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| **Identification of Coal Loading and Unloading Failures with *Hazop Analysis***  1ArRozzaq Huda Huwa, 2Anugrah Nur Prasetyo, 3Dyah Ratnaningsih  *-spacing-*  *1Politeknik Pelayaran Surabaya*  *2Politeknik Pelayaran Surabaya*  *3Politeknik Pelayaran Surabaya*  *-spacing-*  *arrozzaq1234@gmail.com* |
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***Abstract***

*This research discusses the process of loading and unloading coal at the port. This process requires high efficiency and safety to run smoothly. However, sometimes this process encounters obstacles. The purpose of this research is to find out what causes failures in the coal loading and unloading process. This study uses a qualitative method with hazop analysis to identify and analyze problems that may occur. The results of the study show that there are several risks that can occur, such as equipment damage, work accidents, and disruptions in shipping. However, the study also found opportunities for process improvement and the use of new technologies. By using the right technology, the possibility of failure in the coal loading and unloading process can be significantly reduced. The results of this study can be used as a reference to improve efficiency and safety in the coal loading and unloading process at the port.*

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| ***Keywords:*** *Loading and Unloading Bra Stones, Hazel Analysis, Risk Management, Mitigation Opportunities, Risk, Efficiency, Operational* |

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# INTRODUCTION > T.N Roman 11 Bold

Coal loading and unloading is an important part of the energy distribution process that greatly affects our daily energy supply. This process involves moving coal from ships, trucks, or other means of transportation to storage facilities or to facilities that require coal. Although it seems simple, this process involves many complex steps and equipment, so there are various possible problems that can occur [1].

Problems in loading and unloading coal can be from various conditions. For example, the equipment used to move coal can be damaged, or there can be an error in the way it operates. In addition, logistical issues such as delivery delays or coordination issues between teams can also interfere with this process. All of these issues can lead to delays, financial losses, or even safety hazards for workers [3]. On the MV.Mubasyir ship, there are various problems, one of which is related to the *grab crane* which is a loading and unloading equipment, so it takes time and swelling operational costs. To prevent or address these issues, it's important to understand and identify what could go wrong and how to fix them. This is where *Hazop analysis* comes into play. *Hazop analysis* is a technique that helps us to find and assess risks (possible problems) as well as opportunities (opportunities to improve).

By using *Hazop analysis*, we can evaluate potential problems that may occur during coal loading and unloading. For example, we can assess the risk of equipment damage or work accidents, and we can also look for ways to improve the loading and unloading process to make it more efficient [6]. That way, we can design the right solutions to reduce risks and take advantage of existing opportunities [5]. This study aims to apply *Hazop analysis* in the analysis of coal loading and unloading failures. It is hoped that this study can help find solutions to problems that often occur and provide recommendations to improve the coal loading and unloading process, so that it becomes safer and more efficient.

Based on these problems, research was carried out to apply *Hazop analysis* in identifying failures during the coal loading and unloading process. This research aims to find potential problems that could interfere with the process and evaluate opportunities for improvement. Thus, the researcher conducted a study on the identification of failure risk in the coal loading and unloading process using *hazop analysis*.

# METHOD > T.N Roman 11 Bold

This research is an applied research that uses a "qualitative" type of research. Qualitative methods are research that is used to investigate, discover, describe, and explain the qualities or peculiarities of social influences that cannot be explained by quality or described through an approach [4]. Qualitative research is research that produces and manages data that is descriptive in nature, such as interview transcriptions, field notes, images and others. The type of method used is the descriptive method, which is research that aims to solve the actual problems faced and collect data or information to be compiled, explained, and then analyzed. This study uses *Hazop Analysis* to analyze and identify failures in the coal loading and unloading process. This type of research aims to address practical problems faced in the loading and unloading process by providing concrete data-driven solutions [9]. This research is descriptive and analytical, where data is collected to describe the current situation and analyzed to find solutions for improvement.

The implementation of this research was carried out at PT. Octopus Cross the Ocean and takes place on board the MV. Mubasyir. The implementation of this writing was carried out during the sailing undertaken by cadets for 12 months, namely from July 27, 2023 to July 27, 2024.

Direct observation of the coal loading and unloading process to detect problems in *real-time*. Primary data is a data source that can provide data directly to data collectors. Primary data was obtained through the process of interviews with research subjects, observations, and also direct observation in the field. Analysis of incident reports and accidents that have occurred during the coal loading and unloading process. Historical data on equipment breakdowns and operational disruptions that have occurred before.

# RESULTS AND DISCUSSION > T.N Romans 11 Bold

**Results**

**Data Analysis**

In this study, the researcher conducted direct observations in the field and analyzed potential *hazards*. Analysis of the operational risk of the grab crane during loading and unloading activities using *HAZOP* (*Hazard and Operability Study*).

Identification of the risk of grabbing operations during the loading and unloading process is carried out to ensure that loading and unloading activities run well, by understanding the conditions that need to be considered to prevent failure. This can be seen in the following table.

Table 1. Risks of Operation a Grab Crane

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Yes | Parameters | Deviation | Cause | Impact | Risk Level (Low/Medium/High) | Control\ |
| 1 | Grab Operations | Grab is not fully closed | Damage to the hydraulic mechanism | Coal falling poses a danger to the crew | Tall | Perform regular checks on the hydraulic system and  Make sure the operator is in control of the terrain |
| 2 | Payload capacity | Overload | Operator error  who do not pay attention to capacity limits | Coal spilled in the *deck area* and risk of slipping | Keep | Installing the load limit sensor  And inform the operator about the load capacity limit of the tool |
| 3 | *Crane grab maneuver* | *Grab crane* moves uncontrollably | Strong winds and damage to the control system | Potential collision with other objects and a danger to the safety of the ship's crew | Tall | Using a *wind barrier*  and inspect the control system before use |
| 4 | Coal spill | Scattered charge | *Overcapacity* | *The deck* becomes dirty, slippery, and potentially slippery | Keep | Notify operators to improve their expertise and availability of spill control systems such as safety nets or *buffer areas* |
| 5 | Communication | Communication disorders | Radio damaged,  *high noise* in certain areas | Coordination errors between operators and crew | Keep | Using the Backup communication tool, make sure the communication tool is regularly checked and replaced immediately if there is damage to the communication tool |

The risk that occurs during the coal loading and unloading process lies in the coal grab device, which has the potential to cause a collision between  *the grab crane* and the ship structure. This situation can occur due to strong winds and the operator's expertise in operating the *grab crane*.

* 1. **Risk Level of *Operation of Grab Crane* in the Loading and Unloading Process**

Determining the level of risk of operation of *the grab crane* during loading and unloading activities is very important to prevent fatal accidents from occurring. Therefore, it is necessary to assess the potential risks that may arise in each stage of loading and unloading activities carried out at MV.Mubasyir. The assessment aims to avoid negligence during the loading and unloading process. As a preventive measure, it is necessary to map the level of risk in the operation of *grab* cranes in the loading and unloading process [11].

The assessment of the *likelihood*  or likelihood of an accident can refer to the following table:

Table 2. Determination of Likelihood Values

|  |  |  |
| --- | --- | --- |
| Risk | Likelihood Description | Total events (score) |
| Coal load spilled in the *deck area* | Almost certainly in *overcacity condition grab crane* | 3-5 times per year (5) |
| Communication disruption between the operator and the crew | Most likely to occur during bad weather | 1-3 times per year (4) |
| Damage to the hydraulic mechanism on the *grab* | It may occur because it is not properly maintained | 1-2 times per year (3) |
| Damage to the grab cover | It is a small possibility, but it can occur due to the influence of sea waves that cause disruption of ship stability | 1 time in 1 year (2) |
| Coal spill into the sea | rare, but can occur if in extreme circumstances | <1 time per year (1) |

The attribution of *the Concequency* value or the impact of the risk of Grab operation will be explained in the following table:

Table 3. Determination of Concequency Value

|  |  |  |
| --- | --- | --- |
| Risk | Impact | Value |
| Hydraulic grab breakdown | Disruption of operations and time to repair | 4 |
| Spilled load | The *deck area* is slippery and is at risk of causing minor injury | 2 |
| Damage to *the cover grab crane* | Resulting in delays in the loading and unloading process | 4 |
| Coal spill into the sea | Huge financial losses and environmental pollution | 4 |
| Communication disruption between the operator and the crew of the ship | Resulting in uneven coal due to lack of communication | 1 |

* 1. **Calculation of *Likelihood* and *Concequency Values***

After identifying operational risks using *Hazop Analysis.* The next step is to determine the level of possible hazards and impacts that may occur during loading and unloading activities.

The researcher made direct observations while sailing on the MV.Mubasyir. To support the steps of *the hazop analysis.*

In calculating the value, there are several steps that must be known by researchers, namely:

1. Identify risks, determine  *the observed risk* scenario.
2. Likelihood value , in the form of a score given according to the frequency of events.
3. The *concequency* (impact) value, in the form of a score given according to the severity of the impact.

These values are entered and arranged in a table. The following is a table of calculation of *likelihood and concequency values:*

Table 4. Calculation table

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Yes | Risk Scenarios | *Likelihood* | *Concequency* | Risk Calculation | Risk Level | Action |
| 1 | Damage to the hydraulic mechanism of the grab | 3 | 4 | 3x4 = 12 | Tall | Regular inspections and maintenance |
| 2 | Coal load spilled on deck | 5 | 2 | 5x2 = 10 | Tall | Installing the load capacity sensor |
| 3 | Damage to *the cover grab crane* | 2 | 4 | 2x4 = 8 | Tall | Ensuring that bolts and hinges are properly seated |
| 4 | Coal spill into the sea | 1 | 4 | 1x4 = 4 | Keep | Checking grab tools before use |
| 5 | Communication disorders | 4 | 1 | 4x1 = 1 | Keep | Provide backup communication tools |

* 1. **Determination of  *Risk* Matrix Values**

After calculating the result between the probability value and the impact of the occurrence of each grab operation risk during the loading and unloading process, the next step is to determine the risk *matrix*  value. The results of the above values can be seen in the table below:

Table 5. Matrix Values Table

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Yes | *Risk Scenarios* | *Likelihood* | *Concequency* | Risk calculation | Risk Level | category |
| 1 | Hydraulic *mechanical breakdown of grab crane* | 3 | 4 | 3x4 = 12 | 12 | Tall |
| 2 | Coal spill in the *deck area* | 5 | 2 | 5x2 = 10 | 10 | Tall |
| 3 | Damage to *the cover grab crane* | 2 | 4 | 2x4 = 8 | 8 | Tall |
| 4 | Coal spill into the sea | 1 | 4 | 1x4 = 4 | 4 | Keep |
| 5 | Communication disorders | 4 | 1 | 4x1 = 4 | 4 | Keep |

Description of matrix *values*:

1. Value 0-1 (very low): Rare, just monitored and marked with blue.
2. Score 1-3 (low): Risk events are acceptable, it is enough to monitor regularly. Marked with green.
3. Grades 4-6 (medium): Taking a precautionary measure to minimize the risk of an incident. Marked with yellow
4. Score 8-15 (high): It is very necessary to take preventive or mitigation measures as soon as possible, because risk events are a top priority. Marked in red.
5. Value 16-25 (very high): Immediately stop loading and unloading activities until the risk of the incident can be properly handled. Marked with a dark red color.

## Discussion

Based on the results of observations made by researchers related to the identification of the risk of failure during the loading and unloading process using *hazop analysis.* It was found that the risk was caused by maintenance and human factors that caused damage to the *grab crane tool*. The results of the analysis showed that there were 2 high risks (red), 2 medium risks (yellow), and 1 low risk (green). The analysis was carried out using a risk analysis table, accompanied by the determination of matrix values and risk control recommendations [10]. From the results of the data presentation, the author found problems regarding damage to the hydraulic grab crane system on board the ship as follows:

1. **Main Causes of Failure in the Coal Loading and Unloading Process**

Based on the results of observations and interviews, the main causes of failure in the coal loading and unloading process on the MV.Mubasyir ship are:

1. Hydraulic system damage on *grab cranes*, *hydraulic* systems are often problematic due to lack of maintenance, such as not changing oil regularly or excessive pressure caused by loads exceeding capacity. This results in the *grab crane* not being able to open and close optimally.
2. Bad weather, strong winds and heavy rain make it difficult for operators to control the *grab crane* so that the risk of accidents and can damage the ship's structure if  *the grab crane* is difficult to control.
3. *Crane operators*, lack of attention to load capacity causes coal spills resulting  *in slippery decks and increasing the risk of accidents.*
4. Communication interruptions, suboptimal communication devices or high noise during bad weather cause miscommunication between *the operator* and crew.
5. ***Hazop Analysis* can be used to identify and minimize risks during coal loading and unloading.**

*HAZOP (Hazard and Operability Study)* is used to identify each stage in the loading and unloading process with the following steps:

* 1. Identify risks, such as *grab crane* operations, load capacity, *grab maneuvers*, and communication. Each parameter is analyzed to identify possible deviations and their causes
  2. Evaluation of the level of risk, risks are grouped based on the level of *likelihood and* impact *calculated* in the risk matrix. High risks such as hydraulic system damage and overload require action.
  3. Risk control, crews can carry out routine inspections of equipment, especially *hydraulic grab crane* systems, install load capacity limit sensors to avoid *overcapacity*, improve *operator* skills through training, provide backup communication tools to ensure smooth coordination.

1. **How to evaluate the impact of the risk of loading and unloading failure on the MV.Mubasyir ship.**

From the existing events presented, the author groups based on the value of several aspects that affect loading and unloading failure as follows:

* 1. Operational impacts, delays in operating schedules due to equipment damage, such as  *hydraulic grab crane* systems that require repairs.
  2. Financial impact, additional costs for equipment repairs and operational delays
  3. Crew safety, risk of injury due to cargo spillage on the *deck* that causes *the deck area* to become slippery.
  4. From the impact that has been debuted, we can evaluate by conducting regular inspections, especially on the *hydraulic grab crane system*  which is the main cause of loading and unloading failure.

From the risks that have been known and have been taken from the risk of loading and unloading failure, it can be understood that the countermeasures that need to be taken to prevent accidents, especially equipment such as *grab* cranes. It is hoped that it can be a guide for the crew, loading and unloading personnel, and companies in understanding how to manage risks during the loading and unloading process.

# CONCLUSION > T.N Roman 11 Bold

Based on the results of the research conducted on the MV.Mubasyir ship on the risk of failure in the coal loading and unloading process with *HAZOP (Hazard and Operability Study),* I can conclude:

* + - 1. Main Causes of Failure

1. Due to lack of routine maintenance such as oil changes and overpressure, damage to the *hydraulic grab crane system is a problem.*
2. Bad weather can affect operator control and increase the risk of accidents.
3. The excess load capacity taken up by the *grab crane* causes a coal spill in the *deck area*.
4. Damaged communication equipment resulted in communication disruption between *the operator* and  *the ship's* crew.
   * + 1. Methods in Risk Identification

In this study, *hazop analysis* succeeded in identifying and classifying risks based on the level of likelihood and impact. High risks are found, such as damage to *the hydraulic*  system and overload and require precautionary measures.

* + - 1. Impact of Loading and Unloading Failure

1. Operational delays and additional repair costs.
2. Risk of injury to the crew due to the slippery deck area.
3. Causing pollution of the marine environment from coal spills***.***

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