Safety Analysis and Ship Recycling Yard Evaluation of Hong Kong International Convention for The Safe and Environmentally Sound Recycling of Ships

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Abstract. The condition of the Indonesian fleet, which is in its old age, allows ships to be recycled as the best solution. However, conditions in the field, there are still many ship recycling processes that do not obey the rules, especially on the effect of workers and also the effect on the environment. In Indonesia, there are still many ship recycling yards that do not pay attention to the effects on workers and the effects on the environment and most of them are still traditional shipyards. Therefore, one of the best solutions is to renew existing regulations, namely the Hong Kong International Convention for The Safe and Environmentally Sound Recycling of Ships. When the implementation of this convention, the ship recycling shipyard must adjust to the convention. This study focused on the analysis of the assessment of the condition of Occupational Health and Safety (OHS). To evaluate the condition of the shipyard, the Gap Analysis method is by comparing the ideal conditions with the existing conditions at that time. The analysis is carried out using the Hazard Identification Risk Assessment Risk Control (HIRARC) method. This method is carried out by identifying hazards, which then provides a risk assessment and recommends how to control it. Based on result, risk matrix were obtained, which contained the assessment categories of Low, Moderate, High and Extreme. The results of this study through the gap analysis method, the average value is 2.1, which means that this value is still very low because the value of 0 - 2 is categorized as still many sub-clause indicators that do not exist or are not handled. Furthermore, in research using the HIRARC method, 60 risk matrices were obtained, which contained the assessment categories of Low, Moderate, High and Extreme.

1. Introduction
Indonesia is the largest archipelagic country in the world with 17508 islands (the Coordinating Ministry for Maritime Affairs and Investment of the Republic of Indonesia), so it is important for Indonesia to maintain a large fleet of ships to ensure adequate transportation, because the potential of a fleet of ships is very much needed, approximately 90-95% of international commercial goods are transported by sea due to cost efficiency [1].
However, the condition of the age of many Indonesian ships entering old age allows the ships to not be used efficiently anymore. One way to make old used ships have economic value is to carry out the ship recycling process, by taking and reprocessing the used ship materials which is usually done at ship recycling yards [2]. Ship recycling yards in Indonesia are mostly run simply using the beaching method and are limited to the effort of breaking ships into pieces of iron plate sheets [3]. Indonesia has 3 traditionally managed shipyards, namely in Tanjung Jati Village, Madura; Cilincing, North Jakarta; and Tanjung Uncang, Batam. Currently, ship recycling in Madura is generally still carried out in a simple manner and is not equipped with adequate equipment and the ship recycling area is still not well organized so that it poses a high risk to the safety, health of workers and the surrounding environment [4].

Recycling activities for ships that have expired are widely found in India, Bangladesh, Pakistan, China, and Turkey [5][6][7]. From previous research, from several countries mentioned above, many workers are exposed to various occupational hazards which unfortunately cause accidents, illness and even death [8]. In Indonesia, in ship recycling work, the activities that contribute the most to work safety are the risk of being exposed to hazardous materials, the risk of being exposed to sparks, and the risk of being struck by material [9]. In addition, China and Turkey were the first two countries to provide relatively acceptable standards in terms of safety and environmental protection measures [10]. Therefore, with such a high potential for danger, regulations related to the ship recycling process should be improved in Indonesia. The solution is to ratify the Hong Kong International Convention for The Safe and Environmentally Sound Recycling of Ships. The convention intends to address all issues surrounding ship recycling both the effect on workers and the environment [11].

With the issue that Indonesia is getting ready to ratify this convention, through this research it is necessary to study the extent to which ship recycling shipyards in Indonesia apply regulations based on this convention and a risk assessment of potential hazards will also be carried out in one of the ship recycling shipbuilding companies that is in Indonesia.

1.1. Location Overview
An overview of Company X's shipyards located in Madura. This area is one of the traditionally managed shipyards in the Madura area, in this area ship recycling still uses the beaching method and is limited to cutting ships into sheets of iron plate.

2. Method

2.1. Research Flowchart
The research methodology describes the research design which includes the procedures to be taken, data sources, and ways of processing or analyzing the data. The stages of this research methodology are shown in Figure 1.

This flowchart shows 3 main steps, namely in the first process of identifying the problem, gathering information and so on. After obtaining the data in the first stage, proceed to the second stage of the gap analysis process from this stage as a reference in the third stage, namely the HIRARC analysis process.

2.2. Problem Identification
This paper focuses on conditions to assess the gap between existing conditions and ideal or standard conditions based on the Hong Kong Convention, then focuses on occupational health and safety (OHS) assessments.

2.3. Literature Studies
The literature study provides information and supports the analysis of this research. This literature study is based on journals, books, reports and guidelines Hong Kong International Convention for The Safe and Environmentally Sound Recycling of Ships (2009), Resolution MEPC.210(63).
2.4. Data Collection
Data collection here is divided into 2 categories, namely primary data and secondary data. Secondary data is data from literature studies which also includes documentation, government publications, websites, convention regulations and others.

Primary data is data that comes from the first source. In this study, primary data comes from Company X, information is collected directly from the company, which includes observations, interviews, questionnaires and company documents.

![Figure 1. Research Flowchart](image)

2.5. Gap Analysis
Gap analysis is an identification to find out what is needed to cover the gap between the current system condition and ideal or expected conditions. The steps to be carried out are as follows:

2.5.1. Identification of Standard State. Standard conditions here mean regulations that must be met, in this case the Hong Kong International Convention for The Safe and Environmentally Sound Recycling of Ships. Furthermore, it is analyzed and identified related to the standard regulations, then makes a checklist of what are the gap analysis criteria that will be met after analyzing and identifying.

2.5.2. Identifying the Existing Condition. The current state here means the state or condition of a current sample or it can be said that the existing condition of the sample. Furthermore, the analysis and evaluation of the sample is carried out to obtain the current condition. As for the way that can be done to get the current state of identification, namely by: direct interviews, questionnaires, observation of existing systems, then evaluated and analyzed.

2.5.3. Identification of Gap Analysis. After obtaining the identification of the standard state and the current state, analysis and evaluation are carried out to obtain the gaps that occur.
Primary data is data that comes from the first source. In this study, primary data comes from Company X, information is collected directly from the company, which includes observations, interviews, questionnaires and company documents.

2.6. Maturity Level
In this identification, it will be linked to the standard situation by conducting a questionnaire given to the employees of company X, which will later be weighed as the table below.

| Level | Information                                      |
|-------|--------------------------------------------------|
| 0     | None / not handled                               |
| 1     | Coming soon / plan will be handled               |
| 2     | Under construction / in progress                 |
| 3     | There are inadequate conditions / adequately handled |
| 4     | There are adequate conditions / well handled     |

In this assessment, it is also categorized that the values of 0.1 and 2 indicate that there is no component or equipment or there is no handling of a case, while the values of 3 and 4 are categorized otherwise.

2.7. HIRARC Analysis
In recent years, Hazard Identification, Risk Assessment and Risk Control (HIRARC) has become the basis for business planning, management and operations as the basis for risk management [12]. A hazard identification and risk assessment is the process used to identify and evaluate potential and existing hazards in the workplace and the methods used to control or eliminate the identified hazards. The analysis process is divided into three steps:

2.7.1. Hazard identification. Hazard identification is the initial stage in the HIRARC method. At this stage, the first step is to make observations at Company X's recycling yard. What is done includes the physical condition of Company X, Company X facilities and activities in the Company X area.

2.7.2. Risk Assessment. After getting the results of hazard identification, the next step in the HIRARC method is risk assessment. This assessment is used to determine the level of risk from the identified hazards. The level of risk in this assessment is based on a comparison of the likelihood of a risk occurring (frequency) with the severity of the risk (severity). The following in Table 2 is an explanation of the possible level of risk.

Based on Table 2, the level of risk occurrence is determined in five levels. The lowest level has a value of 1, with a description of the possibility of a risk occurring very rarely. While the highest level has a value of 5, with the possibility of risk occurring almost at any time.

| Level | Category      | Detail description                                      |
|-------|---------------|--------------------------------------------------------|
| 5     | Almost Certain| Occur once a day                                       |
| 4     | Likely        | Occur once a week                                      |
| 3     | Possible      | Occur once a month                                     |
| 2     | Unlikely      | Occur once a year                                      |
| 1     | Rare          | Occur once in exceptional circumstances or never happened |
Table 3. Severity scale [13]

| Level | Category      | Detail description                                           |
|-------|---------------|--------------------------------------------------------------|
| 1     | Insignificant | No injuries, low financial loss (< Rp 1 M)                   |
| 2     | Minor         | First aid treatment, on-site release immediately contained, medium financial loss (< Rp 10 M) |
| 3     | Moderate      | Medical treatment required, on-site release contained with outside assistance, high financial loss (< Rp 100 M) |
| 4     | Major         | Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss (< Rp 1 B) |
| 5     | Catastrophic  | Death, toxic release off-site with detrimental effect, huge financial loss (> Rp 1 B) |

Table 3 above shows the severity of the risk occurrence. Similar to the probability of risk occurrence, the feasible level is 1 and the highest level is 5. Identification of Gap Analysis. After obtaining the identification of the standard state and the current state, analysis and evaluation are carried out to obtain the gaps that occur. Tables 2, 3 and 4 are the results of the adoption of the Australian Standard / New Zealand Standard Risk Management 4360:2004.

Table 4. Risk matrix [13]

| Likelihood   | Insignificant | Minor | Moderate | Major | Catastrophic |
|--------------|---------------|-------|----------|-------|--------------|
| 5 Almost Certain | H             | H     | E        | E     | E            |
| 4 Likely     | M             | H     | H        | E     | E            |
| 3 Moderate   | L             | M     | H        | E     | E            |
| 2 Unlikely   | L             | L     | M        | H     | E            |
| 1 Rare       | L             | L     | M        | H     | H            |

Furthermore, the results of the comparison of the level of likelihood and severity of the risk will be used to determine the level of risk. The results of the comparison are shown in Table 4. This value can be used to determine the severity of an accident determined by a Risk Matrix. The description of the table above, namely L (Low), M (Medium), H (High) and E (Extreme).

2.7.3. Risk Control. The next step after the assessment is to do so which will make the decision to take the risk. Risk Control options are divided into five categories, which include elimination, substitution, engineering, administration, and the use of Personal Protective Equipment (PPE) [14][15].

3. Results and Discussion

The requirement for regulation of the Hong Kong Convention is that each ship recycling shipyard must be able to verify compliance with the Ship Recycling Facility Plan (SRFP). The SRFP must demonstrate knowledge and understanding of all applicable statutory and regulatory requirements and a strong commitment to worker health and safety and environmental protection and also describe the operational processes and procedures involved in ship recycling at the Ship Recycling Facility. So there are 4 aspects to this SRFP, namely: Facility Management, Facility Operations and Occupational Safety and Health (OHS), Environmental Protection. In this study the evaluation of Environmental Protection was omitted due to limitations.
3.1. Gap Analysis
In general, gap analysis is useful for assessing how big the gap is between the existing state and the standard state, to determine improvements in the aspects needed to fill the gap. Gap This analysis focuses more on aspects of facility management, facility operations and Occupational Safety and Health (OHS).

3.1.1. Facility Management. In the picture below is a form of gap that occurs in this aspect of management facilities consisting of 4 clauses and 11 questions or sub-clauses.

![Figure 2. Overall maturity level of management facilities](image)

The table below shows that there are 2 clauses that have not been fulfilled, namely clauses 1 and 2 are in the range (0-2) which means that they do not exist and are not handled. Then in clauses 3 and 4 it is at a value of 3 which means this sub clause has existed but has not been sufficient or has been adequately handled.

| Clauses     | Maturity Level |
|-------------|----------------|
| Clauses 1   | Company information | 0.0 |
| Clauses 2   | Training programme  | 2.0 |
| Clauses 3   | Worker management   | 3.0 |
| Clauses 4   | Records management  | 3.0 |

From the results of field observations and the identification of the basic things that make the value of several sub-clauses low, it is because the organizational system is not well organized and can be said to be non-existent.

3.1.2. Facility Operations. In the picture below is a form of gap that occurs in this aspect of management facilities consisting of 6 clauses and 20 questions or sub-clauses.

Table 6 shows that there are 4 clauses that do not meet the value of either category, namely clauses 2, 3, 5 and 6 are in the range (0-2) which means that they do not exist and are not handled. Clause 1 is in the range of values close to 3, which is already present but inadequate or adequately handled. Then in clause 4 it is at a value of 4, which means this sub clause has existed or has been handled.
The cause of many values that are in the value range (0-2) is because in addition to the management system that does not yet exist, the operating system is also not well organized.

3.1.3. OHS. In the picture below is a form of gap that occurs in this aspect of management facilities consisting of 7 clauses and 25 questions or sub-clauses.

![Figure 3: Overall maturity level of management operations](image)

**Figure 3.** Overall maturity level of management operations

| Clauses | Maturity Level |
|---------|----------------|
| Clauses 1 | Facility information |
| Clauses 2 | Permissions, licenses and certificates |
| Clauses 3 | Acceptability of ships |
| Clauses 4 | Ship Recycling Plan (SRP) development |
| Clauses 5 | Ship recycling methodology |
| Clauses 6 | Reporting upon completion |

The cause of many values that are in the value range (0-2) is because in addition to the management system that does not yet exist, the operating system is also not well organized.

3.1.3. OHS. In the picture below is a form of gap that occurs in this aspect of management facilities consisting of 7 clauses and 25 questions or sub-clauses.

![Figure 4: Overall maturity level of OHS](image)

**Figure 4.** Overall maturity level of OHS

In the table 7, the maturity level of each clause is obtained from the average result of each sub-clause. It can be seen in the table that clauses 4, 6 and 7 are at a low value in the range of about (0-2) which
means they do not exist or are not handled. Then in this table, clauses 3 and 5 are at a value of 3, namely there are inadequate or inadequate handling and in clauses 1 and 2 which are close to 4.

| Table 7. Maturity level clause management OHS |
|-----------------------------------------------|
| Clauses                                      | Maturity Level  |
| Clauses 1 Safe-for-entry                      | 3,6             |
| Clauses 2 Safe-for-hot                        | 3,9             |
| Clauses 3 Prevention of bad impacts on human health and the environment | 2,9             |
| Clauses 4 Safe and environmentally friendly hazardous material management | 2,4             |
| Clauses 5 Emergency preparedness and response | 2,5             |
| Clauses 6 Worker safety and training          | 1,6             |
| Clauses 7 Reports on incidents, accidents, occupational diseases and chronic effects | 1,0             |

The number of low clauses is caused by the results in the field, interviews and questionnaire results indicate that safety and there is no emergency response and reporting of incidents, accidents, occupational and chronic diseases that are still not available and implemented. The basic thing from this aspect is the absence of Occupational Health and Safety (OHS) management in this company.

3.2. HIRARCH Analysis

After obtaining the results of the previous gap analysis, then the HIRARC analysis is carried out, from the previous gap analysis data used as a reference for carrying out this stage. This research will focus on 3 activities or areas according to the flow of work at company X, namely:

3.2.1. Area / Activity: Pre-Cutting. In Area / Activity: Pre-Cutting there are various levels of results including 3 Low Risk, 8 Medium Risk, 3 High Risk. In this area or activity there is a high risk that comes from the activity of removing residual oil, which results in minor injuries due to application and tripping but the intensity is often high so it is categorized as high.

The main causes found in the field were the condition of the messy area, many objects that were not neatly arranged and also the workers who did not wear PPE safety, such as gloves, helmets, boat shoes. Then from the results of observations and interviews with the management of waste handling, it is not clear. This is one of the reasons for the high risk and medium risk assessments. The controls that the author can recommend to reduce these risks are:

- Making ventilation holes in a closed area, then the cutting process is carried out from an accessible location, so that difficult-to-reach spaces can be reached safely.
- Checking by a competent person after the preparation is done.
- Create a hazmat category label
- Tidy up/clean up scattered used materials.
- In this area / activity there are still many who do not use PPE (safety helmets, gloves, safety shoes, safety masks).

3.2.2. Area / Activity: Primary Cutting. In this area there are various risk level results including 5 Low Risk, 20 Medium Risk, 8 High Risk. In this area or activity there are 8 high risks originating from ship cutting activities, which resulted in serious injuries due to carelessness in the cutting process and there was also the death of 1 person due to falling material, for an example of the framework table, see Table 8. The main causes found in the field are messy area conditions, limited working conditions and also workers who do not wear safety PPE, such as gloves, helmets, boat shoes. For the medium risk category, so many are mostly caused by not wearing PPE such as safety helmets, gloves, safety shoes, safety glasses, safety masks. The controls that the author can recommend to reduce these risks are:

- Tidying up/cleaning up used materials strewn about
- Replacement on damaged components.
- In the cutting process, use a fastener or crane as an auxiliary lever when cutting.
- In the fire-prone category, prepare an APAR.
- Provide Awareness to Workers about OHS and Housekeeping.
- At the time of cutting and welding make a letter of instruction to do welding.
- From field observations, many workers do not wear PPE, which should be used such as safety helmets, gloves, safety shoes, safety glasses.

| No | Location / Area | Hazard | Possible Harm | Risk Assessment |
|----|-----------------|--------|---------------|----------------|
|    |                 |        |               | Consequence    | Likelihood (L) | Severity (S) | Relative Risk (R) | Descriptor |
| 1  | Safe for Entry  | Lack of oxygen | Coughs, Hard to breathe | 1 | 1 | 1 | Low |
| 2  | Safe for Hot Work | Lack of oxygen | Coughs, Hard to breathe | 1 | 3 | 3 | Moderate |
|    |                  | Inhalation of toxic vapors and gases | Respiratory disorders, Unconscious | 4 | 3 | 12 | High |
| 3  | Remove residual oil | Falling, tripping and slipping Exposure to hazardous materials | Minor injuries, Serious injuries, Minor injuries, Serious injuries | 4 | 2 | 8 | High |
| 4  | Removing the remaining HAZMAT | Exposed HAZMAT | Minor injuries, Serious injuries | 3 | 2 | 6 | Moderate |
|    |                  | Inhalation of toxic vapors and gases | Respiratory disorders, Unconscious | 3 | 3 | 9 | High |

### Table 8. Example HIRARC framework area / activity: pre-cutting

3.2.3. Area / Activity: Material Transfer. In this area there are various risk level results including 3 Low Risk, 4 Medium Risk, 4 High Risk and Extreme Risk 2. In this area or activity there are 2 extreme risks which are very dangerous and there are many high risks that come from the negligence of crane operators and overloaded crane conditions. The main causes found in the field are areas that are not well organized and the area can be said to be narrow in addition to crane operators who do not have operational certificates and then operations at work did not run smoothly, in addition to workers who rarely used PPE, such as gloves, helmets, boat shoes. The controls that the author can recommend to reduce these risks are:

- The risk in this activity is caused by the negligence of the crane operator, one of the best solutions is to increase the SOP and train the crane operator.
Then the author's observations, one of the causes is the narrow area of movement of workers 
and cranes, one solution is to make the distance between the areas where people work, where 
people walk are kept away from crane activities

The condition of the crane is old, the solution can be to use a new crane or break down the 
weight of the load when operating, because based on surveys and interviews, they often 
experience overload.

What is not important is using PPE, by using PPE all forms of accidents can be reduced, because 
in the field there are still many workers who do not use PPE that should be used such as safety 
helmets, gloves, safety shoes, safety glasses.

3.3. HIRARCH Analysis
From the picture 4 as a whole, from the 3 locations analyzed there are 60 potential hazards identified. 
Among them, 11 (18%) potential hazards are Low Risk, 32 (54%) are potential hazards are Moderate 
Risk, 15 (25%) are potential hazards are High Risk, 2 (3%) are potential hazards are Extreme Risk.

![Figure 5. Risk level distribution at Company X](image1)

![Figure 6. HIRARC analysis results in Company X](image2)

From Figure 5 it can be seen that there are 33 potential hazards that occur in the primary cutting 
area/activity, with details of 5 low risk, 20 moderate risk and 8 high risk. From the results of this 
HIRARC analysis, this potential hazard comes from:

- Lack of individual awareness of safety aspects.
- Working environment conditions
• Limited area
• Lack of supervision of workers and actions such as reprimand or dismissal
• Knowledge level
• Unclear organizational structure
• Non-existent OSH management.

4. Conclusions
In research using the gap analysis method, there are 4 aspects of the section namely management facilities, operating facilities and OHS, from here obtained 17 clauses and 56 sub clauses. The average result obtained from each clause is 2.1 which means that there are still many sub clauses that do not exist or are not handled properly because they are in the 0-2 value range. From these three aspects, if we compare the existing condition with the expected condition, the percentage is obtained:
• 31 (55%) Condition None/untreated (Level 0-2)
• 16 (29%) There are inadequate conditions / moderately handled (Level 3)
• 9 (16%) There are adequate conditions / well handled (Level 4)
Meanwhile, for research using HIRARC analysis, there are 4 types of hazards, namely low risk, moderate risk, high risk and extreme risk. From the analysis of all areas/activities, a total of 56 potential hazards were obtained with details:
• 11 (18%) Low Risk
• 32 (54%) Moderate Risk
• 15 (25%) High Risk
• 2 (3%) Extreme Risk
The convention referred to here intends to focus on the effects on workers and on the environment and also on the issue that Indonesia is ready to ratify this convention, so it's time to start evaluating related to this.

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