fatigue, dehydration, heat stroke, loss of concentration, delayed/failed labor, fall from height, broken tools, lacerations/broken bones, burns/disabilities
PMT (CB/Circuit Breaker) testing in the form of breaker testing, simultaneous testing, insulation testing, contact resistance testing, and SF6 gas testing.	high temperature, bad weather slipping from steger / stairs, equipment (keys) exposed to the network and ground leakage PPE	fatigue, dehydration, heat stroke, hearing loss & loss of concentration, delayed/failed work, fall from height, broken tools, lacerations/fractures/skin bruises, electrocution, burns/disabilities
Groundman unloads work equipment	equipment fell on the groundman, wrong position when lifting	Bruises, sprains

b. Hazard source data

Table 4. Hazard source data

Hazard Findings	Risk	Hazard Source
Recording error	Work postponed	Human negligence
Equipment fell on the staff	Bruises, broken equipment	Work attitude
High temperature	dehydration	Work attitude

Entangled harness	Luka memar	Kelalaian manusia
High temperature	Dehydration	Work attitude
Equipment fell on the groundman, wrong position during lifting	Bruises, broken equipment, sprains, muscle injury	Material
High temperature, vehicle noise, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, delayed/failed work, falling from heights, broken equipment, skin tears/fractures, burns/disabilities	Electricity, material, work attitude, weather
High temperature, vehicle noise, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, delayed/failed work, falling from heights, broken equipment, skin tears/fractures/bruises, electric shocks, burns/disabilities	Electricity, material, work attitude, weather
Bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, delayed/failed work, falling from heights, broken equipment, skin tears/fractures, burns/disabilities	Human negligence, electricity, material
High temperature, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, loss of concentration, delayed/failed work, broken equipment, skin tears/bruises, electric shocks, burns/disabilities	Material, human negligence, weather
High temperature, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, loss of concentration, delayed/failed work, falling from heights, broken equipment, skin tears/fractures, burns/disabilities	Electricity, material, weather
High temperature, bad weather, slipping from scaffolding/ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, hearing loss, loss of concentration, delayed/failed work, falling from heights, broken equipment, skin tears/fractures/bruises, electric shocks, burns/disabilities	Human negligence, material, electricity
Equipment fell on the groundman, wrong position during lifting	Bruises, sprains	Work attitude

c. Risk assessment using Hazard and Operability Study

Analysis of hazards and risks in the 2-year maintenance work of Bay Jepara 2 is carried out by assessing the risk level by multiplying the likelihood value with the consequences value as follows. Then the results of the risk assessment can be in the form of a risk matrix. In the risk matrix table we can find out the risk level of the hazard findings.

$$R = C \, x \, L \quad (1)$$

where, R represents the risk level result, C represents the consequences value, and L represents the likelihood value.

Table 5. Risk assessment

Hazard Findings	Risk	Hazard Source	L	C	R	Risk Level
Recording error	Work postponed	Human negligence	2	1	2	Low
Equipment fell on the staff	Bruises, damaged equipment	Work attitude	2	2	4	Low
High temperature	Dehydration	Work attitude	2	3	6	Medium
Entangled harness	Bruises	Human negligence	3	1	3	Low
High temperature	Dehydration	Work attitude	1	2	2	Low
Equipment fell on the groundman, wrong position during lifting	Bruises, damaged equipment, sprains, muscle injury	Material	3	1	3	Low
High temperature, vehicle noise, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, work delayed/failed, falling from heights, damaged equipment	Electricity, material, work attitude, weather	3	4	12	High

Hazard Findings	Risk	Hazard Source	L	C	R	Risk Level
	, skin tears/fractures, burns/disabilities					
High temperature, vehicle noise, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, work delayed/failed, falling from heights, damaged equipment, skin tears/fractures/bruises, electric shocks, burns/disabilities	Material, work attitude, sun, electricity	3	4	12	High
Bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Respiratory problems, fatigue, dehydration, heat stroke, hearing loss, loss of concentration, work delayed/failed, falling from heights, damaged equipment, skin tears/fractures, burns/disabilities	Human negligence, electricity, material	3	4	12	High
High temperature, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, loss of concentration, work delayed/failed, falling from heights, damaged equipment, skin tears/fractures, burns/disabilities	Material, human negligence, weather	3	4	12	High
PPE leakage	es, electric shocks, burns/disabilities					
High temperature, bad weather, slipping from ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, loss of concentration, work delayed/failed, falling from heights, damaged equipment, skin tears/fractures, burns/disabilities	Electricity, material, weather	3	4	12	High
High temperature, bad weather, slipping from scaffolding/ ladders, equipment (keys) contacting the network and ground, PPE leakage	Fatigue, dehydration, heat stroke, hearing loss, loss of concentration, work delayed/failed, falling from heights, damaged equipment, skin tears/fractures/bruises, electric shocks, burns/disabilities	Human negligence, material, electricity	3	4	12	High
Equipment fell on the ground man, wrong position during lifting	Bruises, sprains	Work attitude	3	1	3	Low

Based on the hazard identification table, hazard sources and hazard risk level assessment, 6 activity processes with a high level of potential hazard risk, 1 activity process with a medium level of potential hazard risk and 6 activity processes with a low level of potential hazard risk are found. It is necessary to improve the 6 activity processes with a high level of potential hazard risk as soon as possible by implementing OHS controls in the form of Implementing clear Standard Operating Procedures (SOPs) for all operations and activities in the work environment. Providing appropriate PPE such as helmets, gloves, goggles, safety shoes, and ear protection, and ensuring all employees use them as needed. Conduct regular inspections of all equipment and

machinery to ensure they are in good working order and safe to use. Prepare emergency response plans for situations such as fires, explosions or workplace accidents.

5. CONCLUSION

Based on the results of the research, it can be concluded that the source of hazard or potential danger at a high level of risk comes from materials, electrical voltage, and also work attitudes. Then 6 activity processes were found with a high level of potential hazard risk, 1 activity process with a medium level of potential hazard risk and 6 activity processes with a low level of potential hazard risk.

Suggestions for mandatory control measures from hazards in the high risk level category found are by testing equipment and PPE two to 4 times a year, adding PPE such as safety shoes, full face helmets and wearpacks. Linesman comply with SOPs and provide sanctions if they do not carry out SOPs, provide sufficient drinking water so that dehydration does not occur.

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APPENDIX

Table 6. *Hazop Worksheet*

No	Process	Hazard Findings	Risk	Sources of Hazard	L	C	R	Risk Level
1	Making work notes	Recording errors	Work Postponements	Human error	2	1	2	Low
2	Moving equipment into the truck	Equipment falling and hitting personnel	Bruising, damaged equipment	Work attitude	2	2	4	Low
3	Installing warning signs at the work site	High temperature	Dehydration	Work attitude	2	3	6	Medium
4	Personnel wearing Personal Protective Equipment (PPE)	Harness entanglement	Bruising	Human error	3	1	3	Low
5	Conducting a safety briefing	High temperature	Dehydration	Work attitude	1	2	2	Low
6	Groundman preparing work equipment & raising it onto the scaffold	Equipment falling and hitting the groundman, incorrect positioning while lifting	Bruising, damaged equipment, sprain, muscle injury	Material	3	1	3	Low
7	Workers testing all MTUs at Bay Jepara 2 and cleaning isolators with the help of the PDKB team, as there are still parts that are not de-energized (under voltage)	High temperature, vehicle noise, bad weather, slipping from the ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Respiratory disturbances, fatigue, dehydration, heat stroke, hearing impairment and loss of concentration, workers delayed/failed, falls from height, damaged equipment, lacerations/broken bones, burns/disabilities	Electricity, material, work attitude, weather	3	4	12	High
8	Testing LA (Lightning Arrester) including tan delta testing, insulation testing, contact resistance testing, and LA counter testing	High temperature, vehicle noise, bad weather, slipping from the ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Respiratory disturbances, fatigue, dehydration, heat stroke, hearing impairment & loss of concentration, work delayed/failed, falls from height, damaged equipment, lacerations/broken bones/bruised skin, electric shock, burns/disabilities	Material, work attitude, sun, electricity	3	4	12	High
9	Testing CVT (Capacitive Voltage Transformer) including tan delta testing, insulation testing, and contact resistance testing	Bad weather, slipping from the ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Respiratory disturbances, fatigue, dehydration, heat stroke, hearing impairment and loss of concentration, workers delayed/failed, falls from height, damaged equipment, lacerations/broken bones, burns/disabilities	Human error, electricity, material	3	4	12	High
10	Testing PMS Line (DS/Disconnection Switch) including insulation testing and contact resistance testing	High temperature, bad weather, slipping from the ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Fatigue, dehydration, heat stroke, loss of concentration, work delayed/failed, damaged equipment, lacerations/bruised skin, electric shock, burns/disabilities	Material, human error, weather	3	4	12	High
11	Testing CT (Current Transformer) including tan delta testing, insulation testing, and contact resistance testing	High temperature, bad weather, slipping from the ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Fatigue, dehydration, heat stroke, loss of concentration, workers delayed/failed, falls from height, damaged equipment, lacerations/broken bones, burns/disabilities	Electricity, material, weather	3	4	12	High
12	Testing PMT (CB/Circuit Breaker) including breaker testing, synchronism testing, insulation testing, contact resistance testing, and SF6 gas testing	High temperature, bad weather, slipping from scaffold/ladder, equipment (tools) contacting the network and grounding issues, PPE leaks	Fatigue, dehydration, heat stroke, hearing impairment & loss of concentration, work delayed/failed, falls from height, damaged equipment, lacerations/broken bones/bruised skin, electric shock, burns/disabilities	Human error, material, electricity	3	4	12	High
13	Groundman lowering work equipment	Equipment falling and hitting the groundman, incorrect positioning while lifting	Bruising, sprain	Sources of Hazard	3	1	3	Low