

Identification of Occupational Accident Relations of Shipyard Labour in terms of Individual and Workplace Factors

Muhammad Badrus Zaman¹, Trika Pitana³, Alif Bagas Septianto³

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Abstract— shipyard is an industry that has a major role in trading, the shipyard industry leads another industry to triumph, this has been proved in many countries. Factors that are related to workplace accidents in shipyard workers are disturbed when using a safety harness while working at height, less knowledge about static electricity, do not take measurements of indoor gas before work, working more than eight hours, constant growing pressure. Precautions include checking safety equipment used to work at height, routinely checking cables, electrical circuits, and electrical equipment, conduct indoor gas measurements, make the worker's shift schedule to eight hours per day and increasing workers to complete the job by finding new employees, short briefing.

Keywords—identification, individual factors, occupational accident, shipyard, workplace factors

I. INTRODUCTION

Shipyard industry is an industry that has a very important role in the trading industry. The shipyard industry is an industry that is categorized as a heavy industry because of the equipment used and the complexity of all production processes in the industry. The shipyard industry uses and manufactures a wide range of components manufactured from basic construction materials. There are various production processes in the shipyard that can cause accidents that can affect health and safety. In the shipbuilding industry, it is very necessary that human resources can perform the work process with harsh conditions with dangerous work equipment. Shipyard industry is a very complex industry, which means that a variety of complex jobs must be done in parallel. In addition, sufficient space must be available for storage of various materials and equipment in the shipyard [1].

The process of handling and receiving steel in the production process at the shipyard requires great facilities and space in the shipyard. Once the steel plate is received, inspected, and stored, the steel must also be blasted, cut as needed, shaped to the required design, and welded to obtain steel that can be used in the assembly process. The installation procedure consists of panel formation, block installation, pre-outfitting, complete installation, pipeline determination, air conditioning, electric cable line construction, ship surface preparation, and coating. The whole process in the shipyard must be

done correctly and in a timely manner, and also the mentioned process above should be done carefully. According to Heinrich, the highest chance of industrial accidents is caused by human activities (88%), 10% caused by unsafe working environment, and 2% of work accident caused by the unreasonable factor. The result of his research shows that 98% of accidents can be avoided and can be controlled by human capabilities. Currently, many industrial accidents are caused by human factors. Therefore, it is an important issue to avoid and control human habits in preventing accidents from happening [2].

Workplace accidents are unforeseen and unintentional incidents, which occur in economic activity, causing one or more workers to be injured or lost their lives. An accident is a preliminary event, after which an injury may result, material damage, or environmental damage. Common causes of occupational accidents include altitude, toxic materials, flammable and explosive materials, fire, rotating machinery, harmful gases, frivolous work, equipment misuse or equipment failure, improper work, poor lighting at a place, electrical hazards, and clothing that does not comply with safety standards. Worker carelessness, lack of training and education about work safety, human error in operation, and insufficient workspace are major factors in workplace accidents. Every 15 second, one worker passed away due to work accident or occupational illness. 160 workers suffer from occupational accident every 15 seconds. More than 2.3 million deaths per year are caused by occupational accidents, and there are more than 336 million accidents each year [3].

Turkey is one of the countries that have been researched on work accident in a shipyard. Turkey is ranked 10th for the world's largest ship finish in 2013, completing a total of 68 ships totaling 194000 GT. In Turkey, providing a safer working environment on the shipyard has been important in recent years. From 2004 to 2014, 126 workers died from work accidents. Occupational data in Turkey says that 30.2% of accidents are falling from a height, 23% of occupational

Muhammad Badrus Zaman, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: druz_zaman@ne.its.ac.id

Trika Pitana, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: trika@its.ac.id

Alif Bagas Septianto, Department of Marine Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: alif.bagas.tianto@gmail.com

accidents are objects of falling objects, 16.7% of accidents are fire accidents and/or explosive events, 13.5% electric shock events, 11.1% of occupational accidents are drowning events, and 5.6% are work accidents caused by other things [4].

According to a study conducted by Yilmaz et al in "S" shipyard in Turkey in 2011-2013, from 100 workplace accidents tested, 87% accidents were minor accidents, ie accidents that resulted in the inability of workers to work within 1-3 days, while 13% of accidents are major accidents, ie accidents that result in the inability of workers to work in more than 4 days. In this study, it was found out that there was a loss of 44 working days caused by minor accidents and 138 lost working days caused by major accidents [1]. Information on occupational accidents and reporting are required by conducting surveys and observing the working environment that can later be used to determine the causes and prevention of occupational accidents occurring in the work environment. Epidemiological studies, work plan preparation, medical supervision, and work environment monitoring are essential to help identify the existing problems and anticipate the effect of the work environment on occupational health and safety of workers in a country [5].

According to data released by Lloyd's Register in 2006, China is the biggest country producing new ships, with 1,480 ship units (30.1%), followed by North Korea with 1,426 ship units (29%), Japan with 1,262 ship units (25.67%), and Indonesia with 68 ships (1.38%). Many arguments are arguing about the development of the shipyard industry in Indonesia, such as the economic value of the industry. It is mentioned that the shipyard industry is an industry that can encourage other industries in Indonesia, so the progress of the shipyard industry can advance other industries, thereby making the industrialization process increase in a country [6].

Indonesia as a country that has a vision on maritime, Indonesia needs to increase work productivity in the shipyard sector, according to data presented above in other countries, workplace accident can be a factor that slows down work productivity in the shipyard. It is necessary to conduct research and observation to know the individual factors and workplace factors related to work accident in the shipyard workers in Indonesia in an effort to reduce accidents. For now, there is no official data in Indonesia yet, but may already be done by the company to know the individual factors and work environment related to a work accident in the shipyard. Identification of individual factors and work environment related to work accident at the shipyard was first done by Barlas and Izci. Identification is done by distributing questionnaires to Turkish shipbuilders to provide a quantitative assessment and response of different individuals. The questionnaire consists of four groups: personal data, work environment, personal factors, and commuting factors. The total question in the questionnaire was 56 questions. The results indicate that the low level of education of the shipyard workers, the bad housekeeping of the workshop, the bad weather, the use of improper personal protective equipment, tired and sleepy, overcapacity ship production, untidy work,

overtime working, being a subcontract worker, and heavy workloads are major risk for occupational accident. [4]

The shipyard industry is an industry that aims to make products in the form of ships, floating buildings, or offshore structures, and others for customers. Making the product is done with the specifications required by the buyer. In addition to production, the shipyard industry also provides repair services for ships and other marine buildings. Today's shipbuilding industry is advancing as demand is increasing in the era of globalization and the ease of transporting goods through waterways such as raw materials and components to the rest of the world. The shipyard industry has always been dominated by maritime nations, such as Britain, France, Germany, the United States, Japan, Korea, and China. Currently, the commercial sector of the shipyard industry is dominated by China, Japan, and Korea [7].

According to Indonesian Regulation No.1 1970, every worker is granted protection for the safety of doing work for the welfare of life and to increase national production and productivity, and every other person at work needs to be assured of his safety. Mentioned in this regulation that the requirement of occupational safety is to prevent and reduce accidents; prevent, reduce and extinguish fires; prevent and reduce the dangers of blasting; provide an opportunity or a way to save themselves when a fire occurs or other dangerous circumstances; giving help to accidents; provide self-protection tools to workers; prevent and control the emergence or spread of temperature, humidity, dust, dirt, smoke, vapor, gas, wind, weather, light or radiation, sound and vibration; prevent and control the onset of illness due to physical or psychological work, poisoning, infection and transmission; obtain sufficient and appropriate lighting; maintaining good air temperature and humidity; maintaining sufficient air refreshment; maintain hygiene, health, and order; obtaining harmony between the workforce, the work tool, the environment, the way, and its work processes; secure and facilitate the transportation of persons, animals, plants, or goods; securing and maintaining all types of buildings; securing and expediting loading and unloading, treatment and storage of goods; prevent exposure to dangerous electrical current; adjusting and perfecting security in jobs where the danger of accidents grows higher [8].

Psychologists conduct research on what the definition of occupational safety is and relate the relationship between occupational accidents and factors related to occupational safety cultures, such as heavy workload, emotional stability, and internal or external safety control. Workplace safety is defined by Zohar as a basic perception of the worker about how safe his work environment is. Work safety consists of eight factors: the importance of conducting safety training, safety attitudes from management, the impact of safety culture on promotion, the severity of risks arising from the workplace, the effects of the speed of work on safety, the status of the occupational safety manager, the influence of safety culture on social status, and the status of the safety committee. According to Griffin and Neal, work safety is defined as a climate that exists in organizations

that an individual feels toward the organization that he or she is following. Work safety consists of five factors: the meaning of management, communication, safety implementation, education/training, and safety tools [9].

Prevention of occupational injuries can be done because according to previous research, 98% of accidents can be prevented, and only 2% of workplace accidents cannot be prevented. Prevention of workplace factors are done in various ways as follows [10]: for falling from height accident use and check safety equipment to work at heights, build handrails at elevated workplaces, inspect work surfaces at slippery heights and install web if needed, provide safety training, place warning signs at workplace, for electric exposure use insulated shoes and appropriate work clothes, plug ground electrical systems and switches for electrical leakage, check cables regularly, for fire and or explosion check gas regularly and strictly control, create a hot work action report when needed, make good ventilation, for being struck by object accident cause always work with a rigger, follow the rules of crane use, use appropriate support items, and for squeezed between accident Create an appropriate environment for work, install a sound warning system on the shipyard, use a border for steel sheets.

Prevention of individual factors is done in various ways as follows: for stress and daily life problems, management has to provide assistance in the form of counseling to workers [11]. Not enough rest time while working, shipyard management must give worker enough time to rest because fatigue can increase the risk of the occupational accident [12]. Working more than 8 hours a day shipyard management need to reduce the high level of excessive work by rearranging the activities undertaken, reducing repetitive work, and managing the shifting of orders caused by shipowner demand [4]. The first hour of work and after lunch effect by increasing the concentration of workers before starting work by doing short meetings together before work [4], [13]. Bad weather, these conditions are associated with increased occupational injury risks, more stringent precautions are needed in times of poor weather [4]. Job commitment, workers who are satisfied with their work have a lower accident rate [14], while workers who are not satisfied with their work have a higher risk to experience occupational accident [15].

II. METHOD

This research method is done by doing a shipyard questionnaire survey, identify the individual and workplace factors, then find the right precaution for the individual and workplace factors related to the occupational accident of shipyard workers. The individual factors are analyzed by descriptive analysis, and the workplace factors are analyzed by AHP method by using AHP questionnaire from six experts in the shipyard [10].

A. Creating shipyard questionnaire

A shipyard questionnaire is a tool used to identify work environment factors and individual factors related to workplace accidents in workers in the shipyard. This

questionnaire is a questionnaire used by Barlaz and Izcı in their study issued in 2018. The original questionnaire added the instructions to fill the questionnaire.

Data were collected using the shipyard questionnaire then processed by inputting the data to Microsoft Excel. The amount of data collected were determined by using the Slovin method [16]:

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

Where:

n: number of samples

N: number of populations

e: limit tolerance error (error tolerance)

This calculation output is the number of respondents for this survey. The number of respondents needed for this survey to reach 10% error tolerance is 65 people.

B. Identify workplace and individual factors related to occupational accident

Identifying data obtained from data processed from collecting the result of shipyard questionnaire. The data will be identified to find out the factors of the work environment and what individual factors are influencing by using the Guttman scale, the results of the identification of these factors will be used for further analysis to obtain preventive action at later stages.

C. Analyze precautions for each factor

After The results obtained by using Guttman scale (yes or no question), which has a negative indication if a factor has scored more than 50% from the identification of workplace factors and individual factors will be analyzed for appropriate precautions [17]. precautions are taken using AHP methods on occupational factors and using descriptive analysis of individual factors, the results of the preventive action analysis used to write recommendations and conclusions from this thesis research. Analytical hierarchy process (AHP) is a method used to make the best decisions among many options by using a priority scale determined by the decisions of the experts [18]. Decisions generated by the AHP method are not necessarily consistent when consistency testing is performed, and the results are inconsistent, then decisions need to be reconsidered to obtain consistent results [19].

AHP method can be done by doing some of the following processes:

1. Create a matrix of criteria comparison with the value that has been entered
2. Looking for a priority vector weight, to find this value the cell columns in each matrix must be added and divided by the number of matrixes in each cell.
3. Search for lambda values by dividing the result of the priority vector times by the weight of each column and averaged
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5. Look for consistency index (CI) with the formula:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

6. Finding the consistency ratio value (CR) of results is said to be consistent when $CR < 0.1$

TABLE 1.
 SHIPYARD QUESTIONNAIRE RESULT WORKPLACE FACTOR

Questions	Yes %	No %
Are the precautions taken sufficient in the workplace against parts falling from a height?	87,7	12,3
Do you use personal protective equipment (PPE) (helmet, mask, etc.)?	100	0
Is the use of protective equipment at work checked regularly?	86,2	13,8
Have you take any courses and training in occupational safety?	71,9	28,1
Do you think the training you receive is beneficial?	93,7	6,3
Do you believe that your working area is safe?	73,4	26,6
Do you believe that you have adequate training about the equipment you are using?	76,9	23,1
Do you get your equipment checked on a regular basis?	81,5	18,5
Are precautions taken to prevent falling from height enough for you?	83,1	16,9
Are you afraid that you will be exposed to an accident by falling at heights?	96,9	3,1
Do you use safety harness while working at heights?	100	0
Does safety harness complicate your job while working at heights?	76,9	23,1
Are the precautions taken against electrical contact hazard enough?	78,5	21,5
Are you afraid to get exposed to an accident by electrocution?	95,4	4,6
Are the electrical cables scattered around in the workplace environment?	47,7	52,3
Do you pay attention to the low voltage and high voltage difference while using equipment (sockets, lighting, etc)?	85,9	14,1
Do you have any information about static electricity?	35,4	64,6
Are adequate precautions taken to deal with fire and/or explosion in the workplace?	90,5	9,5
Are you afraid to get exposed to an accident by fire and/or explosions?	96,9	3,1
Has your workplace implemented a hot work permit?	90,6	9,4
Have gas measurements been made in indoor environments before working?	46	54
Do the gas hoses spread around in the workplace environment?	39,1	60,9
Have you done enough training and exercise in fire?	62,5	37,5
Do you find training and exercise useful?	98,4	1,6
Do you pay attention to the exits in your workplace environment?	95,4	4,6
Do you think there are enough exits in your workplace environment?	83,1	16,9
Have you taken a fire safety training?	49,2	50,8
Can you act according to fire safety procedures?	89,1	10,9

III. RESULTS AND DISCUSSION

A. Questionnaire Survey Result on Workplace Factors

Workplace factors in the shipyard questionnaire are in the 9th point question up to the 36th point question, here are the survey results obtained from work environment factors shown in Table 1.

Shipyard questionnaire indicates that 96.9% of workers are afraid of an accident falling from a height, and 3.1% of workers are not afraid of accidents falling from height, these results indicate that workers have not felt safe working at altitude even though at other points workers already use safety tools and also felt the precautions of altitude were sufficiently carried out.

Shipyard questionnaire showed that 76.9% of workers were disturbed using safety devices to work at altitudes, and 23.1% of workers felt undisturbed using safety devices to work at altitudes. 100% of workers use safety equipment while working at high altitudes to prevent the risk of accidents from falling altitudes, indicating that safety equipment to work at altitudes can complicate the work of workers while at altitudes, increasing the risk of accidents falling from altitudes in the shipyard for workers.

Shipyard questionnaire indicates that 35.4% of workers have knowledge of static electricity, while 64.6% of workers have no knowledge of static electricity, this may increase the risk of work-related accidents caused by electricity, electrical contacts can be lethal for workers, sweating while working is susceptible to contact with electrical currents, a low knowledge of static electricity by the worker may cause the worker to be unaware of the things that may cause contact with the electric current. Low worker knowledge of static electricity also makes electric cables scattered indiscriminately in the workplace of workers, shown through a survey of nearly 50%, i.e. 47.7% of workers claimed that electrical wires were scattered around their work environment. Hence the lack of workers' knowledge of static electricity can increase the risk of workplace accidents caused by electrical current contacts.

Workers performed indoor gas measurements before doing indoor work showed that 46% and 54% of workers did not conduct gas measurements first before doing indoor work. This is interesting because 90.6% of respondents claimed a hot work permit in their work environment, but only 46% carried out the gas measurements before working indoors. Not performing gas measurements before working indoors can be the reason for workplace accidents on workers in the shipyard and may also increase the risk of work accidents caused by fire and/or explosion.

Shipyard questionnaire shows that 49.2% of workers have taken fire safety training while 50.8% of workers have not taken fire safety training, this can be one of the factors that increase the risk of work accidents on shipyards that come from fire hazards and / or explosions due to workers' ignorance about the basics of what needs to be done to tackle the dangers of fire.

B. Questionnaire Survey Result on Individual Factors

Individual factors in the shipyard questionnaire are in the question of the 39th point to the 52nd point question, here are the results of the survey obtained from the individual factors shown in Table 2.

Shipyard questionnaire shows that 66.2% of workers have witnessed an accident in their workplace, whereas 33.8% of workers have never witnessed workplace accidents in their workplace. This indicates that occupational accidents occur at least once in their workplace, but the interesting part is when they were asked the question whether workplace injuries witnessed by workers changed the morale of the workers or not, 69.2% of respondents answered the work accidents they had witnessed did not change their morale.

Shipyard questionnaire shows that 63.1% of respondents work over eight hours every day, while 36.9% of respondents work less than eight hours daily. Occupational accidents often occur on overtime and work over eight hours. This factor requires more attention because it can be the cause of other causal factors, such as fatigue or loss of concentration while working.

Shipyard questionnaire shows that 58.5% of workers in increasing employment pressure affect their work, whereas 41.5% of workers feel increasing employment pressure does not affect their work, increasing employment may result from excessive shipbuilding or reparation activities and the shipyard that forgets the main regulation of safety due to dense shipyard activity. As activity in the shipyard increases in the production and reparation process, the number of workers is increasing, and the risk of accidents also increases in these conditions.

Shipyard questionnaire shows that 50% of workers often suddenly thinking about their personal life, while 50% say otherwise, the results obtained are balanced, but factors outside work such as financial problems, fatigue obtained outside the workplace, stressful events, domestic problems, can increase the risk of workplace accidents experienced by workers.

Shipyard questionnaire showed that 93.8% of workers felt that bad weather conditions affected their work, and 6.2% of workers felt that bad weather conditions did not affect the work they were doing. Extreme weather (too hot, too cold, heavy rain) is strongly associated with an increased risk of work accidents.

C. Analysis of workplace factor precaution

Precautions for workplace factors are undertaken to reduce the risk of workplace accidents arising from work environment factors. According to the results of the work environment factor survey, factors related to workplace accidents on workers are falling from the height, the electric shock factor, and the fire and/or explosion factors. The AHP questionnaire was referenced from Barlas's study to choose precautions in the shipyard to reduce the risk of workplace accidents caused by work environment factors.

The results of the analysis obtained through AHP method by distributing questionnaires to six experts K3LL (Health, Safety, and Environmental Protection) at the shipyard of PT. Dumas with the results of the shipyard questionnaire as consideration of the experts. The result can be seen in Table 3.

Table 3 indicates that in the falling from height accident, the precautionary action with the highest value

is to wear and check the safety to work at altitude by wearing and checking the parachute type safety belt, whereas for the type of shock shocked by electricity, the highest value is to check the cable routinely and regularly, and for fire accidents and or explosion, the highest value is to check the gas regularly and strictly control measures.

TABLE 2.
SHIPYARD QUESTIONNAIRE RESULT INDIVIDUAL FACTOR

Questions	Yes %	No %
Are you experiencing intense stress about your work?	23,4	76,6
Have you witnessed any work accident?	66,2	33,8
Has any work accident that you saw or heard changed your morale?	30,8	69,2
Do you feel tired and sleepy at work?	30,8	69,2
Do you effortlessly adapt to work after the holiday?	78,1	21,9
Are your daily work hours often more than 8?	63,1	36,9
Does lunch affect your work	32,8	67,2
Do the first working hours in the morning affect your work?	26,6	73,4
Does constantly growing intense work pressure affect you?	58,5	41,5
Do daily life problems often come to mind while working?	50	50
Do you have enough time to rest during working hours?	81,5	18,5
Do you work as a subcontractor worker?	21,5	78,5
If yes, do you get adversely affected as a subcontractor worker?	44,9	55,1
Does bad weather condition affect your work?	93,8	6,2

TABLE 3.
EXPERT EVALUATION RESULT FOR WORKPLACE FACTOR PRECAUTIONS

Fatality Reason	Precaution	Score
Falling from a height	Wear and check the parachute type safety belts	0.398455897
	Construct handrail at high places of work	0.307324036
	Check against slippery floors, and installing nets where needed	0.152714934
	Arrange educational courses for job safety	0.063797149
	Hang warning signs	0.077707984
Electric shock	Use insulated boots and suitable work clothes	0.23786693
	Install electrical grounding systems and ground leakage relay	0.148760415
	Check cables regularly	0.446766907
	Arrange educational courses for job safety	0.107852345
	Hang warning signs	0.058753404
Fire and explosion	Gasfree regularly and strict control measures	0.395612970
	Produce hot action report where needed	0.342242621
	Make good ventilation	0.134991385
	Arrange educational courses for job safety	0.072933922
	Hang warning signs	0.054219101

D. Analysis of individual factor precaution

Precautions for individual factors are undertaken to reduce the risk of workplace accidents arising from individual factors. According to the results of the survey of individual factors, individual factors related to workplace accidents on workers at PT. Dumas are daily work that exceeds eight hours, persistent job pressures, daily life issues that are often come to mind while working, and poor weather conditions, the following is an analysis of individual factor prevention actions that need to be done.

To reduce the risk of occupational accidents caused by daily work exceeding eight hours, the shipyard may reduce the high level of excessive work by resetting the activities undertaken by reducing repetitive work and managing the change of orders resulting from the request of the shipowner.

To reduce the risk of occupational accidents by increasing employment pressure factors and the day-to-day problems that are often thought of at work, the shipyard can provide assistance in the form of counseling to workers to reduce the pressure and appropriate solutions to problems that workers get to know the condition of workers and do a rigorous recruitment process for new employees to find out the mental state of prospective shipyard employees

To reduce the risk of occupational accidents by bad weather factors, the shipyard must take more strict preventive measures to reduce the risk of accidents in bad weather. If needed the work is stopped if weather conditions are not possible to do the job.

IV. CONCLUSION

Based on the result of research, workplace factor and individual factor that influence on work accident of shipyard worker and also prevention which needs to be done are:

1. Workers feel annoyed using a harness while working at altitude. Precautions that need to be done is to check the safety device used to work at altitude
2. Minimum worker knowledge about static electricity. Precautions taken are to check the cables, electrical circuits, and work tools on a regular basis
3. Workers do not measure indoor gas before working. Precautions taken are to conduct regular indoor gas measurements before work
4. Daily work of workers exceeding eight hours. The precaution taken is to make the worker's shift schedule to be eight hours per day and increase the number of people to complete the job by finding a new employee or subcontractor
5. Working pressures are growing and everyday problems are suddenly unthought while working. The precaution taken is to brief briefly before work to improve worker concentration and morale.

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