# Occupational Health and Safety Analysis Using HIRA and AS/NZS 4360:2004 Standard at XYZ Shipyard

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***Abstract*— A shipyard is defined as a place where ships are repaired and built. Where, various risks from the work process i.e., ship repair, hull cleaning, hull coating, etc., exist. Therefore, it is necessary to carry out risk analysis in the work process at XYZ Shipyard. This study uses a descriptive method with a qualitative approach through interviews and based on hazard identification and risk assessment (HIRA) using the AS/NZS 4360:2004 standard to calculate the risk value. Occupational health and safety assessments are carried out to evaluate risks that exist in the workplace intending to eliminate, reduce, and replace sources of risk with safer equipment or processes, or to reduce risks to the health and safety of workers. In this study, we are focused on the three working processes i.e., ship repairment process, hull cleaning, and coating. As a result, it can be concluded that all the risks which occurred in the work process at XYZ Shipyard i.e., ship repair, hull cleaning, and coating process were controlled.**

*Keywords*— AS/NZS 4360:2004, HIRA, occupational health and safety, risk analysis.

## I. Introduction

The XYZ shipyard is one of the shipbuilding companies engaged in shipbuilding and ship repair. During a decade XYZ shipyard experienced many work accidents and this causes direct or indirect losses for the company. Directly, the company must replace the existing damage and provide treatment and care costs. While indirectly, the company experiencing unproductiveness caused by workers who experience work accidents cannot contribute to the company [1][2]. Furthermore, accidents cause production lines to stop due to tool, machine, and worker errors having problems or difficulty [3][4]. The list of a work accidents at XYZ Shipyard is shown as follows:

Table 1.
List of working accidents at XYZ shipyard

| No | Type of Accident | Number of Accident |
|---|---|---|
| 1 | Work Incident | 20 |
| 2 | Fire | 7 |
| 3 | Occupational Illness | 4 |
| 4 | Other Incident | 4 |
| | Total | 35 |

Based on Table 1, the work accident has the highest amount with 20 accidents, followed by the fire with 7 accidents and the last are occupational illness and another incident with around 11 accidents for each type. The percentage of the working accident is shown in Figure.1.

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Of the many cases of work accidents that occur according to the Figure. 1, it is necessary to conduct research that can identify and analyze the hazards in the worker's workplace.

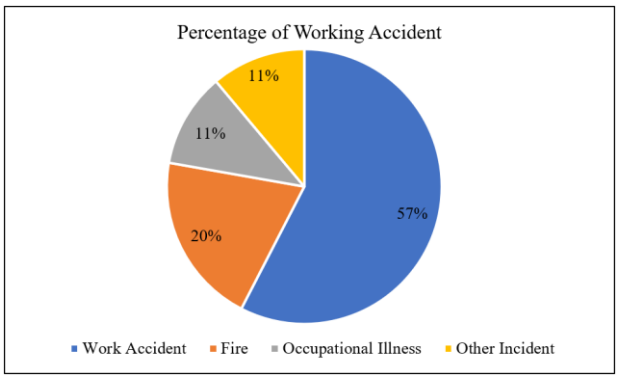


**Figure. 1.** Percentage of working accidents at XYZ Shipyard.

Therefore, by identifying and analyzing these potential hazards makes the company can make mitigation efforts against potential hazards that may occur, and the government as a regulator will be able to carry out supervision and emphasis the implementation of worker health and safety regulations. Study results of this research can be used as a benchmark for occupational safety and health studies in Indonesia and can be a recommendation for the internal management of XYZ Shipyard and the government so that it can help improve the welfare of workers in carrying out work activities within their respective scopes hazard

## II. Method

### A. *HIRA (Hazard Identification and Risk Assessment)*

There are a lot of methods that can be used to identify the value and risk level i.e., FMEA [5-7], FMECA, HAZOP, and HIRA. In this study, we are using the HIRA method to identify the value and risk level. HIRA is defined as a method that is used to identify the

characteristics of the hazard that can occur and evaluate the impact that occurs using a risk assessment matrix [8]. The flow process of HIRA is shown in Figure. 2.

*B. AS/NZS 4360:2004 Standard*

AS/NZS 4360:2004 Standard is Management System Standard that stipulates a minimum standard for the implementation of the Risk Management process in the company [9][10]. Risk management according to AS/NZS 4360:2004 is the application of the policy system management, procedures, and practices for task communication, context setting, identification, analysis, evaluation, control, and monitoring of risks.

In this study, the risk assessment was carried out based on Australian Standard/New Zealand Standard for Risk Management (AS/NZS 4360:2004). The risk assessment is carried out using a semi-quantitative analysis, namely: the qualitative scale that has been described with numerical figures to provide a scale but not like the quantitative analysis.

Calculation of risk in analysis semi-quantitative using the formula of W.T. Fine [11] which explains that the value of risk is determined by the value of the impact or consequences, exposure, and probability.

- Impacts or consequences are the most likely impacts to occur from a potential accident, including property damage and injury.
- Exposure is the frequency of exposure to hazards.
- Probability is the probability that an accident will occur from exposure to hazards resulting in an accident and impact.

The equation of W.T. Fine is shown as follows:

$$\text{Risk} = \text{Consequences} \times \text{Exposure} \times \text{Probability} \quad (1)$$

The matrix used is based on the level of impact or consequence, exposure, and the possibility or likelihood/probability of the occurrence of these potential hazards can be seen in Table. 2 to Table. 6 as follows:

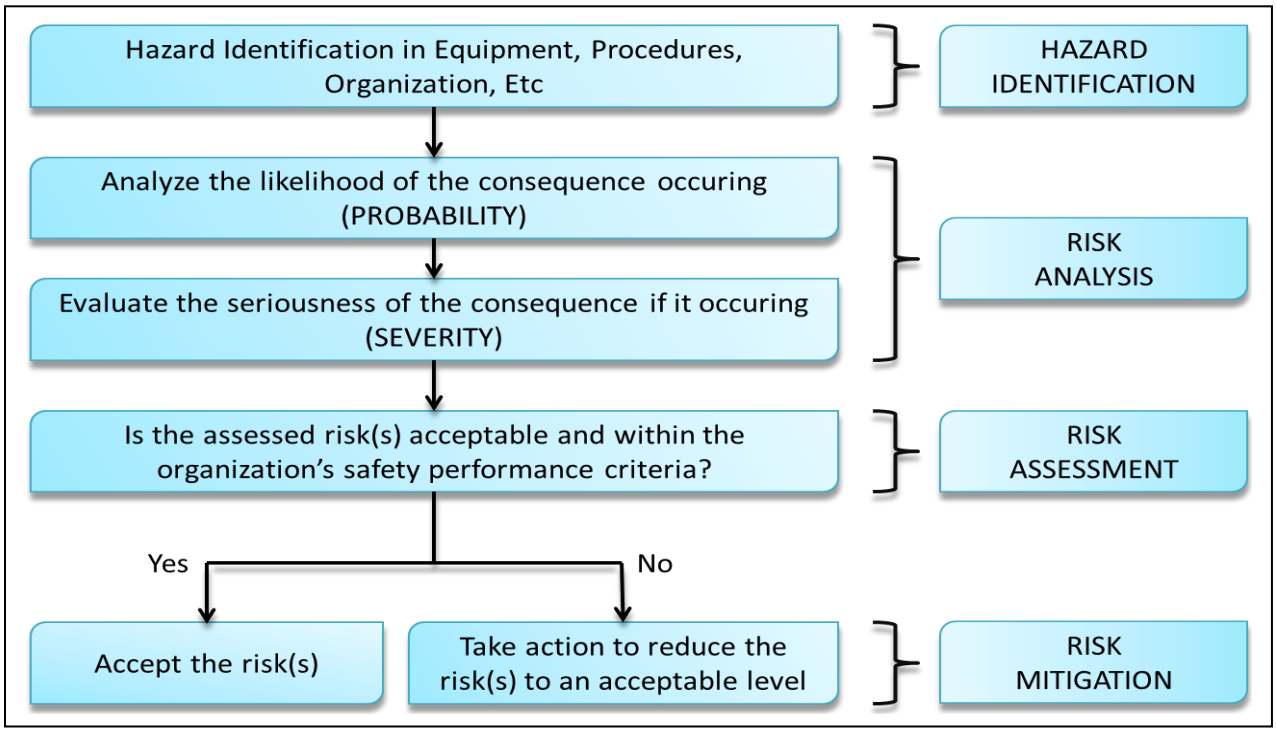


**Figure. 2.** Flow Process of HIRA

TABLE 2.
CONSEQUENCES FACTORS (C)

| Category | Description | Rating |
|---|---|---|
| Catastrophe | Mass death, damage permanent in the local environment. | 100 |
| Disaster | Death, permanent damage that locational to the environment. | 50 |
| Very Serious | Permanent disability, damage temporary environment. | 25 |
| Serious | Serious effects on workers but not permanent, adverse effects on the environment but massive | 15 |
| Important | Need medical staff, emissions occur but do not cause damage. | 5 |
| Noticeable | Minor injury or illness, slight loss of production, minor loss of equipment or machinery but no effect on production. | 1 |

TABLE 3.
EXPOSURE FACTORS (E)

| Exposure | Description | Rating |
|---|---|---|
| Continuously | Occurs > 1 time a day. | 10 |
| Frequently | Happens about 1 time a day. | 6 |
| Occasionally | Happens once a week up to once a month. | 3 |
| Infrequent | Once a month until once a year. | 2 |
| Rare | It is not known when it happened. | 1 |
| Very Rare | It is not known when this happened. | 0,5 |

TABLE 4.
PROBABILITY FACTORS (P)

| Probability | Description | Rating |
|---|---|---|
| Almost certain | Most likely occur. | 10 |
| Likely | Possible occurrence 50:50 accident. | 6 |
| Unusual but Possible | Unusual to happen but possible | 3 |
| RemotelyPossible | Possible events happen very little. | 1 |
| Conceivable | Never happen accidents over the years, but they are possible. | 0.5 |
| Practically Impossible | Very unlikely. | 0.1 |

TABLE 5.
RISK LEVEL

| Risk Level | Description | Rating |
|---|---|---|
| Very High | Stop activity until risk reduced. | 350 |
| Priority 1 | Requires immediate corrective action | 180-350 |
| Substantial | Requires corrective action | 70-180 |
| Priority 3 | Requires attention and supervision | 20-70 |
| Acceptable | The intensity of activities that pose a risk is reduced minimum | 20 |

TABLE 6.
HIERARCHY OF CONTROL

| Risk Level | Rating | Hierarchical of control |
|---|---|---|
| Very High | 350 | Engineering |
| Priority 1 | 180-350 | Administration |
| Substantial | 70-180 | Training |
| Priority 3 | 20-70 | Personal protective equipment |
| Acceptable | 20 | - |

## III. Results and Discussion

### *A. Hazard Identification*

Based on the data collected at the XYZ Shipyard, the source of the hazard was identified especially in the three working processes: ship repair, hull cleaning, and coating process as shown in Table 7-9.

### *B. Risk Assessment Result*

As explained in the previous section, the risk assessment is made by multiplying the consequence, exposure, and likelihood of the selected working process. The basic risk value in this study is defined as the basic risks that exist in the workplace of XYZ Shipyard, while the existing value is defined as the existing risk with control considerations that have been carried out. The assessment result is shown in Tables 10-15.

Table 7.
Hazard identification of ship repair

| Activity | Identified Risk | Impact Possibility |
|---|---|---|
| Welding & Cutting | Electric shock | Minor injury/severe/death |
| | Welding Ray | Minor/severe injuries |
| | Fire exposure | Minor/severe burns |
| | Hot material exposure | Minor/severe burns |
| | Welding dust / fumes | Respiratory disorder |
| | Residual material | Causing injury to the feet or other limbs |
| Grinding Work | Electric shock | Minor injury/severe/death |
| | Material spark exposure | Minor/severe injuries |
| | Fire exposure | Minor/severe burns |
| | Dust / fumes | Respiratory disorder |
| | Residual material | Causing injury to the feet or other limbs |
| Material Flow | Material from height | Major injury/death |
| | Crane operator negligence | Major injury/death |
| | Equipment operational negligence | Minor injury/severe/death |
| | Working position | Minor/severe injuries |
| Semi-Automatic Cutting | Hot material exposure | Minor/severe burns |
| | Equipment operational negligence | Minor injury/severe/death |
| | Working position | Minor/severe injuries |
| | Negligence of workers | Minor/severe injuries |

Table 8.
Hazard identification of hull cleaning

| Activity | Identified Risk | Impact Possibility |
|---|---|---|
| Scrapping | Working position | Minor/severe injuries |
| | Material fall | Minor/severe injuries |
| | Working at height | Falling from a height |
| | Working under the hull | Minor/severe injuries |
| Blasting | Working with a blaster | Inhalation & eyes problem |
| | Blasting machine sound | Hearing loss |
| | Working position | Minor/severe injuries |
| | Working at height | Falling from a height |
| Waterjet | Working position | Minor/severe injuries |
| | Working under the hull | Heavy/light load |
| | Slippery workplace | Minor/severe injuries |
| | Working at height | Falling from a height |
| | High water pressure | Minor/severe injuries |

Table 9.
Hazard identification of coating

| Activity | Identified Risk | Impact Possibility |
|---|---|---|
| Coating process | Working position | Minor/severe injuries |
| | Working under the hull | Heavy/light load |
| | Slippery workplace | Minor/severe injuries |
| | Working at height | Falling from a height |

TABLE 10.
BASIC RISK LEVEL OF SHIP REPAIR ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Welding & Cutting | Electric shock | Minor injury/severe/death | 50 | 3 | 3 | 450 | Very High |
| | Welding Ray | Minor/severe injuries | 5 | 3 | 3 | 45 | Priority 3 |
| | Fire exposure | Minor/severe burns | 15 | 3 | 3 | 135 | Substantial |
| | Hot material exposure | Minor/severe burns | 5 | 3 | 3 | 45 | Priority 3 |
| | Welding dust / fumes | Respiratory disorder | 5 | 2 | 3 | 30 | Priority 3 |
| | Residual material | Causing injury to the feet or other limbs | 1 | 3 | 3 | 9 | Acceptable |
| Grinding Work | Electric shock | Minor injury/severe/death | 25 | 3 | 3 | 225 | Priority 1 |
| | Material spark exposure | Minor/severe injuries | 5 | 3 | 3 | 45 | Priority 3 |
| | Fire exposure | Minor/severe burns | 15 | 3 | 3 | 135 | Substantial |
| | Dust / fumes | Respiratory disorder | 1 | 2 | 3 | 6 | Acceptable |
| | Residual material | Causing injury to the feet or other limbs | 1 | 3 | 3 | 9 | Acceptable |
| Material Flow | Material from height | Major injury/death | 50 | 2 | 3 | 300 | Priority 1 |
| | Crane operator negligence | Major injury/death | 25 | 2 | 3 | 150 | Substantial |
| | Equipment operational negligence | Minor injury/severe/death | 25 | 3 | 3 | 225 | Priority 1 |
| | Working position | Minor/severe injuries | 15 | 2 | 1 | 30 | Priority 3 |
| Semi-Automatic Cutting | Hot material exposure | Minor/severe burns | 5 | 3 | 1 | 15 | Acceptable |
| | Equipment operational negligence | Minor injury/severe/death | 25 | 3 | 3 | 225 | Priority 1 |
| | Working position | Minor/severe injuries | 5 | 2 | 1 | 10 | Acceptable |
| | Negligence of workers | Minor/severe injuries | 5 | 3 | 3 | 45 | Priority 3 |

TABLE 11.
BASIC RISK LEVEL OF HULL CLEANING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Scrapping | Working position | Minor/severe injuries | 5 | 2 | 3 | 30 | Priority 3 |
| | Material fall | Minor/severe injuries | 5 | 3 | 3 | 45 | Priority 3 |
| | Working at height | Falling from a height | 25 | 3 | 6 | 450 | Very High |
| | Working under the hull | Minor/severe injuries | 15 | 3 | 1 | 45 | Priority 3 |
| Blasting | Working with a blaster | Inhalation & eyes problem | 15 | 3 | 6 | 270 | Priority 1 |
| | Blasting machine sound | Hearing lost | 15 | 3 | 3 | 135 | Substantial |
| | Working position | Minor/severe injuries | 5 | 3 | 3 | 45 | Priority 3 |
| | Working at height | Falling from a height | 15 | 1 | 3 | 45 | Priority 3 |
| Waterjet | Working position | Minor/severe injuries | 5 | 1 | 1 | 5 | Acceptable |
| | Working under the hull | Heavy/light load | 5 | 1 | 3 | 15 | Acceptable |
| | Slippery workplace | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Working at height | Falling from a height | 15 | 1 | 3 | 45 | Priority 3 |
| | High water pressure | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |

TABLE 12.
BASIC RISK LEVEL OF COATING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Coating | Working position | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Material fall | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Working at height | Falling from a height | 25 | 1 | 6 | 150 | Substantial |
| | Working under the hull | Minor/severe injuries | 15 | 2 | 3 | 90 | Substantial |

TABLE 13.
EXISTING RISK LEVEL OF SHIP REPAIR ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Existing Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Welding & Cutting | Electric shock | Minor injury/severe/death | 25 | 3 | 1 | 75 | Substantial |
| | Welding Ray | Minor/severe injuries | 1 | 3 | 1 | 3 | Acceptable |
| | Fire exposure | Minor/severe burns | 5 | 1 | 1 | 5 | Acceptable |
| | Hot material exposure | Minor/severe burns | 1 | 3 | 1 | 3 | Acceptable |
| | Welding dust / fumes | Respiratory disorder | 1 | 2 | 1 | 2 | Acceptable |
| | Residual material | Causing injury to the feet or other limbs | 1 | 3 | 1 | 3 | Acceptable |
| Grinding Work | Electric shock | Minor injury/severe/death | 15 | 1 | 3 | 45 | Priority 3 |
| | Material spark exposure | Minor/severe injuries | 1 | 2 | 1 | 2 | Acceptable |
| | Fire exposure | Minor/severe burns | 5 | 2 | 1 | 10 | Acceptable |
| | Dust / fumes | Respiratory disorder | 1 | 2 | 1 | 2 | Acceptable |
| | Residual material | Causing injury to the feet or other limbs | 1 | 2 | 1 | 2 | Acceptable |
| Material Flow | Material from height | Major injury/death | 15 | 2 | 1 | 30 | Priority 3 |
| | Crane operator negligence | Major injury/death | 15 | 1 | 1 | 15 | Acceptable |
| | Equipment operational negligence | Minor injury/severe/death | 15 | 2 | 2 | 40 | Priority 3 |
| | Working position | Minor/severe injuries | 5 | 1 | 1 | 5 | Acceptable |
| Semi-Automatic Cutting | Hot material exposure | Minor/severe burns | 1 | 2 | 1 | 2 | Acceptable |
| | Equipment operational negligence | Minor injury/severe/death | 5 | 2 | 1 | 10 | Acceptable |
| | Working position | Minor/severe injuries | 1 | 2 | 1 | 2 | Acceptable |
| | Negligence of workers | Minor/severe injuries | 1 | 1 | 2 | 2 | Acceptable |

TABLE 14.
EXISTING RISK LEVEL OF HULL CLEANING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Existing Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Scrapping | Working position | Minor/severe injuries | 1 | 2 | 1 | 2 | Acceptable |
| | Material fall | Minor/severe injuries | 1 | 2 | 2 | 4 | Acceptable |
| | Working at height | Falling from a height | 15 | 2 | 3 | 90 | Substantial |
| | Working under the hull | Minor/severe injuries | 5 | 3 | 1 | 15 | Acceptable |
| Blasting | Working with a blaster | Inhalation & eyes problem | 5 | 2 | 3 | 30 | Priority 3 |
| | Blasting machine sound | Hearing lost | 1 | 2 | 1 | 2 | Acceptable |
| | Working position | Minor/severe injuries | 1 | 2 | 2 | 4 | Acceptable |
| | Working at height | Falling from a height | 5 | 1 | 2 | 10 | Acceptable |
| Waterjet | Working position | Minor/severe injuries | 5 | 1 | 1 | 5 | Acceptable |
| | Working under the hull | Heavy/light load | 5 | 1 | 3 | 15 | Acceptable |
| | Slippery workplace | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Working at height | Falling from a height | 5 | 1 | 2 | 10 | Acceptable |
| | High water pressure | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |

TABLE 15.
EXISTING RISK LEVEL OF COATING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Existing Risk | | | Risk Value | Risk Level |
|---|---|---|---|---|---|---|---|
| | | | C | E | P | | |
| Coating | Working position | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Material fall | Minor/severe injuries | 5 | 1 | 3 | 15 | Acceptable |
| | Working at height | Falling from a height | 5 | 1 | 2 | 10 | Acceptable |
| | Working under the hull | Minor/severe injuries | 1 | 1 | 2 | 2 | Acceptable |

TABLE 16.
RISK REDUCTION OF SHIP REPAIR ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | Existing Risk | Risk Reduction | Risk Level |
|---|---|---|---|---|---|---|
| Welding & Cutting | Electric shock | Minor injury/severe/death | 450 | 75 | 83,3% | Substantial |
| | Welding Ray | Minor/severe injuries | 45 | 3 | 93,3% | Acceptable |
| | Fire exposure | Minor/severe burns | 135 | 5 | 96,3% | Acceptable |
| | Hot material exposure | Minor/severe burns | 45 | 3 | 93,3% | Acceptable |
| | Welding dust / fumes | Respiratory disorder | 30 | 2 | 93,3% | Acceptable |
| | Residual material | Causing injury to the feet or other limbs | 9 | 3 | 66,7% | Acceptable |
| Grinding Work | Electric shock | Minor injury/severe/death | 225 | 45 | 80% | Priority 3 |
| | Material spark exposure | Minor/severe injuries | 45 | 2 | 95,6% | Acceptable |
| | Fire exposure | Minor/severe burns | 135 | 10 | 92,6% | Acceptable |
| | Dust / fumes | Respiratory disorder | 6 | 2 | 66,7% | Acceptable |
| | Residual material | Causing injury to the feet or other limbs | 9 | 2 | 77,8% | Acceptable |
| Material Flow | Material from height | Major injury/death | 300 | 30 | 90% | Priority 3 |
| | Crane operator negligence | Major injury/death | 150 | 15 | 90% | Acceptable |
| | Equipment operational negligence | Minor injury/severe/death | 225 | 40 | 82,2% | Priority 3 |
| | Working position | Minor/severe injuries | 30 | 5 | 83,3% | Acceptable |
| Semi-Automatic Cutting | Hot material exposure | Minor/severe burns | 15 | 2 | 86,7% | Acceptable |
| | Equipment operational negligence | Minor injury/severe/death | 225 | 10 | 95,6% | Acceptable |
| | Working position | Minor/severe injuries | 10 | 2 | 80% | Acceptable |
| | Negligence of workers | Minor/severe injuries | 45 | 2 | 95,6% | Acceptable |

TABLE 17.
RISK REDUCTION OF HULL CLEANING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | Existing Risk | Risk Reduction | Risk Level |
|---|---|---|---|---|---|---|
| Scrapping | Working position | Minor/severe injuries | 30 | 2 | 93,3% | Acceptable |
| | Material fall | Minor/severe injuries | 45 | 4 | 91,1% | Acceptable |
| | Working at height | Falling from a height | 450 | 90 | 80% | Substantial |
| | Working under the hull | Minor/severe injuries | 45 | 15 | 66,7% | Acceptable |
| Blasting | Working with a blaster | Inhalation & eyes problem | 270 | 30 | 88,9% | Priority 3 |
| | Blasting machine sound | Hearing lost | 135 | 2 | 98,5% | Acceptable |
| | Working position | Minor/severe injuries | 45 | 4 | 91,1% | Acceptable |
| | Working at height | Falling from a height | 45 | 10 | 77,8% | Acceptable |
| Waterjet | Working position | Minor/severe injuries | 5 | 5 | 0% | Acceptable |
| | Working under the hull | Heavy/light load | 15 | 15 | 0% | Acceptable |
| | Slippery workplace | Minor/severe injuries | 15 | 15 | 0% | Acceptable |
| | Working at height | Falling from a height | 45 | 10 | 77,8% | Acceptable |
| | High water pressure | Minor/severe injuries | 15 | 15 | 0% | Acceptable |

TABLE 18.
RISK REDUCTION OF COATING ACTIVITIES

| Activity | Identified Risk | Impact Possibility | Basic Risk | Existing Risk | Risk Reduction | Risk Level |
|---|---|---|---|---|---|---|
| Coating | Working position | Minor/severe injuries | 15 | 15 | 0% | Acceptable |
| | Material fall | Minor/severe injuries | 15 | 15 | 0% | Acceptable |
| | Working at height | Falling from a height | 150 | 10 | 93,3% | Acceptable |
| | Working under the hull | Minor/severe injuries | 90 | 2 | 97,8% | Acceptable |

Based on the result of the basic risk in Table 10-12, it can be analyzed that the risk level of each work process of ship repair, hull cleaning, and coating consists of five levels as shown in Figure. 3.

- Acceptable = (11/36)x100% = 30,55%
- Priority 3 = (12/36)x100% = 33,3%
- Substantial = (6/36) x 100% = 16,7%
- Priority 1 = (5/36) x 100% = 13,9%
- Very High = (2/36) x 100% = 5,55 %

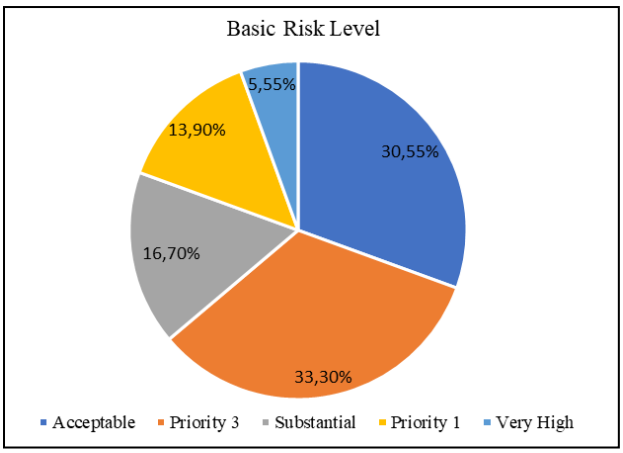


**Figure. 3.** Result of basic risk level.

However, the result of the existing risk level based on Table 13-15 is shown in Figure. 4. It is shown that the risk level are consist of acceptable which reaches 83,3%, priority 3 with 11,1%, and substantial with 5,56%.

- Acceptable = (30/36)x100% = 83,3%
- Priority 3 = (4/36)x100% = 11,1%
- Substantial = (2/36) x 100% = 5,56%

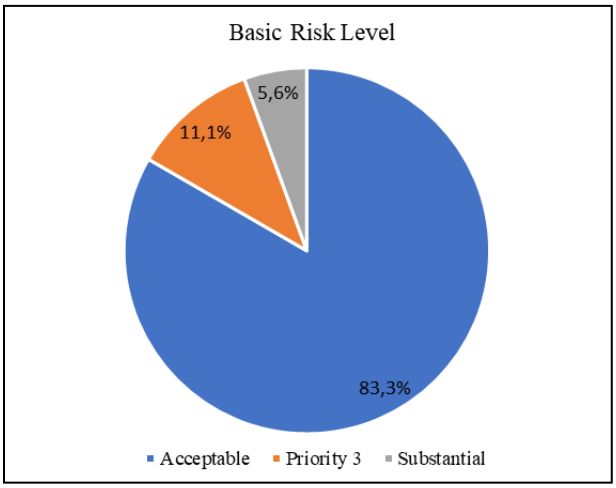


**Figure. 4.** Result of existing risk level.

The comparison of basic risk and existing risk levels is shown in Figure. 5. Based on Figure 5, it can be seen that in the existing risk, priority 1 and very high levels have not occurred. It was influenced by the mitigation that has been conducted by the XYZ Shipyard. Based on this result, it can be concluded that all the risks of the three selected work processes i.e., ship repair, hull repair, and coating process were controlled.

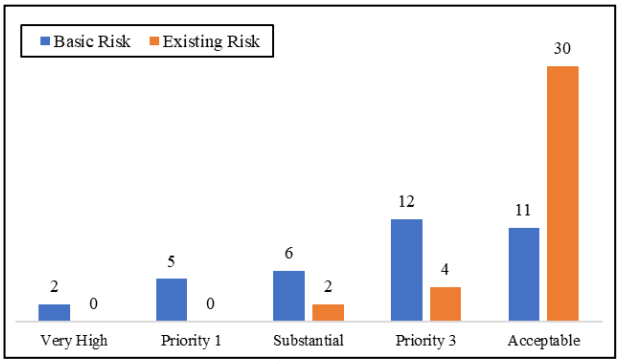


**Figure. 5**. Comparison of basic risk and existing risk level.

## IV. CONCLUSION

It was identified that the basic risk are consist of five risk levels i.e., acceptable with 30,55%, priority 3 with 33,3%, substantial with 16,7%, priority 1 with 13,9%, and very high is 5,55%. However, after the mitigation was conducted the risk level was decreased from five to three levels in the existing risk i.e., acceptable with 83,3%, priority 3 with 11,1%, and followed by the substantial level with 5,56%. It can be concluded that all the risks which occurred in the work process at XYZ Shipyard were controlled.

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