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Regular Research Article

Application of Failure Mode and Effects Analysis (FMEA) to Analyze Occupational Safety Risks in General Cargo Ship Loading and Unloading Activities at Makassar Port

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Abstract: Makassar Port as one of the main ports in Indonesia has an important role in the national logistics system, but the loading and unloading activities of general cargo ships have the potential for high occupational safety risks. This study aims to identify, evaluate, and prioritize risks that can occur during the loading and unloading process at Makassar Port. The analysis of occupational safety risks in the loading and unloading activities of general cargo ships uses the Failure Mode and Effect Analysis method approach by identifying the failure mode, the impact of failure, and the cause of failure that occurs at each stage of loading and unloading activities and involves the assessment of Severity, Occurrence, and Detection to determine the Risk Priority Number (RPN). Through the application of FMEA method, an in-depth identification of work stages, failure modes, effects, causes, and Risk Priority Number (RPN) values for each work activity is obtained. The results of the analysis that show the failure mode with the highest RPN value in this study are in the loading and unloading activities which then become a reference for designing mitigation steps or appropriate repair solutions by implementing a safety briefing before starting the activity, a safety area on the dock for activities, ensuring the load is in accordance with the capacity of the lifting equipment, training for heavy equipment operators, controlling or monitoring by the PnC team, communication and mutual coordination between operators and field workers. The conclusion of this study is that the approach using the FMEA method is effective in identifying and evaluating work safety risks in loading and unloading activities. With the results of risk mapping, the port can take more targeted preventive measures.

Keywords: FMEA; Loading and Unloading; Occupational Safety; Port of Makassar; Risk.

1. Introduction

Indonesia is geographically an archipelagic country with two-thirds of the ocean area larger than the mainland. This means that Indonesia has great potential to become the world's maritime axis. The Maritime Axis is a strategic idea that was realized to ensure connectivity between islands, the development of the shipping and fisheries industry, the improvement of sea transportation and the focus on maritime security. In a maritime country like ours, the role of ports is very important for maritime activities. Ports are one of the links in the transportation network.

A port in a general sense is a facility or an area located along the coast or waters, equipped with various facilities to support sea transportation activities. The port functions as a place where ships dock to carry out loading and unloading activities for goods and passengers. Ports are vital infrastructure in the marine transportation system that functions as a place for ships to dock, board and drop off passengers, load and unload goods, and center of economic and logistical activities. The definition of a port can be comprehensively explained based on government regulations, the views of experts,

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its functions, and facilities. According to Government Regulation of the Republic of Indonesia No. 61 of 2009 concerning Ports, a port is a place consisting of land and/or waters with certain boundaries that are used for government and business activities [1].

A port is a protected area of water used as a place for ships and other watercraft to dock, load or unload passengers, goods, or animals, repair, refuel, and other activities. It is equipped with a pier for mooring ships, cranes for loading and unloading goods, transit warehouses, and storage facilities for longer periods of time, while waiting for distribution to their destination or further shipment. In addition, ports are gateways and facilitators of relations between regions, islands, even continents and nations [2].

The port serves as a place for ships to dock, get on and off passengers, and load and unload goods. In addition, the port is equipped with shipping safety facilities and other supporting activities to support intra- and intermodal transportation movements. A port is a place used for ships to dock, get on and off passengers, load and unload goods, in the form of terminals and where ships dock. The port is also equipped with shipping safety and security facilities and port supporting activities as well as a place to move intra and between modes of transportation. The definition of the port is according to the Regulation of the Minister of Transportation PM 51 of 2015 concerning the Implementation of Sea Ports [3].

Ports are generally located on the border between sea and land or located on rivers or lakes. The port according to Fair consists of three parts, namely: (1) waters or ponds that provide shelter; (2) waterfront facilities such as moorings, docks, warehouses or passenger service facilities, cargo, fuel, supply materials for ships; (3) buoyancy equipment such as rescue boats and lifting equipment in the waters [4].

The port has several main functions, including as a gateway where the port functions as an exit and entry point for goods and passengers and becomes an official route for international and domestic trade. Then the port also functions as a center of economic activity, where the port supports local and national economic activities by creating jobs and encouraging trade between regions. In its activities, the port is of course equipped with several facilities, including a dock as a place for ships to moor to load and unload goods or passengers, then there is a crane used to move cargo from the ship to the mainland or vice versa, then there is a storage warehouse. Apart from that, safety facilities are also available at the port.

The functions of ports described in the previous paragraph are also similar to those described by Salim & Budianto, who state that ports have the main function of providing a place for ships to dock to facilitate the loading and unloading of goods and passengers, as well as a place for the distribution and storage of goods. Ports also function as gateways for international trade, enabling the movement of goods from one country to another. In addition, ports can function as centers of economic activity, supporting related sectors such as manufacturing, fishing, and tourism [5].

Recognising the importance of occupational safety in the port industry, governments and international organizations have established various regulations and standards to protect workers from potential hazards. However, the implementation of these regulations and standards often faces obstacles, such as lack of awareness, limited resources, and complexity of work processes. Therefore, a proactive and systematic approach in risk management is needed to identify, evaluate, and control occupational safety risks effectively. Occupational Safety and Health (OSH) are an effort that aims to protect the health and safety of workers by carrying out duties or work in the workplace. This effort includes all actions, rules, procedures, and policies implemented to prevent work accidents, occupational diseases, and health problems caused by unsafe work environments or conditions. Occupational safety and health are defined as a set of measures and policies taken to create a safe, healthy, and comfortable workplace for all workers with the aim of preventing accidents, losses, and occupational diseases [6].

One method that has been proven effective in risk analysis is Failure Mode and

Effects Analysis (FMEA). FMEA is a structured and systematic analysis technique to identify potential failures in a process or system, analyze its causes and impacts, and determine appropriate preventive measures. According to Rakesh, Jos & Mathew, FMEA is a systematic model for identifying and preventing problems in a system. In general, FMEA is defined as an analysis method used to identify, evaluate, and reduce potential failures in a system, process, product, or service [7]

The FMEA method allows risk management teams to prioritize the most critical risks and develop effective control strategies. FMEA method is a technique used to identify potential problems or failures in a system, process, or product and assess their impact. This method works by identifying potential failure modes, analyzing their effects, and assessing the severity, likelihood of occurrence, and detection of these failures. The application of the FMEA method in the port industry can be very helpful in improving operational efficiency and preventing problems that can be detrimental to port operations.

This study aims to fill this gap by applying the FMEA method to comprehensively analyze occupational safety risks in activities or activities at the port. Through the identification of potential failures, analysis of causes and impacts, and the determination of appropriate preventive measures, this research is expected to make a significant contribution to improving occupational safety and reducing the risk of accidents. The results of this research are expected to be a guide in developing an effective and sustainable safety management system, as well as creating a safe and healthy work environment for workers. There are three main variable processes in FMEA, namely severity, occurrence and detection [8].

2. Research Methods

The writing of this article uses literature and research study methods. Literature study, where the author collects library data, reads and notes, and manages research materials from several articles and books. The research carried out includes qualitative research. The first stage began with data collection through direct observation of loading and unloading activities, interviews with workers, and distributing questionnaires to respondents involved in these activities. The data obtained is then analyzed by identifying various potential failures that can occur at each stage of loading and unloading, finding the main cause of each failure, and assessing the severity of the impact, the frequency of likely occurrences, and the system's ability to detect risks before they cause accidents. From the results of the analysis, the Risk Priority Number (RPN) value is calculated for each failure mode, so that it is known that the risk with the highest RPN value is the top priority to be addressed through proposed corrective and mitigation actions. The next stage is more structured data processing using the FMEA approach. At this stage, risks are categorized and classified based on failure mode, effect, and causes according to the FMEA standard. Each risk was then scored on the severity, occurrence, and detection components on a scale of 1 to 10, where a score of 10 indicates the highest level of risk. The calculation of the RPN value is carried out by multiplying the three scores using the formula:

RPN = Severity x Occurrence x Detection (1)

This RPN value is used to sort risks based on priority, whereby the risk with the highest RPN value is the focus in the preparation of proposed improvement or mitigation actions. In the final stage, this study concludes the results of an objective analysis to provide a comprehensive picture of the level of occupational safety risks in loading and unloading activities as well as formulate appropriate prevention strategies to improve work safety and reduce the potential for accidents. The location of this research is held at PT. Pelindo (Persero) precisely in the Port of Makassar. The following are the three main variable processes in FMEA that function to determine the serious value of the potential failure mode. The determination of categories is based on severity, occurrence, and detection values [9]. The three main variables of FMEA are as follows:

- Severity (S)
  Severity is a matter of identifying the

potential impact of a failure by ranking or assessing failures according to the consequences caused. The level of failure influence (severity) has a ranking of 1 to 10. Rank 1 is the lowest level of seriousness (small risk) and rank 10 is the highest level of seriousness (large risk) [10].

An explanation of the severity of the failure mode for each value can be seen in Table 1.

Table 1. Severity Table

Criterion	Rating
Hit by debris, stung by insects, bitten by insects	1
Sunburn, bruising, light sliced, scratched	2
Blisters, heatstroke, minor sprain, minor slipping or slipping	3
Minor burns, scratches/cuts, frosnip (frostbite/heat)	4
Sprains/sprains, minor cracks/fractures, cramps or spasms	5
Treated for more than 12 hours, fractures, shifted bones, frostbite, burns, difficulty breathing and temporary memory loss, slipped falls	6
Treated for more than 12 hours, with ruptured blood vessel wounds, great memory loss, major losses, etc	7
Requires serious treatment and causes permanent disability	8
Death of an individual (a person)	9
Death of several individuals (mass)	10

- Occurrence (O)

  Occurrence is the possibility that such causes may occur and result in a form of failure during the lifetime of the product's use. The determination of the ranking or occurrenceance value is ranked 1 to 10. Rank 1 is a low incidence rate (infrequent) and rank 10 is a high incidence rate (frequent) [10].

  An explanation of the frequency of failures (occurrences) for each value can be seen in Table 2.

Table 2. Occurrence Table

Chances of failure	Failure rate	Rating
Failure is unlikely	< 1 per 1,000,000	1
	1 per 100,000	2
Failures are very rare	1 per 50,000	3
	1 per 10,000	4
Failure only happens once	1 per 5000	5
	1 per 1000	6
Failure occurs repeatedly in the same area	1 for 600	7
	1 for 400	8
Failure is always recurring	1 per 100	9
	1 for 10	10

- Detection (D)

  detection is a way (procedure), test, or analysis to prevent failures in services, processes, or customers. In determining the ranking or detection value it consists of rankings 1 to 10. Rank 1 is the level of control that can detect failure (always can) and rank 10 is the level of control that cannot detect failure [10].

  An assessment of the detection level can be seen in Table 3.

Table 3. Detection Table

Detection	Criterion	Rating
It is impossible, it is possible to detect a potentially destructive cause	Very low	10
		9
Small, possible to detect potentially damaging causes	Low	8
		7
It is possible to detect potentially damaging causes	Keep	6
		5
It is likely to detect potentially damaging causes	Tall	4
		3
It is very likely to detect potentially damaging causes	Very High	2
		1

3. Result

3.1. Observation and Interview Data Results

The following are the results of data obtained from direct observation and interviews

with workers involved in the field during the loading and unloading process activities:

- KM. Yulian 88
  In the process of loading and unloading flour bags/sacks weighing 50kg, the application of the principles of Occupational Safety and Health (OSH) still faces obstacles, especially because workers do not always use Personal Protective Equipment (PPE) such as safety helmets. This shows that the biggest challenge in the implementation of OSH comes from the discipline of the workers themselves. Meanwhile, supporting equipment such as ship cranes have been regularly maintained weekly, as well as inspected before and after use, with a maximum lifting capacity of 50 tons. For land transportation, trucks with a carrying capacity of 23 tons are used to facilitate the distribution of dismantling products. On May 21, 2025, there was a quite dangerous event. Several sacks of flour fell from the transport net when they were moved from the hatch of the ship to the truck, at the time of the incident there were several workers under it. Fortunately, there were no casualties because the workers managed to avoid them quickly. This incident is a reminder that if there is an accident due to the negligence of workers in complying with OSH, the loading and unloading workers company will bear its responsibility, especially if the PBM used is private and the incident occurs during working hours.
- KM. Kendhaga Nusantara 6
  In the process of loading and unloading cargo containers, supervision is carried out strictly because it is carried out directly by Pelindo (SPMT) to ensure the suitability of goods coming through trucks and the smooth running of activities in the field. All workers or PBMs involved have used complete Personal Protective Equipment (PPE), so that work safety aspects are more guaranteed. The ship crane used has a maximum lifting capacity of 25 tons, with a regular maintenance schedule every two months, to maintain the reliability of the equipment. Although unsafe incidents are rare, there are still occasional potential accidents, for example, a worker once jumped into the sea to avoid a container that was not in the right position when lifted by a crane at that time. These potential dangers generally stem from human negligence or poor communication between workers. Therefore, evaluation is always carried out after the loading and unloading process is completed or during break hours to identify any weaknesses. In addition, the crew also carried out a safety checklist after loading and unloading was completed as a preventive measure to prevent similar incidents in the future.
- KM. Lucky Ship 88
  In the process of loading and unloading cargo ships with jumbo cement loads, the implementation of Occupational Safety and Health (OSH) is carried out strictly. All workers or loading and unloading companies always use complete Personal Protective Equipment (PPE) and before the activity starts, a meeting is held with the crew to equalize procedures so that unwanted things do not happen. If unsafe actions are found, for example, workers are under heavy equipment that is operating, an evaluation is immediately carried out by giving a warning so that discipline to the rules and Occupational Safety and Health (OSH) is maintained. The boat cranes used on this ship are also always checked before and after use, although there has been a slight disturbance in the swing system of one of the cranes. Fortunately, the operator quickly realized the masalag and immediately stopped its use to prevent potential harm. Even if safety procedures are implemented, some potential work accidents still occur. One of them is caused by crane operators who are not proficient enough in operation, as well as real cases of work accidents such as boom crane breaks or wire crane breaks due to excess load carrying capacity. This even caused a victim to break his leg in an incident at Makassar Port. To minimize risk, ship crews routinely attend OSH training once every three months, usually conducted at sea, to

improve skills and awareness in dealing with high-risk working conditions.

- KM. Eden
  In loading and unloading activities Cargo with cement load type sling bag, safety procedures are a top priority with the obligation to wear work clothes or warepack, safety shoes, helm, and gloves. In addition to the completeness of Personal Protective Equipment (PPE), attention is also paid to the condition of the ship's mooring rope when docked, because a fragile mooring rope can be one of the sources of potential work accidents so it must be routinely inspected and replaced immediately if damage is found. All workers, both laborers and PBM, have complied with the applicable occupational safety and health SOP. Crane The ship also receives periodic maintenance, where before use an engine test is always carried out (running test), while thorough maintenance is carried out once a month after the loading and unloading activities are completed. Before the activity starts, it is always held safety meeting which discusses work directions, activity plans for the day, checking the completeness of PPE, and setting guard hours for the crew involved. Even though the implementation of OSH has been done well, there is still the potential for unsafe events that have occurred, such as damage to wire crane during the loading and unloading process as well as workers under the crane when the heavy equipment is operating. For this reason, the supervision of activities is carried out strictly by Chief Officer with Pelindo. Evaluations are also routinely carried out after the activity is completed or during break hours, which includes performance appraisals per shift, identification of factors causing work delays until targets are not achieved, as well as evaluation related to the implementation of OSH to improve safety and work effectiveness in the next loading and unloading activities.

3.2. Processing of Questionnaire Data Results

The data processing of the questionnaire results was carried out to identify the risks that had the most effect on occupational safety. The data obtained through the questionnaire was then analyzed using FMEA method, where each potential failure was assessed based on three main aspects, namely severity, occurrence, and detection ability. From these three aspects, the Risk Priority Number (RPN) value is obtained, which is the basis for determining risk priority.

By identifying the work process in detail, a comprehensive understanding of the flow and stages of general cargo loading and unloading activities is obtained. The results of this identification are an important basis in the risk analysis process using the FMEA method, especially in identifying potential failures that may occur at each stage of work. Based on the results of the processing, it is known that there are three risks with the highest RPN values. These values indicate that these three risks are the most critical issues and should receive special attention by formulating alternative remedial solutions aimed at reducing the risks that have been identified and creating a safer and more productive work environment. The three activities with the highest risk are:

- Loading and Unloading
  Loading and unloading activities are the most crucial stages in the operational process of general cargo ships. At this stage, the complexity of the work, the involvement of many parties, and the dynamic conditions of the work environment make this activity have a high level of risk. The Risk Priority Number (RPN) value for the loading and unloading stages can be seen in Table 4.

Table 4. RPN Loading and Unloading Value Table

Failure Mode	Effect	Cause	Control	S	O	D	Total RPN
Goods that fall during the loading and unloading process, miscommunication between crane operators, field managers (signalman) and workers below	Damage to goods, worker injuries, equipment damage due to loads exceeding lifting capacity, slow productivity and unmet targets	Operators do not understand the working capacity of the equipment (not certified), the absence of a standard communication system, lack of work coordination training	Implementing safety briefing, safety control and monitoring by the PnC team, communication and mutual coordination and evaluation	10	4	7	280

- Open Activity or Gate In/Out
  Open activity or gate in/out activities are one of the important stages in the loading and unloading process at the Port of Makassar which is directly related to the movement of goods from and to the port area. At this stage, the goods unloaded from the ship will go through the entry and exit process through the port gate, thus involving interaction between various parties, including port officers, transport vehicle drivers, and loading and unloading workers. The Risk Priority Number (RPN) value for the loading and unloading stages can be seen in Table 5.

Table 5. RPN Open Activity or Gate In/Out Value Table

Failure Mode	Effect	Cause	Control	S	O	D	Total RPN
Heavy and irregular vehicle traffic and loaded goods exceeding the capacity of the truck	Vehicle accidents, traffic jams, damage to goods	There is no supervision of overload, no traffic control at the port	Weighing load loads, supervising trucks that are active	9	6	5	270

- Inspection and Opening of the Hatch
  The inspection and opening of the hatch is one of the very important initial stages in the series of loading and unloading processes for general cargo ships. At this stage, the condition of the hatch and the lid must be ensured to be safe before the goods transfer activity is carried out. This makes the inspection and opening of hatches not only a technical procedure, but also a preventive measure that determines the smooth running of the next work process. The Risk Priority Number (RPN) value for the loading and unloading stages can be seen in Table 6.

Table 6. RPN Value for Inspection and Opening of Hatches Table

Failure Mode	Effect	Cause	Control	S	O	D	Total RPN
Falling of the hatch lid, falling into the hatch because standing on the edge of the hatch, exposure to harmful gases (chemicals) from inside the hatch	Serious injury to workers, exposure to chemical gases/gas poisoning	Broken lifting system or imperfect locking system, not using masks/ respirators, workers standing too close to the edge of the hatch	Ensure the condition of the equipment is good, use appropriate PPE, carry out a safety area in the position of the hatch to be opened	10	3	7	210

4. Discussion

After identifying the mode of failure, impact, and cause of failure as well as assessing the Risk Priority Number (RPN) value, the next step is to formulate alternative repair solutions aimed at reducing or eliminating the risks that have been identified. The preparation of these Alternatives is focused on the failure modes that have the highest RPN values, as they indicate the most urgent level of risk priority to address. By developing and implementing alternative repair solutions appropriately, it is hoped that the level of risk to occupational safety can be significantly reduced, as well as create a safer and more productive work environment at the Port of Makassar.

- Loading and Unloading

  Based on the results of the calculation of the Risk Priority Number (RPN) value, loading and unloading activities are recorded as the activity with the highest risk value compared to other activities. This shows that the potential for failure at this stage can not only cause disruption in the smooth running of the work process but also have direct implications for worker safety and damage to goods that are unloaded and loaded. Therefore, the repair solution based on the failure mode and the cause of failure in the Loading and Unloading stages/activities can be seen in Table 7.

Table 7. Loading and Unloading Repair Solutions Table

Failure Mode	Cause with high RPN value	Repair Solutions
Goods that fall during the unloading/loading process, miscommunication between crane operators, field managers (signalman) and workers below	Operators do not understand the working capacity of the equipment (not certified), the absence of a standard communication system, lack of work coordination training	Implement safety briefing before starting activities, safety areas at the pier for activities, ensuring the load according to the capacity of the lifting equipment, training for heavy equipment operators, controlling/monitoring by the PnC team, communication and mutual coordination between operators and field workers.

In the failure mode in Table 7 above, it is one of the most serious occupational safety risks and this problem is usually caused by a lack of communication and coordination between crane operators, signalmen, and workers in the work area. In response to these conditions,

there are several improvement solutions that need to be implemented consistently, including:

1 Implement safety briefing before the activity starts, to ensure that all workers in the work area (loading and unloading) understand work procedures, potential hazards, and communication methods to be used.
2 Creating and enforcing safety zones, this solution is to limit movement around the machine's working point and reduce the risk of accidents.
3 Ensuring that the load does not exceed the capacity of the lifting equipment, this solution is a form of technical control and the application of equipment operational standards.
4 Providing special training to heavy equipment operators, this training can be an important provision to improve professionalism, technical competence, and understanding of work safety procedures.
5 Controlling and monitoring, the Planning and Control (PnC) supervision team must actively monitor the field to ensure that all procedures are carried out as they should.
6 To improve communication and coordination of the work team, there needs to be a clear and mutually agreed work communication system, both in the form of hand signals and communication aids.

- Open Activity or Gate In/Out

The results of the Risk Priority Number (RPN) calculation analysis show that open activity or gate in/out activities rank second with the highest risk value. This is due to potential failures such as irregular vehicle queues, miscommunication between officers, and the risk of work accidents due to lack of supervision in the gate area. These potential risks can have serious impacts, both in the form of delays in the distribution of goods, damage to cargo, and threats to worker safety. Repair solutions based on failure mode and cause of failure at the Open Activity or Gate In/Out stage can be seen in Table 8.

Table 8. Open Activity or Gate In/Out Repair Solution Table

Failure Mode	Cause with high RPN value	Repair Solutions
Goods that fall during the unloading/loading process, miscommunication between crane operators, field managers (signalman) and workers below	Operators do not understand the working capacity of the equipment (not certified), the absence of a standard communication system, lack of work coordination training	Implement safety briefing before starting activities, safety areas at the pier for activities, ensuring the load according to the capacity of the lifting equipment, training for heavy equipment operators, controlling/monitoring by the PnC team, communication and mutual coordination between operators and field workers.

In Table 8, the failure mode above is a problem that often arises in building and dismantling activities. This condition can cause congestion, slow down the logistics process and even increase the risk of work safety. To overcome this problem, the following repair solutions are prepared:

1 A system for scheduling the entry of trucks to the port area must be implemented. Scheduling the arrival of vehicles in rotation will reduce congestion and make the flow of vehicles smoother.
2 Stricter supervision should be carried out by gate/weighing post officers on each vehicle entering and exiting to ensure that the load does not exceed the permitted capacity.
3 The implementation of an electronic gate portal is implemented to ensure

that only vehicles that are verified and in accordance with cargo requirements can access the port's operational area. With this system, trucks that do not meet the load requirements or are not scheduled cannot enter the loading and unloading area.

- Inspection and Opening of the Hatch
  The results of the analysis using FMEA method show that this activity occupies the third position with the highest Risk Priority Number (RPN) value. The high value of RPN is caused by the potential for significant failure, such as the risk of the hatch lid falling, exposure to harmful gases from inside the hatch, and workers falling into the hatch due to negligence or lack of safety procedures. Repairing solutions based on failure mode and the cause of failure at the Open Activity or Gate In/Out stage can be seen in Table 9.

Table 9. Repair Solution Table Inspection and Hatch Opening

Failure Mode	Cause with high RPN value	Repair Solutions
Falling of the hatch lid, falling into the hatch because standing on the edge of the hatch, exposure to harmful gases (chemicals) from inside the hatch	Broken lifting system or imperfect locking system, not using masks/ respirators, workers standing too close to the edge of the hatch	Ensure the condition of the equipment working properly, ensure that the operator is experienced and in good condition, uses PPE that is in accordance with the load to be unloaded (use a gas detector/mask), carry out a safety area in the position of the hatch to be opened

To overcome the failure mode contained in Table 9, a series of steps or repair solutions are needed, including:

1 Inspection and maintenance of the tool, it is important to carry out regular inspection and maintenance of the tool to ensure that all the equipment is in good condition and suitable for use, especially the lifting system and locking the hatch lid.
2 The use of PPE according to the risk of the load, to prevent exposure to hazardous gases, workers are required to use PPE that is appropriate to the risk of the load, such as masks or respirators and use a gas detector before entering or opening the hatch.
3 Assignment operator, the operator responsible for hatch opening must be an experienced individual, have certification and be in excellent condition.
4 The implementation of safety areas needs to be created, a safe zone or safety area around the hatch to be opened. This area must be restricted and guarded so that only interested officers can be near the hatch. This step can minimize the risk of other workers falling into the hatch during the process.

5. Conclusion

Based on the results of the study, it can be concluded that general cargo ship loading and unloading activities at the Port of Makassar have various potential modes of failure, such as hatch cover falls, workers falling into the hatch, exposure to hazardous gases, falling cargo, the risk of collision or impact, and miscommunication. The main factors causing these risks include lack of operator training, incomplete use of PPE, inappropriate work procedures, miscommunication, and suboptimal supervision, which can lead to operational disruptions and worker injuries. The calculation results show that the activity with the highest Risk Priority Number (RPN) is loading and unloading. To reduce these risks, the most effective corrective measures include

conducting safety briefings, establishing safety areas, training and certifying operators, improving communication between workers and crane operators, and strict supervision by the Planning and Control (PnC) team.

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