Assessment of Occupational Safety Risks in Ship Repairs at the Fisheries Service Employees Cooperative Shipyard (FSECS)

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***Abstract*— Various activities at the FSEC shipyard found many potential dangers in each element of work activity. The FSEC shipyard requires risk assessments and critical points in each ship repair activity to overcome these problems. So, research is structured with the aim; a) identify and describe repair activities at FSEC yards; b) determine critical points along the repair, along with sources of danger and consequences. This research data analysis uses the FMEA method to identify each type of work and risk assessment. Based on the identification that are assumed to be crucial in the flow of ship repair activities, 26 activities were recorded including; a) preparation 10; b) process 10 and; c) post ship docking 6. Based on 26 activities, a total of 40 ships were recorded as sources of danger from docking preparations, ship docking processes and post-ship docking. Based on the results of data processing and analysis, it was concluded that 6 activities were included in the critical risk category, including; holding the ship as it is being lowered, the ship entering the docking area, removing the remaining barnacles, turning on the grinder, grinding the upper and lower hull of the ship and getting on and off the ship.**

Keywords— *Work Safety, Shipyards, Failure Mode and Effect Analysis.*

I. INTRODUCTION

Accident work is something that is unplanned, uncontrolled and unpredictable [1]. Previously, the government had issued regulations regarding work accidents, namely Government Regulation Number 50 of 2012 concerning the Implementation of an Occupational Safety and Health Management System (OSHMS)[2]. Article (5) paragraph (1) states that every company is obliged to implement OSHMS in its company. Furthermore, paragraph (2) explains every company that employs at least 100 workers or has a high level of potential danger. Implementing OSHMS can make companies more efficient in carrying out operations and as branding company to increase value. The most important thing is to implement the regulations set. Provisions regarding Occupational Health and Safety (OHS) have been clearly regulated, but in reality most companies have not met OHS standards [3]. [4] said that shipyard companies have a high risk of danger in their production processes, including work at heights, work in confined spaces, lifting work, using electricity and working above the water surface. [5] said that the shipbuilding industry is very at risk of work accidents, considering that the equipment and materials used in the production process are relatively dangerous, both heavy materials and toxic materials.

One of the shipyards that has a high risk of danger is the Muara Angke Fisheries Service Employees Cooperative (FSEC) yard. The existence of a FSEC shipyard is very important, because it is needed to meet maintenance needs [6]. The FSEC shipyard is located in the former Center For Fishing Technology (CFFT) complex which only actively provides fishing vessel repairs. The workers carry out this activity from 08.00 to 16.00 WIB, with a 1 hour lunch break. Based on data in January 2023, 25 to 30 fishing vessels carry out repairs every month. Production data from the FSEC shipyard (CFFT 2013) shows that on average every month it is capable of serving 28 ships [7]. There are three stages in the ship repair process carried out by workers at the shipyard starting from; a) docking preparation boat; b) ship docking process and; c) post docking boat.

Various activities at the FSEC shipyard found many potential dangers in each element of work activity. This can be seen from; a) the layout of equipment placement is not neat; b) electrical cables are scattered in various directions and; c) there are no warning signs in the work area. Apart from that, other conditions that can be seen from the way of work include; a) workers do not wear welding masks; b) workers face shields when grinding; c) not wearing a helmet when working and; d) not using a safety belt when working at height. Apart from that, the shipyard does not yet have a work unit responsible for OHS in its organizational structure. Considering the number of services and the many activities in the ship repair process, these are demands that workers must complete when carrying out the work. Ship owners and shipyard

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managers are more focused on completing their work targets than on the safety of their workers. This is proven by research [8] which states that shipyard managers are fixated on work patterns that are usually carried out, thus ignoring OHS aspects. If this condition is leftunchecked, it has the potential to increase the risk of work accidents.

The FSEC shipyard requires risk assessments and critical points in each ship repair activity to overcome these problems. Thus, this research was prepared with the aim of; a) identifying and describe the flow of work at the FSEC shipyard; b) determine critical points along the work flow, along with sources of danger and their consequences. This research was carried out using a direct observation approach at the shipyard and questionnaires to actors involved in the ship repair process. Data analysis in this research using the Failure Mode and Effect Analysis (FMEA) method is used to identify each type of work and risk assessment how often and how severethe risk is. The hypothesis of this research is that, by knowing the potential dangers and risks of work accidents in each line of work, alternative risk mitigation can beprepared for work at the shipyard.

II. METHOD

A. Types and Sources of Data

The data collection method in this research was carried out through direct observation or observation in the field and distributing questionnaires. The type of data collected for the first objective is to identify and describe the flow of ship repair work at the FSEC shipyard from the ship docking preparation stage, ship docking process and post ship docking. The sources of data collected come from shipyards and ships. The second type of data is risk assessment questionnaire data which is distributed to determine the weight and preference value of each criterion according to respondents. The source of data collected came from respondents directlyinvolved in the ship repair process.

B. Data Collection Techniques (sample)

The data collection method in this research is trought obsesvation, interviews and questionnaires. The sampling technique is carried out using the Non Probability sampling method (Accidental sampling and Purposive sampling)

a) The accidental sampling method is applied to obtain samples of ships that are the object of observation withthe number of samples based on conditions in the field.This method was chosen because the ships that will dock *at* the shipyard are not regularly scheduled. The ships used as research samples were ships that were carrying out docking activities at that time. The sample ships selected in this study ranged in size from 5 GT to200 GT. Based on data from the FSEC shipyard, an average of 30 ships dock every month. Therefore, the number of ships taken was 30 ships.
b) The purposive sampling method was applied for sampling respondents. The respondents who were the targets of purposive sampling in this research were 2 shipyard operational managers, 13 shipyard workers and 15 people responsible for ship repairs (field coordinators).

C. Data Analysis

a) After obtaining the required data and grouping it based on objectives, the first objective is to analyze each type of activity in the FSEC yard. This analysis is carried out by identifying and describing work at the shipyard starting from preparation for ship docking, the ship docking process and the ship docking process. Next, at each stage of work, a work safety analysis is carried out.
b) Based on the results of data analysis in objective 1, a risk assessment is then carried out, obtained throughthe FMEA approach. This method is focused on assessing the risk of the impact of failure and identifying actions to reduce failure. [9], said that the FMEA method can be used to analyze the potential causes of a disturbance, the probability of its occurrence and how to detect the disturbance. Based on FMEA assessment can determine critical points along the work flow.

There are steps in implementing FMEA are as follows;

a) Review activities that might give rise torisk.
b) Assess the seriousness of the Severity accident(S).
c) Assess the level of accident frequency Occurance (O).
d) Assess the level of detection of accident Detection (D).
e) Calculate the priority level of RPN.
f) Prioritize failure modes for further handling.

TABLE 1.
MEASUREMENT OF SEVERITY, OCCURANCE AND DETECTION PARAMETERS

Score	Severity	Occurance	Detection
1	There isn't any	Almost never	Difficult
2	Low	Seldom	Quite difficult
3	Curently	A little often	It's a bit difficult
4	Tall	Often enough	Just normal
5	Very high	Often	Almost certainly

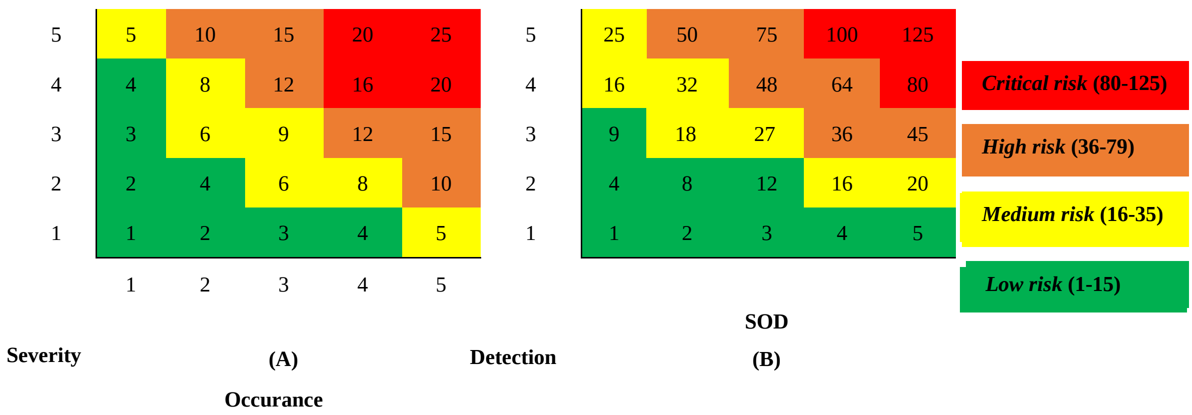

Figure 1. (A) Critical Matrix Diagram dan (B) Modified Critical Matrix Diagram

Parameter measurements refer to the theory [10] which is modified when it occurs. This is done according to the time of work at the shipyard which is evaluated generally once every year. The assessment uses a scale of 1 to 5 aslisted in Table 1.

Based on the assessment of respondents from shipyard operational managers, shipyard workers and field coordinators in the ship repair process, there are potential risks work accidents are predominantly sought based on variables that have a high level of risk. The next step is carried out by finding the ratio level of the critical risk diagram is shown in Figure 1.

RPN = Severity x Occurance x Detection...............(1)

D. Research Framework

The research framework is one part of the preparation of this research, functioning to expedite the completion process. The following are the research framework steps based on the research objectives including;

(a) Objective one. The initial stage in data collection was a literature study, used for studying theory and science related to the problems studied. Literature studies come from the internet, journals, articles and book. Next, at the same stage, a pre-research survey is carried out to get a general picture and researchers can find out the problems that occur in the field. Next, identify and describe potential dangers in each flow of ship repair and maintenance work at the shipyard. The analysis obtained is in the

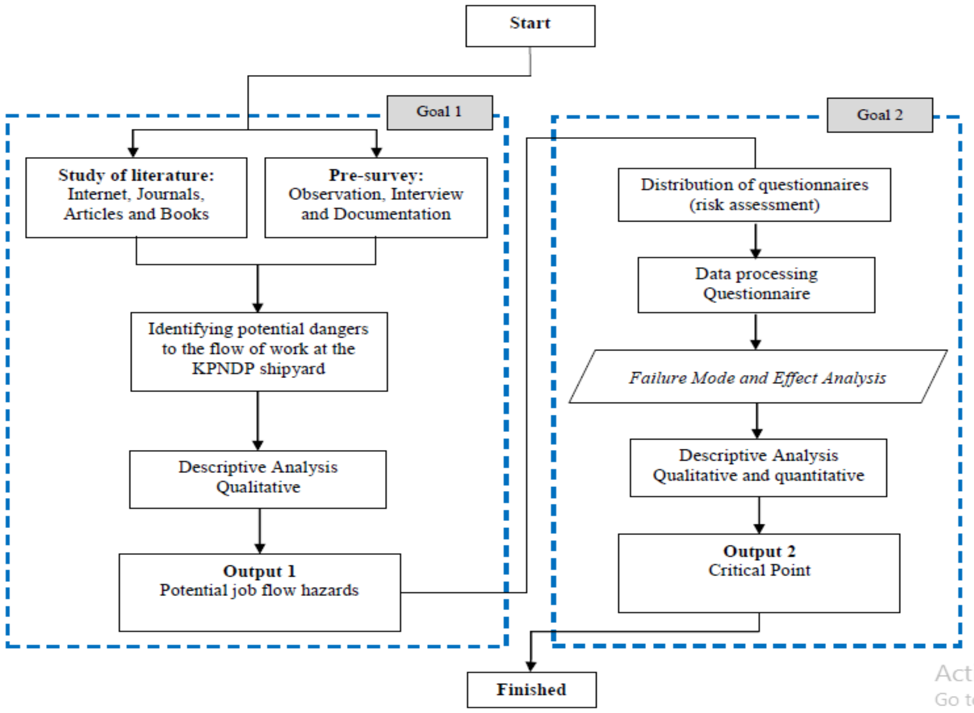

Figure 2. Research Framework

The critical matrix diagram (A) refers to theory [11] which was modified by adding a detection number. So the Risk Priority Number (RPN) value can be used to determine the grouping of hazard sources seen in the modified matrix diagram image (B). The RPN calculation formula is as follows:

form of qualitative descriptive analysis. The resulting output is an identification and description of the potential hazards of the work flow that the researcher has determined.

(b) Second objective. The second stage carried out a risk assessment by distributing questionnaires to determine the weight and preference value of each criterion according to respondents. Next, data processing is carried out using the FMEA method with the aim of determining critical points along the work flow along with the dangers and risks. The analysis obtained is quantitative descriptive. The resulting output is the value of critical points in each work flow.

The framework is presented in Figure 2 above.

III. Results and Discussion

A. FSEC Shipyard Profile

The FSEC shipyard is one of the shipyards located in the former CFFT complex, precisely in Muara Angke, North Jakarta. The responsible shipyard FSEC is under the authority of the DKI Jakarta Provincial Maritime Food Security and Agriculture Service (PMFSAS DKI Jakarta Province. However, the management of ship repair activities at FSEC has been delegated to the Muara Angke Fishing Port Management Unit (FPMU) so that monitoring is carried out by FPMU Muara Angke. This is in accordance with the agreement between DKPKP and FSEC regarding cooperation in asset utilization with a rental agreement Number 9966/-072.26 dated December 14, 2016 (BPAD Jakarta Province 2016).

Repair activities at the shipyard are only carried out during the day. The FSEC shipyard has 5 slipway lanes where 4 lanes can accommodate 2 ships and 1 lane can only accommodate 1 ship. All slipway routes are capable of lifting ships weighing 5 GT to 200 GT. The method used to lift the ship is the slipway dock method where the ship is straightened and seated on a trolley, then the ship is pulled from the surface of the water with a steel-roped crane via a rail that juts out into the water. There are several things that must be considered before towing the ship, including; a) the ship must be empty; b) minimum possible fuel; c) ensure that the ship is straight and not tilted; d) the ship is ensured to be properly wedged and; e) the shipis towed slowly.

Based on shipyard data (FSEC 2023), on average every month it serves 24 to 28 ships. However, in the period October and November (2023) the number increased to 37 to 40 ships carrying out repairs. Ship repair activities at the FSEC shipyard are divided into two: a) Annual maintenance (repair of light vessels) is carried out by the ship owner routinely after carrying out fishing operations. b) Large docks (heavy ship repairs), where major dock repairs are assumed to be similar to annual maintenance, but large docks require a long time and are complex.

B. Identify the Ship Repair Process Flow

Ship repair activities start from registration (determining the schedule for the ship to dock), determining the tools and materials needed for repairs to determining skilled workers. The ship owner will contact the shipyard to ask to register the ship and enter the repair queue. Once the queue file is complete, the shipyard will issue a permit and ship queue number. Regarding this matter, the ship owner gives full responsibility to someone who is generally called the field coordinator. So, everything is Concerns with ship owners can be handled by the field coordinator. After getting the dock boarding schedule, at that time the field coordinator contacted the captain to immediately berth the ship at the docking pool. If at that time the tracks are empty and it is still daytime, the ship will be immediately raised to the dock. Several stages when

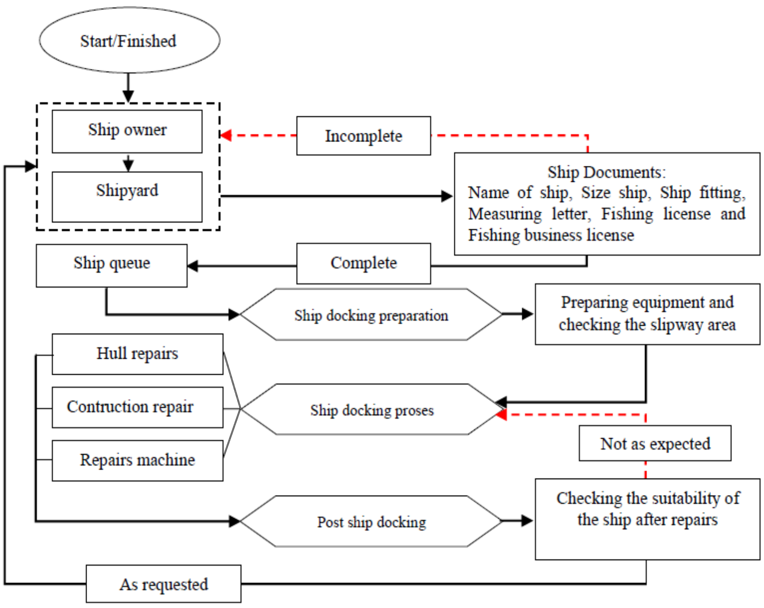

Figure 3. Ship Repair Flow

carrying out ship repairs at the FSEC shipyard consist of docking preparations ship, ship docking process and post ship docking as follows;

a) Preparation for Ship Docking

The process of preparing a ship to dock is an activity carried out after the ship owner and the shipyard have agreed on several administrative requirements which they have completed. Next, the shipyard will ensure that the tools used to raise the ship are ready. In this case, there is a division into several work teams including; a) 1 dock master is tasked with supervising and conveying the code from the diver to the winch machine operator; b) 1 winch machine operator is tasked with operating the machine and applying oil to the roll slings; c) 2 divers on duty at the bottom of the bow and stern of the ship, precisely positioning the keel of the shipso that it is in the middle of the lorry; d) 6 people tasked with regulating the balance and installation of the beams on the ship's hull and; e) 1 person is tasked with climbing the rope attached to the bow of the ship to provide impetusto the winch machine.

The stage of raising the ship begins with ensuring conditions at the shipyard, such as removing rubbish or objects around the rails, which is done by several divers, so that there are no obstacles when the truck goes up or down. Next, the lorry is placed on the rail and then lowered into the water by the operator with the help of a machine, along with bringing the ship closer to the slipway. In the process of raising the ship, the dock master is on land in front of the ship. Then the diver adjusts the position of the ship so that the keel of the ship is directly on the two lorries. If the front and rear keels of the ship are in the correct position, the diver will give a code to the machine operator while installing a block as a block and the machine operatorwill slowly pull the ship. As the ship was slowly pulled up, the divers helped clearaway the barnacles using scrap tools.

The length of towing the ship depends on the size of the ship and the number of wire rope carriers when used. Ships measuring <100 GT require 1½ to 2 hours, while ships measuring >100 GT require 2½ to 4 hours. The larger the size of the ship, the more wire rope carriers used, and vice versa. This will determine how fast and slow the ship will be towed. Ships measuring <100 GT only use 2 wire roperopers, while ships >100 GT use 5 wire rope ropers.

b) Ship Docking Process

The next activity is the ship docking process, where all workers have freelanced status. There are several repair steps carried out when the ship is on the dock, including; 1) ship hull repairs (entire bow to stern). The repair steps for the ship's hull began with brushing off the remaining barnacles that had previously been scraped by the divers. The number of workers carrying out brushing is 3 to 5 people, depending on the size of the ship. After part of the ship's hull began to dry, the workers cleaned the remaining paint that had peeled off using a grinding tool. This is done so that when the putty sticks quickly and dries. Next, the workers carry out the activity of applying putty, followed by applying the mixture (resin and catalyst) and 4 to 7 layers of fiber. Components used during repairs include; putty, resin, catalyst and fiber; 2) Repair of ship construction (bow, decks and decks). Ship construction repair steps depend on the level of damage. If the wood on the bow, trusses and deck is rotten, the next step is to replace the wood. This repair activity can affect the length of work time. The processing time required by workers can reach 4 to 8 days and; c) Engine repair (propulsion system). Repair steps in the engine section (propulsion system), based on facts in the field, no engine repairs were found. Mechanic workers only repair and maintain ampere dynamos, gearbox maintenance, tire coupling maintenance, oil seal replacement, plunger replacement, nozzle replacement and oil refilling. This work is carried out by 2 to 4 people.

c) Post Ship Docking

The final activity is post-docking, starting with checking the ship from the ship owner's files and the physical appearance of the ship that has been repaired. If during the inspection there are still damaged parts or the workers are not careful in repairs, then coordination will be carried out between the ship owner and the field coordinator. Next, the field coordinator will order the workers to carry out repairs as soon as possible, because for every ship thatexceeds the agreed time, additional fees will be charged. After the repair check is declared complete, the shipyard will prepare to lower the ship. The tools used in the lowering process are assumed to be the same as when raising the ship. The time required to lower the ship is very short, 10 to 20 minutes. Next, the shipyard workers returned to their residences to wash and clean themselves.

C. Risk Assessment in the Ship Repair Work Flow

The risk assessment stage is a worksheet created to facilitate the process of assessing a list of work activities that have sources of danger and potential dangers caused by giving a score of 1 to 5 with the reference listed in Table 1. The RPN calculation is used to determine the level of the source of danger. Whole ship repair activities at the FSEC shipyard have been identified and described. Based on the identification results that are assumed to be crucial in the flow of ship repair activities, 26 activities were recorded, as shown in Tables2, 3 and 4.

TABLE 2.
RISK ASSESSMENT RESULTS OF SHIP DOCKING PREPARATION

Kode	Activity	Code SD	Source Danger	Potency Danger	Consequence	Control at moment	S	O	D	RPN
A1	The ship enters the docking area (berths)	SD1	The captain was not carefull	Collision between ships	Ships repair costs are increasing	No supervision	5	4	4	80
		SD2	The ship's crew (ABK) were less careful	Ship crew who fell/were trapped by the ship	Medical costs for crew members	No supervision	4	3	4	48
A2	Check the condition of the rails	SD3	Workes are not careful when controling the slipway	Workers are stabbed or cut by sharp object around the tracks	The worker suffered injuries to his body so he was temporarily unable to work	Shipyard foreman	3	2	2	12
		SD4	Disposal of used rivets	Workers accidentally kick or step on hard or sharp objects around the rails	The worker experienced bruises and infection (tetanus) so that the worker could not work for 5-7 days	Shipyard foreman	3	4	3	36
A3	Clean up rubbish left over from the docking process in the slipway area	SD5	Workers pay less attention to leftover tools or dangerous materials that have been used previously	The worker was stabbed by a hard object or cut by a sharp object	The worker suffered injuries to his body so he was temporarily unable to work	Shipyard foreman	3	3	2	18
A4	Operates the slipway towing winch machine	SD6	The vanbelt hasn't been replaced in a long time	The winch vanbelt broke	The worker suffered minor injuries due to a broken machine vanbelt	Shipyard foreman	4	3	2	24
		SD7	Workers do not use ear muffs	Noise	Hearing disorders	Control machine operator	4	5	3	60
A5	Tow the ship to the designated slipway	SD8	Rising water levels and a shortage of workers	The ship is difficult to control	Less efficient processing time	Shipyard foreman	4	4	2	32
		SD9	Workers are not careful	The worker was trapped in the ship's hul	The worker suffered a broken bone	Shipyard foreman	4	3	2	24
A6	Perform dives to position the ship	SD10	Workers are not careful	The worker was trapped in the ship's hull	Workers suffer from minor injuries or even death	Shipyard foreman	3	3	3	27
		SD11	Dirty shipyard pool water (polluted by waste)	Attacked by skin disease	Workers experience itching and irritation	Lack of control by the shipyard	3	4	2	24
A7	Straightening or leveling a ship	SD12	The winch engine suddenly stops	The ship crashed	Time is less efficient and cash costs are getting bigger	Shipyard foreman	5	3	3	45
		SD13	The ship is not on its stand	The ship tilts to the left or right	Time is less efficient and cash costs are getting bigger	Shipyard foreman	4	2	3	24
		SD14	Workers are not careful	Workers trapped by ship	Workers suffer minor injuries and even death	Shipyard foreman	3	3	4	36
A8	Added blocks to the ship's hull	SD15	The placement of the blocks is not quite right.	The ship is tilting left or right	Workers can be trapped by ships, causing death	Shipyard foreman	4	2	3	24
A9	Apply oil to the wire rope	SD16	The winch engine stops	The wire rope roll rotates back	Workers were thrown by the wire rope, causing fatal injuries or death	Shipyard foreman	5	3	3	45
A10	Attach the iron to the trolley	SD17	Delay in attaching the load block to the trolley	Snatched by wirbroke	Less efficient processing time due to the ship being towed	Shipyard foreman	4	2	3	24

TABLE 3.
RESULT OF THE RISK ASSESSMENT OF THE SHIP DOCKING PROCESS

Kode	Activity	Code SD	Source Danger	Potency Danger	Consequence	Control at moment	S	O	D	RPN
B1	Disposal of remaining barnacles using a grinding machine	SD18	The grinding wheel was replaced late and was not used correctly	Affected by a grinding wheel fracture	Suffered from minor to major injuries	Supervision of coordinators	5	4	4	80
		SD19	Not using a mask	Exposure to dust	Out of breat	Supervision of coordinators	4	5	3	60
B2	Turning on the grinder	SD20	Cable skin is peeling	Electric shock	Suffering from burns	Supervision of coordinators	4	5	4	80
B3	Grinding parts hull and head under the ship	SD21	Grinding too far above the upper	Eyes and nose exposed to dus	Suffering from minor to major injuries	Supervision of coordinators	4	5	4	80
		SD22	Workers do not wear masks	Noses are exposed to dus	Out of breath	Supervision of coordinators	4	5	3	60
B4	Replacement of rotten wood on the ship's hull	SD23	Storing hard objects too far away	Affects workers below	Bruised wounds	Supervision of coordinators	3	5	3	45
		SD24	Workers are not careful	Hand hammered and sawed	Hands bruised and cut	Supervision of coordinators	3	4	2	24
B5	Caulking of the ship's hull	SD25	Workers do not use safety belts	Falling from a height	Broken bones and concussions	Supervision of coordinators	4	4	3	48
B6	Replaced wood cracks	SD26	The wooden or bamboo steps are rotten	Falling from a height	Broken bones and concussions	Supervision of coordinators	4	3	2	24
B7	Coating the fiber by applying a mixture (resin and catalyst)	SD27	Mixed splash (resin and catalyst)	Exposed mixture (resin/catalyst)	Peeling skin, reddish skin, sore and burning sensation	Supervision of coordinators	4	4	3	48
B8	Ship interior repairs	SD28	Welding sparks	Fire	Big loss	Supervision of coordinators	5	2	3	30
		SD29	Wet workers' gloves	Electric shock	Bruises and burns	Supervision of coordinators	3	3	3	27
		SD30	Workers do not use PPE (masks and glasses) when welding	Exposure to welding fumes	Stinging and pain in the eyes and irritation of the respiratory tract	Supervision of coordinators	4	4	3	36
B9	Get on and off the ship	SD31	The stair steps are round	Falling from a height	Broken bones and bruises	Supervision of coordinators	5	4	4	80
B10	Removing or installing the propeller	SD32	The number of workers is low	Hit by a propeller	Broken bones and bruises	Supervision of coordinators	4	3	3	36

TABLE 4.
RESULT OF THE SHIPS POST-DOCKING RISK ASSESSMENT

Code	Activity	Code SD	Source Danger	Potency Danger	Consequence	Control at moment	S	O	D	RPN
C1	Check the condition of the rails	SD33	Workers are less careful when controlling rail conditions	Workers are stabbed or cut sharp objects around the track	Workers suffered minor injuries from high injury	Shipyard foreman	2	2	4	16
C2	Clean up rubbish left over from the docking process	SD34	Hazardous waste from previous shop docking	Worker impaled by object was cut by a sharp object	Suffered from minor injuries	Shipyard foreman	2	1	4	8
C3	Operates the slipway towing winch machine	SD35	The vanbelt hasn't been replaced in a long time	The winch vanbelt broke	The worker suffered minor injuries due to a broken machine vanbelt	Supervision of machine operator	4	2	3	24
		SD36	Workers do not use ear muffs	Noise	Hearing disorders	Shipyard foreman	4	3	2	24
C4	Doing dives	SD37	The ship withdrew suddenly	Workers are squeezed	The worker suffered a broken hand	Shipyard foreman	3	3	3	27
C5	Holding a ship that is being lowered	SD38	Workers are not careful	Workers are entangled in ropes	The worker's hand was broken	Shipyard foreman	5	5	4	100
		SD39	The strap has not been replaced for a long tim	The rope broke	Jumped	Lack of supervision	3	4	4	48
C6	Removing the wooden beams supporting ship	SD40	Workers let go when there is activity on board the ship	Hit by a hard object from above	The worker had bruises		3	2	4	24

Meanwhile, the total sources of danger from 26 ship repair activities in table 2 show 40 sources of danger, including; a) preparation for ship docking 17 sources of danger; b) ship docking process 15 sources of danger and; c) post docking ofthe ship 8 sources of danger.

Based on the RPN value calculation above, it is known that the highest RPN value in repair activities recorded 6 sources of danger which are included in the Critical Risk category including; Workers were not careful, The captain was not careful, The grinding wheel was replaced late and was not used correctly, Cable skin was peeling, Grinding too far above the upper and The stair steps were round. The next stage is to group the sources of danger.

D. Grouping Hazard Source Cetegories.

Classification of hazard sources is carried out using three assessment criteria including; severity, occurrence, detection. The risk level consists of the lowest including; a) low risk recorded 2 sources of danger; b) medium risk recorded 18 sources of danger; c) high risk recorded 14 sources of danger and; d) critical risk recorded at 6 source of danger. Hazard source grouping is carried out to determine the level and priority of each risk that has been identified. The following is a diagram of the grouping of 40 sources of danger shown in Figure 4.

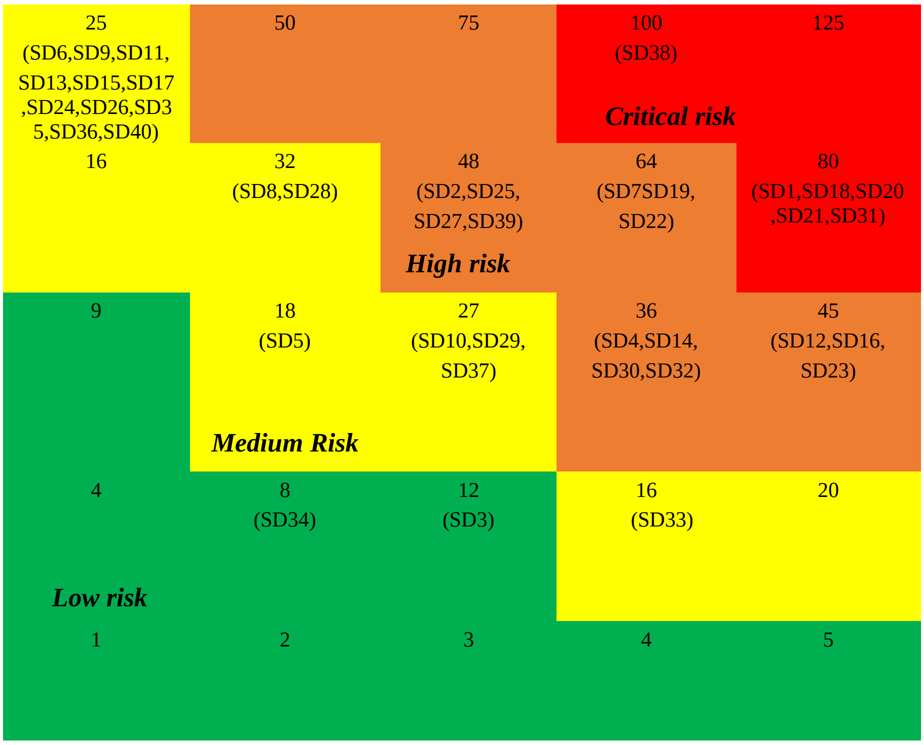

Figure 4. Hazard Source Group SOD Diagram

E. Mitigation of Hazard Sources

Based on the grouping of danger sources in the critical risk diagram, 6 sources of danger are recorded including;

1) Holding the ship while it is being lowered: the activity of holding the ship while it is being lowered is carried out byworkers after the ship has completed the repair process. Shipyard workers at that time will also lowering the ship into the water with the help of a winch, steel slings and workers. The aim of holding the ship is to prevent the ship from descending too fast and turning. This work will have fatal consequences if the workers assigned to hold the ship do not know the techniques and have long enough work experience, so the workers are at risk of getting entangled in the ropes. So, the proposed mitigation is the assignment of workers' duties according to work experience.
2) The ship enters the docking area (berth): the activity of entering the ship into the docking area requires expertise inoperating the ship However, the condition of the shipyard pool is narrow and the captain's visibility is limited. This will make it difficult forthe captain to operate the ship, so it is impossible for the ship to hit another ship that is anchored. There is a big possibility of increasing repair costs. So, the proposed mitigation is that crew members and shipyard foremen should communicate so that accidents such as collisions between ships do not occur.

TABLE 5.
PRIORITIES FOR MITIGATION OF HAZARD SOURCES

No	Activity	Code SD	Source of Danger	RPN/ Category	Mitigation
1	Holding a ship that is being	38	Workes are entangled in ropes	100	Placement of worker duties in accordance with work experience.
2	The ship enters the docking area (berths)	1	The captain was not careful	80	Crew members and shipyard foremen should communicate so that accident such as ship collisions do not occur. The person responsible repairs should check the equipment regulary
3	Disporal of remaining barnacles	18	The grinding wheel was replaced late	80	Requires reporting from both shipyard workers and repair workersto report damage to equipment or other facilities.
4	Turn on the grinder	20	The cable skin is peeling	80	Workers do not need to force the use of old grinders and immediately replace them with new grinders. Workers should use face shields to avoid exposure to dust.
5	Grinding the upper and lower hull parts of the ship	21	Grinding too high above the head (not the corret way to use it)	80	Connect the grinder to bamboo so that the working reachis long.
6	Get on and of the ship	31	The satir steps are round	80	Shipyard managers should change the shape of the ladder steps from round to square so that the ladder steps are notslippery.

3) Disposal of remaining barnacles: workers carry out barnacle cleaning activities after the ship's hull is scrapped. A grinding wheel that is deliberately used as a tool to cut nails or nuts will have different resistance to a grinding wheel that accidentally hits a nail or nut. If the grinding bladeaccidentally hits this object, it will quickly break. This is proven in the case of cleaning the ship's hull. So, the proposed mitigation is that the person responsible for repairs should check the equipment regularly. Likewise, para Workers are required to report damage to equipment or other facilities.
4) Turning on the grinder: the grinding machine really needs electric current to operate. To create safe work, equipment must also be in goodcondition. The habit of workers when starting the grinder is rarely to check the machine. Most likely workers will experience electric shock. So, the proposed mitigation is that workers do not need to force themselves to use old grinders and immediately replace them with new grinders.
5) Grinding the upper and lower hull parts of the ship: after removing the remaining barnacles, workers will grind the entire hull again to clean the rust to make the caulking or painting process easier. However, when doing this work the workers are not paying attention to how it works, such as grinding too overhead. This behavior is an unsafe condition, so it is possible that workers will be exposed to sparks or hot objects. So, the proposed mitigation is that workers should use face shields so that they are not exposed to dust and rust and connect the grinder with bamboo so thatthe working distance is long.
6) Going up and down the ship: the movement of workers when carrying out ship repairs is very dynamic, the workers move up or down the ship. The tool used to climb to the top is a round ladder. So, workers have the potential to slip and fall. So, the proposed mitigation is changing the shape of the steps from round to square so that the steps are not slippery.

IV. CONCLUSION

Based on the results of data processing and analysis, the following conclusionswere obtained:

1. The results of identifying hazards in ship repair activities at the FSEC shipyard recorded 26 activities which were assumed to be crucial, including; 10 activitiesin preparation for ship docking, 10 activities in the ship docking process and 6 activities in post-ship docking.
2. The results of data analysis using FMEA showed that 6 activities were included in the critical risk category, including; holding the ship when it is being lowered, the ship entering the docking area, removing the remaining barnacles, turning on the grinder, grinding the upper and lower hull of the ship and going up and down the ship

This research suggestion, seen from the RPN values inworksheet tables 2, 3 and 4, requires a Hierarchy of Controls method with OHSAS 18001 guidelines that adapts the shipyard's ability to determine priority values and mitigation.

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