SHIP RECYCLING WITH A WAY TO REDUCED HAZARDOUS EFFECT ON THE ENVIRONMENT.

A thesis submitted in partial fulfillment of the requirements for the award of the degree of

Master of Technology in Marine Engineering and Management

by

PRATIK GADGIL
(Reg. No.1701215010)

under the guidance of

Dr. KALYAN MITRA
(Faculty & Convener, IMU Kolkata Campus)

Department of Marine Engineering
Indian Maritime University Kolkata Campus

Kolkata -700088.

19 June 2019

INDIAN MARITIME UNIVERSITY KOLKATA CAMPUS

Department of Marine Engineering

CERTIFICATE

This is to certify that the thesis entitled **"SHIP RECYCLING WITH A WAY TO REDUCED HAZARDOUS EFFECT ON THE ENVIRONMENT."** submitted by Pratik Gadgil to Indian Maritime University Kolkata Campus for the award of the degree in Master of Technology in Marine Engineering and Management, is a bonafide record of the project work carried out by him under our supervision. The contents of this thesis, in full or in parts have not been submitted to any other institute or University for the award of any degree or diploma.

The Project has been carried out at Indian Maritime University Kolkata Campus.

Kalyan 19/06/2019

Dr. Kalyan Mitra

Project Guide
Indian Maritime University.

Kolkata Campus.

Kalyan 19/06/2019

Dr. Kalyan Mitra

Academic Co-ordinator
Indian Maritime University.

Kolkata Campus.

External Examiner

(H. R. HARE)

INDIAN MARITIME UNIVERSITY KOLKATA CAMPUS

EVALUATION SHEET

Name of the candidate	PRATIK GADGIL
Title of the project	SHIP RECYCLING WITH A WAY TO REDUCED HAZARDOUS EFFECT ON THE ENVIRONMENT.
Specialization	MARINE ENGINEERING AND MANAGEMENT
Date of Examination	19TH JUNE, 2019

This dissertation is approved by the Board of Examiners

External Examiner: (H. R. HARE)

19/06/2019

Internal Examiner:

INDIAN MARITIME UNIVERSITY KOLKATA CAMPUS

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to thank my guide **Dr. Kalyan Mitra, Faculty, Indian Maritime University, Kolkata**, for permitting me to take up my project work, guide, mentor and encouraging me during the entire project tenure. Because of his guidance and enlightenment, I was able to complete my project. Under his Aegis, I learned a lot about management tools, the process of ship breaking and also about the technique to solve problems.

I would like to express my gratitude to **Shri KRISHNANDU DAS, HoD MARINE ENGINEERING** for allowing and helping for arranging passes of Kolkata port trust for data collection and providing a practical experience of Ship breaking yard.

I would also like to thank all staff and worker of **AMAR IRON UDYOG PVT. LTD. (SHIP BREAKING YARD, KOLKATA PORT TRUST)** for helping, sharing and demonstrating all the process, hazardous, storage, safety of ship breaking yard.
The completion of this project is not just due to efforts of one single person rather it bears the imprint of a number of persons who directly and indirectly helped me in completing the present study.

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

IMO	International Maritime Organization
EU	European Union
DWT	Dead Weight Tonnage
IHM	Inventory of Hazardous Material
PVC	Polyvinyl Chloride
PCB	Polychlorinated Biphenyls
SAW	Simple Additive Weighted
AHP	Analytic Hierarchy Process

ABSTRACT

Ship recycling is a complex process of dismantling of the obsolete vessel, during this process a large amount of hazardous waste is produced which causes great environmental and health impact. To reduce this effect many laws and regulation are implemented but still there are cases of environmental impacts.

This work is carried out to minimize the effect of hazardous material produced during ship dismantling. The data was collected from ship recycling yard of kolkata port trust. The list of quantity of hazardous material, average cost of disposal, average cost of transportation and storage cost is obtained. I consulted with maritime expert that is surveyors, ship recycling managers, chief engineers who suggested to use Analytic Hierarchy Process. Criteria in this process is based on expert suggestion and most preferred way for obsoleting vessel was found to be dry docking, Further based on data of quantity of hazardous material the preferred way of ship obsoleting was proposed. Further most hazardous material was calculated based on ship yard policy and it was found to be Asbestos and PCB. This method can be used in the industry as it give a whole view about best recycling method for green ship recycling, preferred method for vessel obsoleting based on inventory of hazardous material and also suggest potential hazard present in recycling yard based on ship recycling yard policy.

CHAPTER-1

INTRODUCTION

1.1 GENERAL INTRODUCTION

The earth's 2/3 surface is covered by water and it is one of the factors that 90% of world trade depends on water transport. When one thinks about transport it might be passenger, cargo, chemicals, crude oil, etc., the only watercraft which come to our mind is the ship. As of 2016, there were more than 49,000 merchant ships, totaling almost 1.8 billion deadweight tons. Of these 27 to 30 % were oil tankers, 41 to 45% were bulk carriers, and 12 to 15% were container ships but ship as every other machine have its own life cycle of 25 to 30 years, but what happen to these ship after their tenure of operation?, what one do with old ship?, if someone scraps ship then how scrapping is done? Is it hazardous to scrap a ship? How much pollution is produced by ship? These are some of the questions which are less discussed but is an important part of the maritime field.

"Ship Recycling" had become part of the maritime industry as a green solution for old vessel because around 95 to 97 percent of the parts and equipment of a ship can be reused. Ship recycling started nearly at the end of 1880 and then it slowly shifted to South Asia continent by the end of 20 century in a country like India, Bangladesh, Pakistan and some part of China. The recycling process involves the careful handling of harmful materials and systems, safer dismantling operations.

Today with increasing awareness of environmental protection, the world is turning towards reducing the environmental impact through ship recycling. Some of the effects that ship dismantling has on the environment are due to fires that produce toxic gases, hazardous waste. There is some research available on the immediate impacts on the marine ecosystem near some ship breaking yards (beaches) of South Asia

This is the time when the international engineering community and the green NGOs have started showing their presence in the scene. The gravity of problems related to safety and environment pollution caused by the ship breaking activities will have to be addressed in detail and immediate initiatives are to be implemented and

research projects are to be initiated immediately, otherwise, the threat can go to a very dangerous level, even affecting mother-nature. The research aims at the study of ship recycling, comparison of different recycling method, categorizing of the inventory list and proposing the best method for recycling as per hazardous waste.

1.2 BACKGROUND AND MOTIVATION

The aim of this study is to deliver a report that presents the state, challenges, hazardous waste generated from ship dismantling and give ideas on how to develop the industry in the future. Ships were dismantled to recycle the steel they are built of, But now it is about dismantling with green environment, health impact and safety of human life at dismantling site. It is a relatively young industry as there has been a need to break ships made of steel only for around 5 decades from now. Until recent years the industry has been taking place mainly in the developing countries in Asia at the expense of nature and laboures but as the awareness about the industry has risen there is increasing pressure to invest in the sustainability of ship dismantling. The industry is growing in India due to low labour cost, the easy policy of transfer and easy disposal of waste generated by ship.

Recent there was a blast at Chittagong ship-breaking yard of Bangladesh where 2 workers were killed and 5-9 were injured, this was due to waste oil situated near main engine room where workers where gas cutting steel plate. Being a Research student of such esteemed organization it's my duty to either reduce the hazardous waste of ship dismantling or suggest changes in the design of ships for reducing such haphazard effect on a human being or reduce such incident.

This awaked me to understand the ship recycling and the problem relates to it, followed by comparing various method of recycling and compare them. Further, provide a solution to reduce this problem in ship recycling. As a result of which there low environmental impact, low heath issue and increase of safe and green ship recycling. For this various study was carried out, various report where study and detail analysis was done

1.3 OBJECTIVE AND SCOPE

The ship breaking has to be given a comprehensive formulation of the framework as the disassembly and recycling of ship rather than as hull steel recovery. The details of ship recycling have addressed in the present study. The problem is identified from various paper, with this various recycling yard are also covered in order to gain exact problem related to ship
Recycling which is further combined by fishbone analysis.

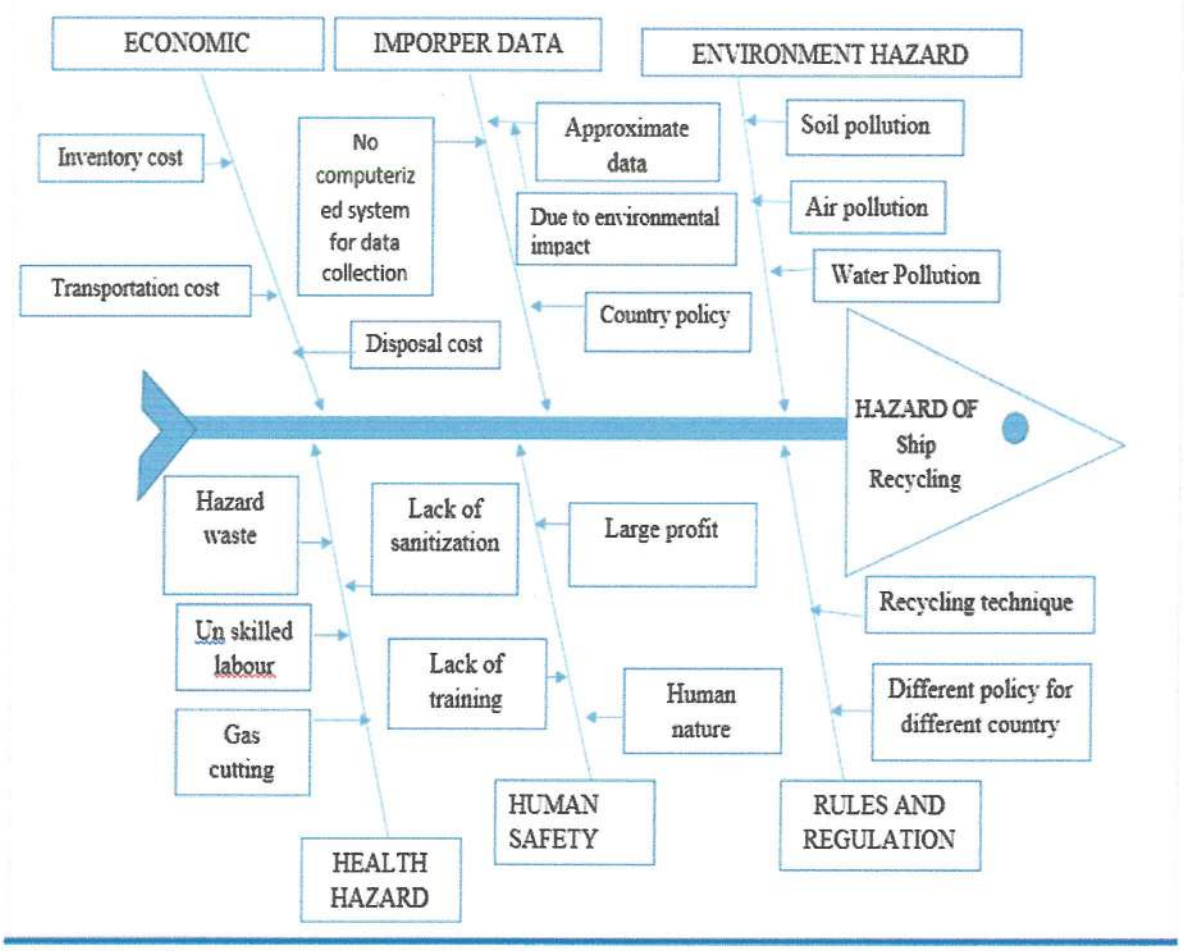


Figure 1 Fishbone Analysis

The objective of this project are as follow-

- To review the literature on ship dismantling, recycling, disposal of hazardous waste and various other rules and regulation related to dismantling and acquire through an understanding of the current status of the industry.

- To Rank obsoleting method based on various parameter like (environmental impact, health impact, safety)
- To suggesting a type of recycling processes based on an inventory of hazardous material.
- To understand the inventory of hazardous material, followed by classification of hazardous material based on environmental effect, cost (inventory cost, disposal cost), disposal time to know the most potential hazard based on Recycling yard.

This study can help to reduce accident, environmental impact and health effect as it suggest the best solution available in the maritime field and also provide various technologies to reduce pollution.

1.4 THESIS STRUCTURE

CHAPTER- 1 INTRODUCTION

CHAPTER-2 LITERATURE REVIEW

CHAPTER -3 SHIP RECYCLING & HAZARDOUS MATERIAL

CHAPTER-4 ANALYTIC HIERARCHY PROCESS (AHP) AND RANKING

CHAPTER-5 INVENTORY OF HAZARDOUS MATERIAL.

CHAPTER-6 PREPARATION OF SMART SYSTEM

CHAPTER-7 RESULT, CONCLUSION AND FUTURE SCOPE.

CHAPTER-2

LITERATURE REVIEW

[EU Ship Recycling Regulation: What's in it for South Asia?], 2014, in this author, have explained about the European Union regulation background, advantage and problems about the EU regulation. [1]

[K. P. Jain, J. F. J. Pruyn, J. J. Hopman], 2013, in this paper the author have done critical analysis of Hong Kong international convention for knowing the effectiveness to meet the objective, structure and development of convention, convention focus on ship and ship recycling facilities, regulation concentrating on the design, construction, operation and maintenance, major stakeholders and their work, strengths and weaknesses of the convention. [2]

[N. M. Golam Zakaria1 and K. A. Hossain], 2012, In this author have stated the general problem faced in shipyard of Bangladesh, brief development and guideline to overcome this problem are mention. This general problem is divided into sub headings safety problem which describes that most of the accident like falling of worker or plate from height occur due to lack of safety, training. Health problem like eye redness, tearing, burning sensation, blurring of vision, conjunctivitis, Abdominal, urinary, muscle and skin problems as well as nutritional deficiency were also identified among the workers which were mainly caused due to toxic metal, oil and chemical contamination as well as excessive workload, long working hour, monotonous works, irregular eating, insufficient diet, unsafe drinking water. An environmental problem like air and land pollution due to the toxic material. [3]

[Yen-Chiang Chang, Nannan Wang, Onur Sabri Durak], 2010, the author have discussed the structure, history, enforcement of Hong Kong convention, discussed the communication and exchange of information procedure, deficiency of the convention are also pointed.[4]

[Ship dismantling: a status report on South Asia, a project funded by the European Union], 2010, this report gives the information regarding the environmental effect,

various rules for environmental protection, Impact of ship recycling on the environment. [5]

[Aslam Khan, Raisa Bashar, Gias u. Ahsan, Nazmul Ahsan Khan] 2018, In this authors have done a case study about health risk assessment of the worker with the summaries report of the current condition of ship yard at Chittagong second capital of Bangladesh. In the report, the author has summaries the current situation by doing an in-depth interview and semi-structure quarries and found following things about labor which includes (condition of food, sanitation, the habitat of labors, medical facilities for labor, participation in training, cause of fatalities among yard, health issue the worker suffer). The author has also listed various type of accident based on their interview and at the end, he has recommended the training program for the labor. [6]

[Hasan Ruhan Rabbi and Aevelina Rahman] 2016, have described the present situation of ship breaking and recycling of Bangladesh in which they have mention about the declaration which they needed from the owner of the ship, the methodology used such as beaching technique was used and gas cutting was used for metal cutting. They have also mentioned about the environmental pollution caused due to toxic material like asbestos, a persistent organic pollutant which is generated during ship scrapping. Further worker safety and worker-right violation are also mentioned, at last, they have mentioned the technique and precaution for disposal of asbestos and suggestions for worker safety are marked. [7]

[Mosabbir. Pasha, Aziz. Hasan Mahmood, Istiakur. Rahman, and Abul. Hasnat], 2012 This study was done by the author at SRS SHIP BREAKING YARD to assess the impact of ship breaking and recycling by an environmental impact assessment, this study also reflects the water quality in adjacent areas of SRS Ship Breaking Yard to criticize the impact of SBRI. Water quality parameters like Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Electric conductivity (EC), PH, Turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chloride, Ammonia (NH3), Oil and Grease Concentration were measured in the surroundings of SRS Ship Breaking Yard and compared to international standards.[8]

[IMO GUIDELINES FOR THE DEVELOPMENT OF THE INVENTORY OF HAZARDOUS MATERIAL] 2015, In Annex 17 under Resolution MEPC.269(68) this guideline was adopted on 15/May/2015, In this guideline, the objective of this regulation to assist the regulation 5 of Hong Kong International Convention for the safe environmentally sound recycling of ship, 2009. It is declared to be called as the convention (the inventory of hazardous material). Further, this guideline showed the people who will be responsible, the aim of this guideline is to give details of hazardous waste present on board as (material contained in ship structure, operational generated waste, and stores). This guideline has listed and classified the material which is to be written in the inventory with the rules (a requirement for inventory generation is given, Form of Supplier's Declaration of Conformity & form of a material declaration), example and test carried for generating inventory list for the new and existing ship.[9]

[REGULATION (EU) No 1257/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC], of 20 November 2013, this official journal gives information about The purpose of this Regulation is to prevent, reduce, minimize and, to the extent practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by ship recycling. The purpose of this Regulation is to enhance safety, the protection of human health and of the Union marine environment throughout a ship's life-cycle, in particular to ensure that hazardous waste from such ship recycling is subject to environmentally sound management, This Regulation also lays down rules to ensure the proper management of hazardous materials on ships and gives the ratification of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 ('the Hong Kong convention), details about the regulation applicability dates, whom will be excluded or included in this regulation.[10]

[BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL By Katharina Kummer Peiry], 2010, gave the background, objective of the Convention, center around the following principal the reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal; the restriction of transboundary movements of hazardous

wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and a regulatory system applying to cases where transboundary movements are permissible, subsequent development after enforcement AND CONTRIBUTION TO THE DEVELOPMENT OF INTERNATIONAL LAWS. [11]

[Technical EIA guidance manual for ship breaking yard prepared for ministry of environment and forests government of India], 2009, in this draft the government have given the details about the EIA Environmental Impact assessment, about Ship recycling and about various hazardous waste, it's effect, impact, source, control, testing, infrastructure of ship breaking yard, layout of yard, form and responsibility of various government bodies. It has also provided data about hazardous waste produced. [12]

[HONG KONG INTERNATIONAL CONVENTION FOR THE SAFE AND ENVIRONMENTALLY SOUND RECYCLING OF SHIPS, 2009] this Convention undertakes to give full and complete effect to its provisions in order to prevent, reduce, minimize and, to the extent practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by Ship Recycling, and enhance ship safety, protection of human health and the environment throughout a ship's operating life AND give details about the regulation needed for safe recycling. [13]

[REGULATION (EC) No 1013/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on shipments of waste], of 14 June 2006, this official journal gives the Regulation for establishes procedures and control regimes of the shipment of waste, depending on the origin, destination and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination. It gives details on whom this regulation will be applicable or excluded from the scope of regulation, the procedure for documentation and also about other rules. [14]

[shipmanagementJun-Ki Choia, Daniel Kelleya, Sean Murphyc, Dillip Thangamanib], 2015, this paper show economic and environmental relationship on standard method used by developed country, substandard method used by

developing country and reefing and suggest that standard method should be preferred over substandard though profit is slightly less environmental impact is negligible, whereas reefing can be a potential option as support marine environment and tourism. [15]

[K.P. Jain, J.F.J. Pruyn & J.J. Hopman], 2014, In this paper the author have given a link between first and last stage of ship life that is a relation between the ship design and it's scrapping, which will leads to effective disposal of hazardous waste and will reduce the recycling cost by suggesting ways like reducing or replacing hazardous material, accurate inventory list of hazardous material & making ship easy to dismantle and at last showing the economic impact of design for recycling.[16]

["Fate of Shipbreaking Wastes in Turkey"], 2009 is a report by the NGO Platform on Shipbreaking which aim at the disposal of hazardous waste like asbestos, PCB, ballast water, oil, batteries, other hazardous waste generated from the ship breaking yard, in this report the waste management of turkey had been explained which can be used as a base for hazardous waste treat at Alang, India. [17]

[Manoj T Thomas], 2007, in his case study on the Alang ship breaking yard described the situation of the worker, impact of breaking on environment and steps taken by the supreme court of India for protection of the environment.[18]

[Technologies and Management Strategies for Hazardous Waste Control], in this report, the author have mentioned about various technologies for hazardous waste management, the process to reduce the hazardous waste, future development in these technologies.[19]

[Yogesh Kumar, Rupesh Kumar Khaparde, Komal Dewangan, Gautam Kumar Dewangan, Jalam Singh Dhiwar, Devprakash Sahu], 2017, it is a case study of inventory management by FNS Analysis for sponge iron plant in which they have analyzed and studied about the balance between critical stock, cost, and minimum inventory.[20]

[Singh, G. and Ahuja, I.S.] (2012), this paper show the evolution and implementations of JIT, the approach suggested by the different researcher are studied, discussed and reason for failure is checked. On the other hand, it also discussed the success factor and facilitators of JIT.[21]

[Occupational Safety and Health Administration U.S. Department of Labor] 2010, have mentioned in safe work practice for shipbreaking about the procedure to be carried for ship breaking starting from the survey, towing, mooring, cutting, safety, training and all the other steps responsible for safe cutting of vessel.[22]

[Thanasis Karlis, Dionysios Polemis, Anastasios Georgakis] 2016, in this paper the author has evaluated the effect of the current exchange rate on ship scrap value by regression analysis to evaluate the hypothesis. As a result, they got a strong relation between ship scraping price and current exchange rate. In this paper, the author has also mentioned about the situation of ship demolition across the world. [23]

[ROLANDO D. LEGASPI] 2000, in this author has given details of the impact of economic and environment on ship breaking, problems, factor affecting the life cycle of the ship and also mention about ship scrapping procedure.[24]

[R. W. SAATY] 1987, in this author, has explained the theory about analytics hierarchy process, discuss some idea and result related to AHP.[25]

[Dr. Zahi Abu-Sarhan] 2011, the author has shown the application of AHP in reengineering project of an information system.[26]

[Manisha Ketkara, Omkarprasad S. Vaidya] 2013, in this the author has shared the application of the SIMPLE additive weighted method for developing order policy based on multiple inventory classification schemes. [27]

CHAPTER- 3

SHIP RECYCLING AND HAZARDOUS MATERIAL

3.1 Ship recycling

Ship breaking is the process of dismantling obsolete vessels for scrapping or disposal. Conducted at a dry dock or along side or beach, it includes a wide range of activities, from removing all gears and equipment to cutting down the ship's infrastructure. Ship breaking is a difficult process, due to the complex structure of ships.

Ship breaking activity began in the 1970s and since then it has gained a reputation for being profitable but at a great environmental cost. Various disposable materials are being discharged and spilled from scrapped ships and often get mixed with the beach soil and seawater which in turn has a negative impact on our coastal environment, biodiversity, and ecosystem.

3.1.1 Recycling across the world

In mid-1980 around three-quarters of the demolition, activity was made in Taiwan, China, and South Korea. Today only China is still within the top shipbreaking countries. India, Bangladesh, and Pakistan are now among the leading shipbreaking countries. Based on data from Clarksons SIN (2015) these four countries hold 82% in terms of a number of ships and 92% in terms of DWT demolished (figure-2). These data is similar to the data from Reddy and Manoharan (2014) that report 75% and 93% in terms of a number of ships and DWT demolished respectively. Based on trend and data it seems that shipbreaking is located usually in low-cost labour countries as the process is highly labour intensive (Samiotis, et al., 2013)

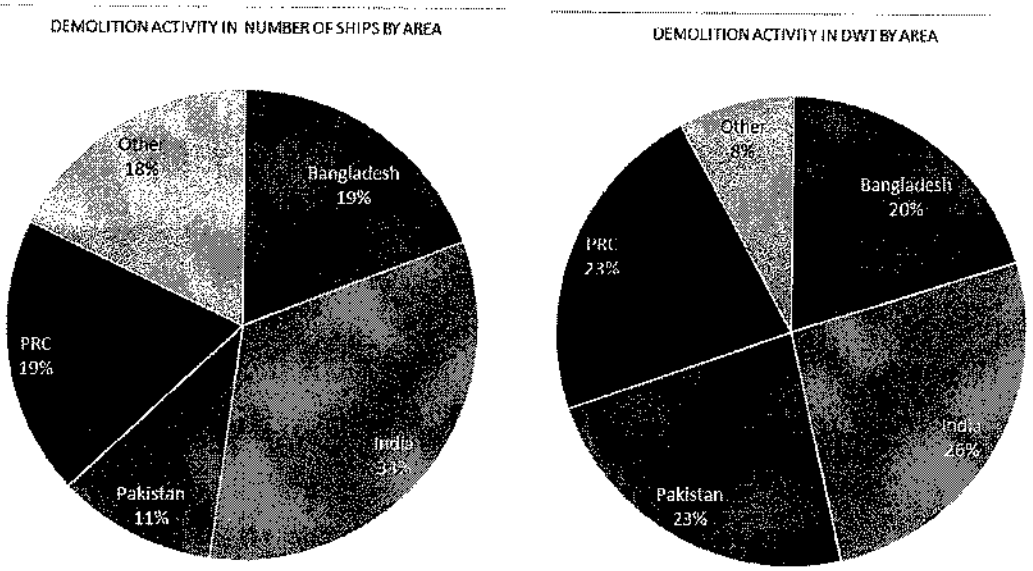


Figure 2 Demolition Activity by Major Country

Source: Authors' elaboration with data from Clarksons SIN, 2015

Lightship Displacement Tonnage (LDT) is the most important measurement unit in the ship-breaking process (Pour, et al., 2012). The price a ship is sold for demolition is almost always quoted on a per lightship ton basis. This gives an estimate of the useful material after the demolition. (Mikelis, 2007). The type and size of a ship determine the LDT. Equal in size but of different types of ships have different LDT. Again ships of the same type but of different size differ in LDT.

According to Knapp et. al. (2008) earnings, and thus freight levels, have a negative effect on the decision to send a ship to the demolition yards. The higher the freight rates the higher the earnings from ship operation. Thus high freight rates allow even inefficient, aged and technologically obsolete vessels to operate profitably. As long as a ship is profitable the ship owner is reluctant to sell it for scrap and thus a negative relationship exists between freight levels and a number of ships scraped (fig-3).

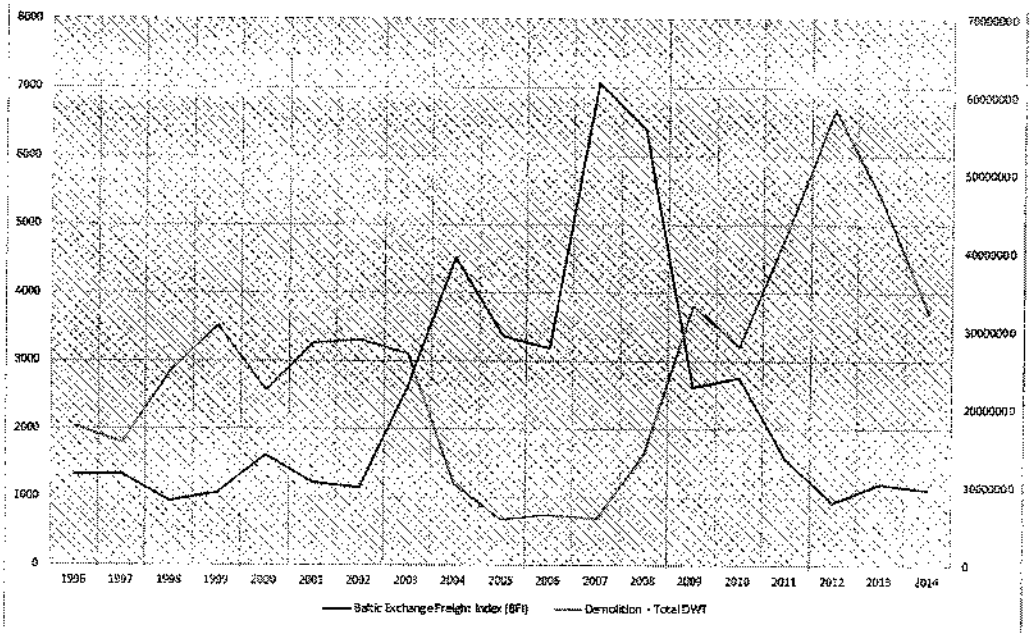


Figure 3 BFI Index and Demolition Activity In DWT 1996-2014

Source: Authors' elaboration with data from Clarksons SIN, 2015

On the other hand, the decision to sell a ship for scrap has a positive relationship with the scrap price, i.e. the price the vessel is sold for demolition. Scrap prices are connected with the demand for scrap steel (Merikas, et. al., 2015). This relation is the result of the use of scrap steel in the steel production process (World Coal Association, 2016). In addition due to price, differences scrap steel is becoming increasingly important as an alternative source of iron ore (WANG, et al., 2014). The largest steel producers are by far China with around 48% of worlds' crude steel production in 2015 (Worldsteel Assocation, 2016). Apart from China, only India is within the top 10 crude steel producing countries that are also among the top ship dismantling countries (fig-4). This means that the scrap steel produced in those two countries would most probably be consumed locally.

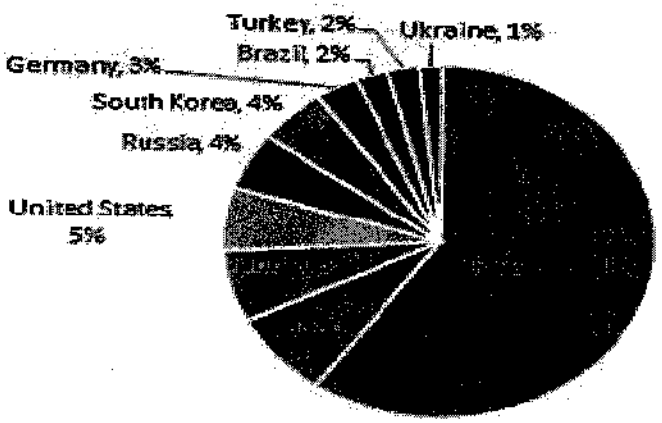


Figure 4 Top 10 Producers' Percentage of the World's Crude Steel Production

Source: Authors' elaboration with data from World Steel Association (2016)

3.1.2 Ship recycling in India

Ship recycling was started in India before independence, the first dismantling was seen in Kolkata and Mumbai in 1912. When the first economic recession came around and the fleet owner thought that it was better to scrap ship than to maintain them, there was a huge line of the ship to be demolished. Meanwhile, it was found that the profit was decreasing as the metal was not sold and labour were asking for High payment, it was that time India market came into the scene as it was providing cheap labours. Since then the emphasis was given to find a various suitable site for this activity.

Various ship breaking yard in India are-

Table I Major Ship Centers In India

No	State	Locations
1	Andhra Pradesh	Vishakapatnam
2	Gujarat	Alang
		Sachna
3	Karnataka	Tadri
		Mangalore

No	State	Locations
		Malpe
4	Kerala	Baypore
		Cochin
		Azhikkal
5	Maharashtra	Mumbai
6	Tamilnadu	Tuticorin
7	West Bengal	Kolkatta

Among these major ship recycling center, Alag is the most popular and most preferred recycling yard in India as it has a favorable parameter for beaching method like high tidal range, firm, seabed, gentle seaward slope, simple policy, etc. The first vessel- M. V Kota Tenjong was beached at Alang on 13 February 1983. Since then yard had seen significant growth. The CPCB in Delhi has prepared an environmental guideline for ship scrapping industry aiming to minimize the effect of the yard on the surrounding environment through the proper location of breaking yard and by preparing and implanting an EMERGENCY MANAGEMENT PLAN.

3.2 Ship recycling process

Ship recycling being the last activity in the life cycle of a vessel, certain important commercial and engineering operations are to be carried out well in advance to facilitate the objectives of dismantling and recycling. Thorough knowledge regarding these background activities are essential for understanding and realizing the ship recycling processes and treating ship recycling as a modern industrial business activity. A schematic representation of the flow of related activities has been given below-

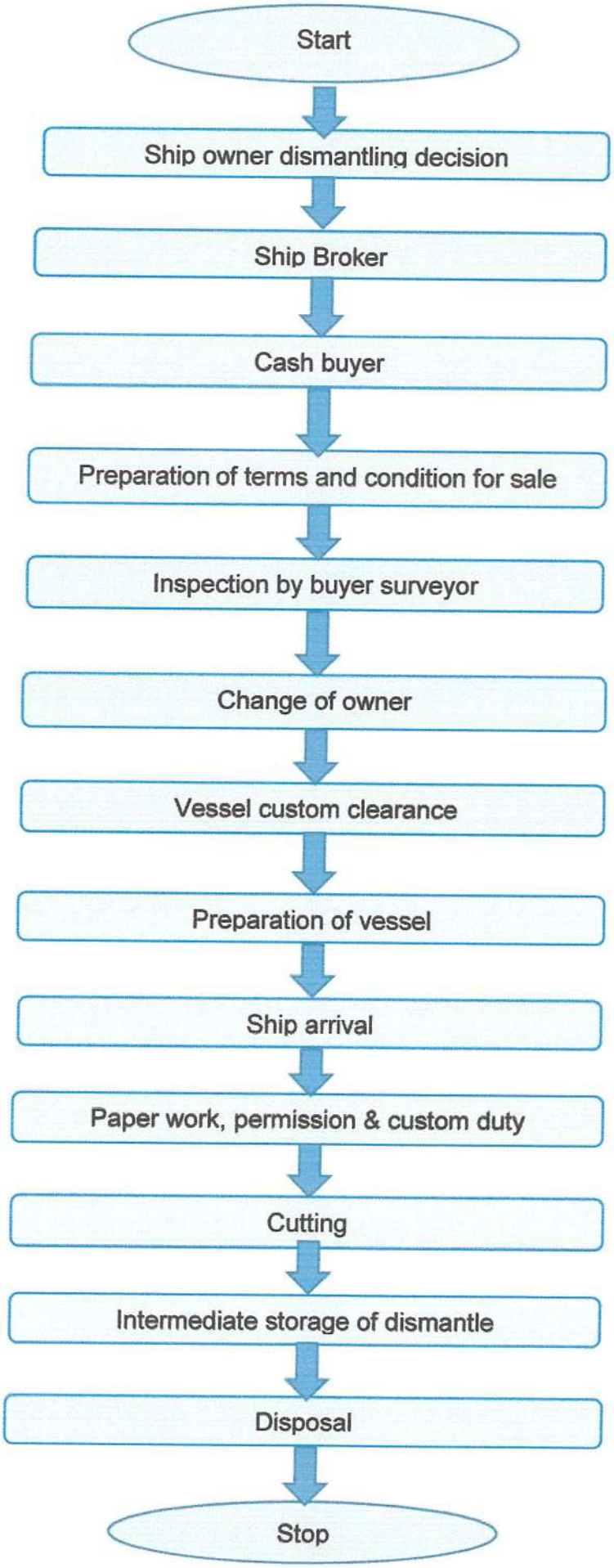
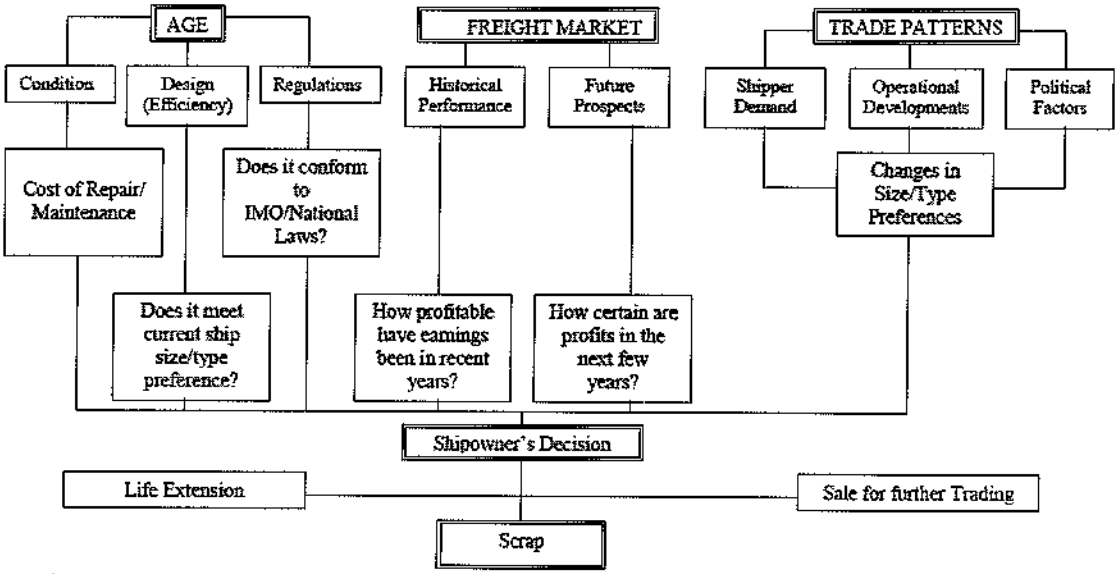


Figure 5 Flow Chat of Ship Dismantling

- Ship owner dismantling decision

It is but natural that the ship-owners main interest is to maximize the earning capability of his ship; this covers even during the disposal of the ship. The ship-owner has an option to deal directly with the ship-breaker or through a shipbroker, but often times the assistance of the shipbroker is preferred. The knowledge and experience of the shipbroker in the prevailing market condition are of great benefit to the ship-owner. Dismantling decision is taken by ship owner based age, freight market, trade pattern which is done as shown in the below fig-

FIG. 2.1: SCRAPPING DECISION PROCESS



Source: Drewry Shipping Consultants (Ship Scrapping, 1996, p. 58)

Figure 6 Scrapping Decision Process

Source- Drewry shipping consultants (ship scrapping, 1996, p, 58)

- ship broker or intermediaries-

In the shipping industry, there is regular purchase and selling of ship which generally done through are cognized group of broker or trading houses. It is normal that the owner will involve shipbrokers, or trading houses, or international traders

specializing in ship scrapping. The shipbroker acts as a middleman in the sale. His knowledge of the current and expected market situation and the efficiency to search for potential buyers usually ensures a better deal. the shipbrokers receive for the ship will then be relayed back to the ship-owner. The amount of time that will take the ship off from the negotiating table will depend on the prevailing market condition and volume of ships available.

For a good quality ship, fierce competition among buyers usually prevails, and within a matter of hours, the ship being offered will be disposed of to a qualified buyer. On any sale that is successfully concluded, the shipbroker will be earning a commission in the magnitude of 1% - 2% of the total sale price (Drewry, (1996). On some occasions, an independent shipbroker usually puts up the capital fund to buy a vessel "as is", "as is, where is", in lay-up or after the discharge of the last cargo. The said shipbrokers are only active in this scheme if there is a customer waiting, otherwise, they have to take control of the ship until the required payment and delivery is formalized.

The period between when the deal has been made and the time of delivery is regarded by the shipbroker as the most difficult time. A sudden change in the market may lead to renegotiations and then the shipbreaker may raise some contention regarding the condition of the ship when it reaches the shipbreaking site.

- Cash buyer

Shipbroker finds the potential buyer or a cash buyer that is (a person who is able to buy something, especially a property, without needing to take out a mortgage or loan to do so) who wishes to take the ship.

- Preparation of terms and condition

The shipbroker is also required to prepare the written contract between the concerned parties. Drewry Shipping Consultants Ltd. (1996) point out that there is

no predefined or prescribed format for the Memorandum of Agreement (MOA), but a typical agreement usually has standard clauses.

- Inspection by buyer

In this survey from the buyer, side inspects the ship and check the ship condition and verify that the condition is the same as that mansion by the buyer.

- Change of owner

After successful completion of the survey, the owner changing procedure is done and the ship is sail to ship breaking country.

- Custom clearance

In this, if the is ship is of the foreign flag than it is asked to anchor at the sea until the ship pays the customs duty and berth availability.

- Ship arrival

The ship is sailed to berth or beach or dock based on the process used by the ship breaking yard. All the safety measure for ship breaking taken.

- Preparation of vessel

All the inspection by the ship breaking yard is done, all the machine are checked and before ship crew leaves the vessel all the machine are switched off. As soon as the crew leaves the vessel, the vessel is sealed by the customs department and all crew, their vehicle, their Luggage is check

- Permission, paperwork & custom duty

In this process, the ship breaking yard person have to pay the customs duty to the customs department for custom clearance for ship breaking. Further, they also have to pay duty to the environmental department and take permission for hot work and pollution board for ship recycling. After this department gives permission to cut.

- Cutting

Before the labor are asked to cut the vessel with the gas torch following things are done-

- Remove fuels, oils, other liquids and combustible
- Remove equipment.
- Remove and dispose of asbestos and PCBs.
- Prepare surfaces for cutting
- Cut metal

- Intermediate storage

After the material is cut they are stored in the intermediate storage at the location from which either they are sold or kept at the same passion until they are purchased by the buyer.

- Disposal

After the selling of most of the recycled material the ship yard is left with material which can't be sold or recycled or hazardous are sent to the disposal yard.

3.2 Hazardous material

Ship contains a wide range of hazardous substance such as sealants containing PCB, various types of asbestos, 1000s of liters of oil (engine oil, hydraulic, etc.), paints and other. Detail list is provided in the Inventory of Hazardous Material.

3.2.1 Effect of hazardous material in ship recycling-

There are several studies done by various authorities such as (governments, NGOs, and international and bilateral agencies) that indicate that waste from ship breaking may pollute sea water, increasing its turbidity, acidity, and salinity. This may impair the process of photosynthesis and decrease phytoplankton reproduction.

- Asbestos-

a) The worker may be exposed to asbestos while removing asbestos from cable, circuit breaker, pipes, floor tiles, these fibers are lighter I weight and can be in the atmosphere for a long time.
b) The size of this fiber is in the range of 0.1 to 1 micron in length.

- PCB-

a) They are ingested, inhaled or absorbed through the skin and circulated in the body and get stored in fatty tissue.
b) These cause cancer in an animal whereas in human it may be cancer-causing or may not be cancer causing

- BILGE & BALLAST

a) The above can affect the environment and health in the following way-
b) Bilge and ballast water can' t be removed without treatment as it can cause cancer and lead poisoning
c) Bilge contain toxic organic material damage to the kidney and liver.

d) This oil when left in water causes the poison to fish and other marine organism.
e) It may also affect the environment as micro-organism and pathogens can get in the ecosystem from the plant.

- Oil & fuel

a) The primary danger to the worker due to fuel and oil is a fire
b) Some crude oil and high-end product have toxic contain which is harmful to the worker.
c) Exposure to such toxic causes damage to lungs, liver, kidney, heart and nervous system.

- Paints

a) Removing paint has a huge impact on human health and the environment
b) Chemical and solvent used in stripping paints or coating emit volatile organic compound and hazardous air pollutants into the atmosphere.
c) Other removal method causes dust, emission of lead and other contaminants.
d) Waste of paints has a negative effect on the environment if they not properly contained and disposed of.

3.2.2 Impact of hazardous material on ship recycling

- Asbestos

labours who continuously breathe in asbestos fibers with lengths greater than or equal to 6 µm may develop a slow buildup of scar-type tissue in the lungs and in the membrane that surrounds the lungs. This scar-type tissue does not work like normal lung tissue and so breathing becomes difficult. Blood flow to the lung also

be decreased, and this causes the heart to enlarge. This disease is called asbestosis.

People with asbestosis have shortness of breath, often accompanied by a cough. This is a serious disease and can eventually lead to disability or death in people exposed to high amounts of asbestos over a long period. Asbestos workers have increased chances of getting two principal types of cancer: cancer of the lung tissue itself and mesothelioma, a cancer of the thin membrane that surrounds the lung and other internal organs.

- Oil

Oil is mainly composed of hydrocarbons and sulfur. Oil is spilled in the water body while cutting ships into pieces and hampers aquatic lives and even causes their death too. For that reason, the ships are made free of oil before cutting starts.

- Heavy Metals

Metals of concern associated with the ship-breaking industry are toxic heavy metals such as lead (Pb), mercury (Hg) and cadmium (Cd), iron (Fe) alloy such as steel, aluminum (Al) and zinc (Zn). Heavy metal affects primarily the peripheral nervous system and can cause impairment of hearing, vision, kidneys, heart, and the reproductive system.

- Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are released during torch cutting and afterward when paints continue to smolder or when wastes are deliberately burned. About 250 PAHs are known. Some harmful PAHs are Naphthalene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo (a) anthracene, Chrysene benzo (k) fluoranthene, Benzo (a) pyrene, Benzo (ghi) perylene, Indenopyrene. Some PAHs have been shown to cause cancer in laboratory animals, and also in humans following occupational exposure at high concentrations. A number of PAHs have been shown to be genotoxic (i.e. they interact with the genetic material in cells).

- Polyvinyl Chloride (PVC)

Lots of equipment and materials in ships are made of PVC. PVC poses serious threats to environmental health at every stage of its existence (production, use, and disposal). At the end of its life, PVC waste creates intractable disposal problems because it is expensive and unsafe to burn. It releases hazardous chemicals into groundwater and air when buried, and is not so easily cheaply recycled. Polyvinyl chloride (PVC) can have a negative impact on the environment and human health. PVC has been known to cause Raynaud's syndrome, scleroderma, cholangiocarcinoma, asthma angiosarcoma, liver cancer, brain cancer, acroosteolysis and risks of impaired human reproduction, etc.

Among other pollutants exposed when breaking a ship, Sulfuric acid, Radioactive materials, Paint and preservative coatings, Bilgewater, Polychlorinated Biphenyl Compounds (PCBs) are noteworthy most of which causes respiratory problems and nervous attack.

3.3 Rules and regulation related to hazardous material of ship recycling

IMO GUIDELINES FOR THE DEVELOPMENT OF THE INVENTORY OF HAZARDOUS MATERIAL 2015

In Annex 17 under Resolution MEPC.269(68) these guideline was adopted on 15/May/2015, In this guideline, the objective of this regulation to assist the regulation 5 of Hong Kong International Convention for the safe environmentally sound recycling of ship, 2009. It is declared to be called as the convention (the inventory of hazardous material). Further, this guideline showed the people who will be responsible, the aim of this guideline is to give details of hazardous waste present on board.

REGULATION (EU) No 1257/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC, of 20 November 2013

This official journal gives information about The purpose of this Regulation is to prevent, reduce, minimize and, to the extent practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by ship recycling. The purpose of this Regulation is to enhance safety, the protection of human health and of the Union marine environment throughout a ship's life-cycle, in particular to ensure that hazardous waste from such ship recycling is subject to environmentally sound management, This Regulation also lays down rules to ensure the proper management of hazardous materials on ships and gives the ratification of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 ('the Hong Kong convention).

BASEL CONVENTION

objective of the Convention is to reduce the movement of hazardous waste between the nations especially to prevent transfer of hazardous waste from a developed country to a less developed country, another factor is sound management of waste in underdeveloped country and a regulatory system applying to cases where transboundary movements are permissible, subsequent development after enforcement and contribution to the development of international laws.

HONG KONG INTERNATIONAL CONVENTION FOR THE SAFE AND ENVIRONMENTALLY SOUND RECYCLING OF SHIPS, 2009

This Convention undertakes to give full and complete effect to its provisions in order to prevent, reduce, minimize and, to the extent practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by Ship Recycling, and enhance ship safety, protection of human health and the environment throughout a ship's operating life and give details about the regulation needed for safe recycling.

[REGULATION (EC) No 1013/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on shipments of waste], of 14 June 2006

This official journal gives the Regulation for establishes procedures and control regimes of the shipment of waste, depending on the origin, destination, and route of the shipment, the type of waste shipped and the type of treatment to be applied to the waste at its destination. It gives details on whom this regulation will be applicable or excluded from the scope of regulation, the procedure for documentation and also about other rules.

Gujarat maritime board-

It is the governing body of world largest ship breaking yard. It has its own rules and regulation regarding handling and disposal of asbestos and waste oil

Supreme court of India-

This has given a historic ruling in connection with the denial or permission of infamous French aircraft carrier to Alang ship recycling yard. These guidelines are very specific and actual implementation at the recycling yard.

3.4 The guideline, source, and removal of hazardous material

3.4.1 Asbestos

It is a mineral with a long thin fibrous crystal. It is resistant to heat, electricity, absorbs sound, chemical damage and had a tensile strength. Was considered as a miracle material and was widely used in shipbuilding particularly in ship insulation. However, the risk associated with asbestos- including the risk of mesothelioma cancer and lung diseases caused by inhaling the toxic fiber- make it a hazardous material to be dealt with. Hence it is considered as the main source of environmental. health and safety concern.

- ✓ Source of Asbestos-

- Bulkhead and pipe thermal insulation
- Bulkhead fireproof
- Exhaust duct insulation
- Electric cable material

- Brake lining
- Floor tiles and deck underlay
- Sound Damping
- Sealing putty
- Packing in shaft and valve
- Pipe Hanger

This can be spread to families of the worker as worker cloth was in contact with the asbestos.

✓ Asbestos Removal practices and procedure-

❖ Worker protection-

- The facility has to perform air surveillance in the working area where asbestos is removed, conducting initial exposure assessment regularly and periodic monitoring to be done
- The worker should be exposed to only 4 hr in asbestos removing the area
- Regular interval medical checkup.
- The facility must be established and maintain an accurate record for each worker subjected to medical surveillance, record to be maintained for 30 year

❖ Worker exposure limit-

- Worker not to be exposed to airborne asbestos concentration in excess of either of permissible exposure limit PEL-
    - 0.1 fiber per cubic centimeter (f/cc) of air averaged over an 8-hour shift.
    - 1 f/cc of averaged over a sampling period of 30min.

❖ Worker training-

- The worker should be trained for free
- Training should be given before joining and also once afterward in a year

- The supervisor should be trained about the material its identification and its removal

❖ Training record-

- The document should be maintained of training attended and completed by each worker and supervisor, these record must be maintained for one year past the last day of employment.
- PPE should be provided to the worker, respiratory should be provided free of cost, another protection thing like, gloves, shoes, hamlet should be provided.

❖ Hygiene facilities for the worker-

- A decontamination area which includes equipment room, shower area, clean room.
- The facility must be provided for the lunch area which is free from the airborne concentration of asbestos
- The supervisor should look after the handling of asbestos.

✓ Best practice to control asbestos emission-

- Regulated asbestos-containing material should be wet that is should contain large humidity as fiber has a capability to absorb the humidity and as a result, it gets heavy and falls faster, thus reducing the asbestos level
- Carefully handling the floor of asbestos
- After removal, they should be raped in leak-proof material, which doesn't allow air to be in contact
- The thing to be done in a regulated area-
    - The regulated area should be marked and the limited worker should be allowed to enter
    - The only authorized worker should be allowed to enter
    - All worker entering in this area should wear an appropriate mask

✓ Engineering control and work practices during the removal of asbestos-

- A worker will not be able to read the sign in English hence native language and signboard should be used.
- In addition to control, the emission appropriate step should be taken
- Negative pressure enclosure system should be used

3.4.2 Polychlorinated biphenyls (PCB)

PCB are a man-made organic chemical used in electrical, heat transfer and hydraulic equipment as a plasticizer in paints, plastics and rubber product, etc.

PCB is found in the older vessel and can range in toxic and vary in from light to waxy solid and is sold under name of Arochlor. These were used to property like nonflammability, chemical stability, high boiling point, and electrical insulation.

✓ Source-

- Cable insulation
- Rubber and felt gasket
- Transformer
- Voltage regulator, switches
- Adhesives
- Oil-based paints
- Plasticizer

✓ Measure for handling PCB-

❖ Worker protection practice

- Exposure to PCB in the workplace includes two time-weighted average for chlorodiphenyl. They are-

- 1 mg/m3 of workplace air over an eight-hour work shift for chlorodipenyl containing 42% chlorine.
- 0.5 mg/m3 of workplace air over an eight-hour work shift chlorodiphenyl containing 54% chlorine.

- Worker exposes to PCB in an eight-hour work shift of 40 hour week should not exceed this concentration.

❖ Use of PPE-

- Appropriate PPE should be used as per the required
- Gloves, shoes, respiratory equipment should be used to stop inhaling fumes of this PCB.

❖ Training practice-

- No cost should be charged for providing training
- Effective respiratory training in written and operation should be given, inspection, fit test, cleaning, maintenance and storage, medical examination, program evaluation should be carried out.
- Training on PCB sampling removal for liquid and non-liquid PCB.
- Training for determining the presence of PCB.

✓ PCB storage-

- There should be an adequate facility for storage of PCB, which protect it from coming in contact with water and floor having continuous curbing with a minimum 6-inch high curb.
- The floor and curbing must provide containing volume equal to at least two times the internal volume of the largest PCB article or container storage inside or 25% of the total internal volume of all PCB article.
- Floor and curbing constructed of Portland cement, concrete or a continuously smooth, non-porous surface which prevent or minimize penetration of PCB.
- No drain valve should present

✓ Disposal of PCB liquid, item, waste, and electric cables-

- The facility must follow strict requirement for the disposal of PCB containing or PCB containing liquid, article, container, spill material, bulk remediation waste, and bulk product waste. Depending on the item and its PCB concentration the following kinds of disposal may be required:
    - Licensed incinerator
    - Hazardous waste landfill

3.4.3 BILGE AND BALLAST WATERS-

It is an important activity in ship breaking to remove and dispose of bilge and ballast water, improper conducting can produce environmental, health and safety.

Bilgewater consists of stagnant, dirty water and other liquid such as condensed steam, valve and piping leaks that are allowed to drain to the lowest inner part of a ship hull. Bilgewater may be found in holding tanks onboard, often referred as bilge tank.

Bilgewater during operation may produce due to leakage, spills, boiler blowdown and during ship scraping sure to rainwater, removal of asbestos and can cause effect during cutting. The different type of ballast included during operation-

- Clean ballast
- Compensated fuel ballast
- Dirty ballast
- Mud ballast
- Chromated ballast water

✓ Measure –

❖ Boom to contain accidental discharge-

- The shipbreaker should keep the certain length of the boom and should wrap against the ship to be cut in order to reduce the chance of oil discharge.
- Boom, oil sorbents and barrier can be used to reduce the impact.

❖ Cleaning tank/ compartment onboard-

- All the tank should be cleaned to remove any residual oil or waste prior to additional ship breaking activity.
- The worker should follow to reduce the dangerous impact
- Continuous air should be provided in order to remove gas concentration
- Before cleaning certificate should be taken by marine chemist or authorized person respective maritime board.

✓ Discharging bilge and ballast-

- During scrapping the bilge is transferred from the tank to onshore storage tanks
- This transferred wastewater should be tested

3.4.4 Oil and fuel-

Some of the ships which are sold for scrapping may contain diesel fuel, fuel oil, natural and synthetic oil used as lubricants and hydraulic oils.

This oil may refer to crude oil, kerosene, animal oil and fat, edible and inedible seed oils from plant.

✓ A source in the ship-

- Diesel fuel and fuel oil may be contained
- Lubricant oil in engine slum
- Oil, fuel, sludge is found the machinery and piping system

- Used oil finds in the spent lubricating fluid which has been removed from the engine crankcase, transmission, and gearboxes.

✓ Impact during oil spill-

The severity of oil spill depended on a variety of factor, including various factor, including physical properties of the oil whether it is oil is a petroleum or non-petroleum based. Each type of oil has a distinct property that affects the way it spread and break down-

- Oil has both long term and immediate both effect which is dangerous to wildlife and environment
- Light refined petroleum product gets spread and penetrated into porous soil.
- Fire and hazardous are very high, but get evaporated and leaves no residue.
- Oil spill immediately begins to react and change itself and became a threat to natural resources, birds, and animal and get into the food chain.
- Marine reef and short lines are at risk of being shorelines are at risk of being smothered by oil that washes ashore.
- Spilled oil can harm birds and mammal in any ways as a contact of oil with the feather can freeze to death. as a complex structure of the feather get damage

✓ Measure to control oil spills-

Some of the most important activities during ship scrapping are-

- Preventing oil discharge
- Being prepared to respond to a spill
- Knowing how to respond to spill and recover spilled material.

✓ Removal

It is the same as for bilge and ballast water.

3.4.5 Paints-

The removal of paints prior to cutting may not be necessary for certain circumstance. However, wherever it is necessary, the specific requirement must be followed. In addition, the removal of paints generated waste that must be managed and disposed of according to rules and regulation

✓ Source-

Paint is found in both side of ship interior and exterior of the surface of a ship. These paint can cause a fire may be a toxic compounds such as PCB, heavy metal and pesticide. Some paints contains at most 30% of heavy material.

✓ Measure –

❖ Handling procedure-

Paints and coating are removed in one of three ways-

- Chemical stripping-

Paints and coating are removed by chemical stripping using solvents, such as methyl ethyl ketone and 1,1,1trichloroethane. Now, this solvent can be toxic, flammable is the rub, wiped or brushed on the surface than removed along with paints and coating using rags and wipes.

Toxic solvent- when the toxic solvent is used the area should be enclosed in order to prevent the escape of vapor into workspace, vapors should be removed through proper natural or mechanical ventilation and in concentration that is safe and under the limit. The worker should be provided by proper respiratory protective equipment and suitable clothing.

- Flammable liquid-

Additional precaution should be taken for flammable solvent by providing proper ventilation so that the concentration of vapor is below 10% of lower explosion limit. Explosion proof light should be used.

- Abrasive blasting-

Paints and coating are removed by blasting a surface with abrasive, such as copper slag, coal slag, steel grit, and mineral grit. Blasting generates large amounts of

dust, abrasive waste and paint chip. Blasting generates a large amount of dust, abrasive waste and paints chip.

-equipment like hose and fitting should be required to meet the condition, the hose should prevent shock and from static electricity.

The nozzle should be attached to the hose by fitting that evil prevents the nozzle from disengaging by accident, and nozzle attachment should be metal and fit onto the hose externally.

✓ WORKER PPE-

The facility should protect its worker from conducting blasting in enclosed spaces by hood air fed respirator or by positive pressure air helmet.

- Mechanical removal-

This involves a powerful tool or flame to remove paints and coating.

- Power tool-

The use of power tools, such as grinder, wire brushes, sander, chipping hammer and another impact tool, a worker using these tool should be protected from eye injuries by making use of Google.

- Flame removal-

It should not be used on greasy or soft preservative coating or paint containing PCBs

✓ WORKER EXPOSURE LIMIT-

All the paint contain lead and it should be approx. 50 Fg/m3 of air averaged over an eight hour work day.

The facility should control the exposure of worker.

❖ Flammability test to paint and coating-

- Flammability should be checked before cutting the surface.
- The highly flammable coating should be removed prior to metal cutting to prevent ignition
- This procedure should be done under the control condition.

❖ Toxic of paint and coating

- The test should be conducted to determine the toxic in paint and coating
- All should be considered as toxic is not tested
- All the coating and paint should be stripped to 10 cm from the area to be heated and also ensure that worker is protected.

✓ **Removal-**

The removal of paint and coating, regardless of the process used, generated waste that must be managed and disposed of.

Chapter-4

Analytic Hierarchy Process (AHP) and Ranking

4.1 Obsoleting vessel

India has become the largest industry for ship breaking about 250 to 260 ship are dismantle per year at Alang in Gujarat. These use beaching technique for cutting, but the amount of environmental effect is more. So in order to know about the best technique of cutting obsolete vessel one have to compare this technique.

A different method for obsoleting the vessel is-

- Beaching Method
- Dry dock method or Berth Method
- Buoy Method
- Slipway method
- Reefing

4.1.1 Beaching Method-

It is the most used way across the world, about 95% of the developing country used this method for ship breaking, taking advantage of the high tidal variation. An area like the Chittagong area in Bangladesh, Alang in India and Gadani in Pakistan. In this method run on to the beach using own propulsion at full speed and as little ballast as possible. The flat bottom of the ship and the uniform beaches allow the ships to sit steadily on the beach sand. The workers drill holes into the beached ship through which sea water enters, washing the oil-contaminated tanks at high tides. The primary breaking takes place in the inter-tidal zone, where the bow is cut open to access objects of value. Thereafter, the hull plating, large segments of the ship's structure are opened and sequentially extracted and are either winched or towed ashore. Oils, gaseous wastes, asbestos, etc., are removed. Next reusable items are collected separately and steels are cut by oxygen cutting. The steels cut are dragged by winches if they are large, but mostly the large blocks are cut into small pieces to carry by people. The pieces cut again into two by four-meter pieces are sold for cold rolling

The beaching method is mostly used in developing countries where the environmental regulations and labor rights are either rather weak or not existing. The majority of workers earn not more than EUR 2 a day and child labor is commonly found. Workers do not have sufficient safety gears that can protect them during accidents caused by falling heavy metal plates, gas explosions or gas suffocation at the site. In addition, people who are exposed constantly by toxic pollutants are suffering from fatal occupational diseases, such as lung cancer. Moreover, tons of pollutants that are absorbed into the sand and accumulated on the yards can be washed back into the sea, which causes environmental damages such as changing the climate, rising sea level, destroying the biodiversity of the region or extinguishing fishing communities (NGO Shipbreaking Platform, 2011).

4.1.2 Dry dock method or Berth Method

This method involves docking the ship at shore, where water can be pumped out in order to Dismantle, it is called as the safest and cleanest ship breaking way where the chances of polluting waters by accident are zero and the dock is cleaned before the next ship comes to be recycled in order to avoid accumulations of contaminants. . It is claimed that the dry-dock method meets the requirements of the Environmentally Sound Management (ESM) guidelines of the Basel Convention, which requires an "impermeable surface" during dismantling. Drydocking has been acknowledged as a more environmentally friendly method of ship dismantling However, the method is relatively more expensive than other methods to build and maintain drydock, so it is only found in some countries like- Harland, Wolff, Denmark.

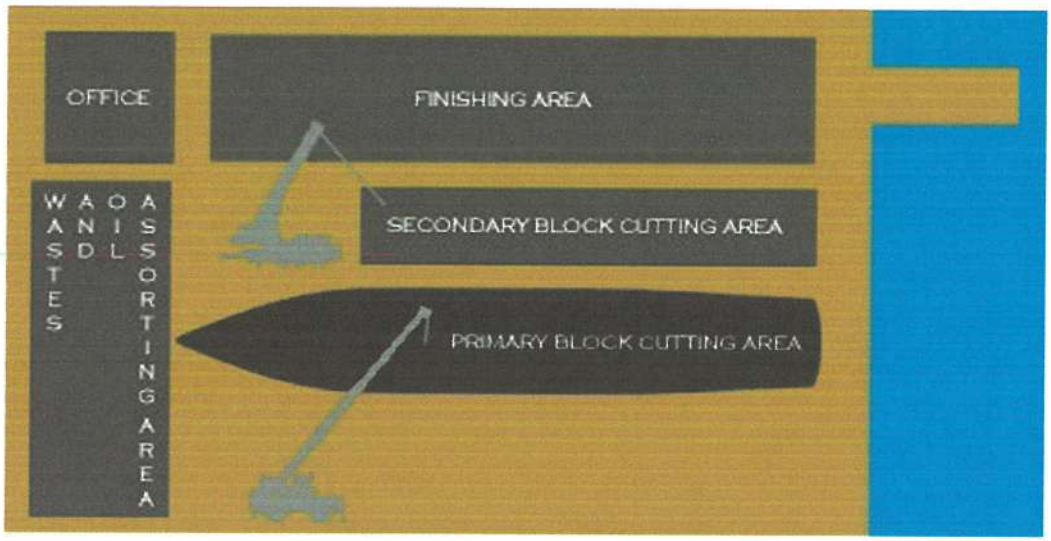


Figure 7 Dry-Dock Method

Source: Adopted and simplified from "Final Report on Ship Recycling in Korea according to The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships", Korea Coast Guard, 2009, p.104

4.1.3 Buoy/Alongside Method

This method is readily found in China, Kolkata port trust. The ship is anchored alongside in the jetty in waters at the wharf. Than boom is warped around the ship in order to take safety precaution. The pieces are taken apart from the top to bottom until only the double bottom is left. The process is called 'Top-down'. The workforce is also better trained, afforded greater protection and there is a higher degree of mechanization in the processes in comparison to the practices being followed in other ship breaking yards. The pieces broken are carried by cranes on the shore. The ship remains with the only double bottom is continued to break until either lifted out in one piece or sent to dry dock for final cutting. Since there is no tide, concentrations have less possibility to disperse and can be properly monitored and controlled and cleaned.

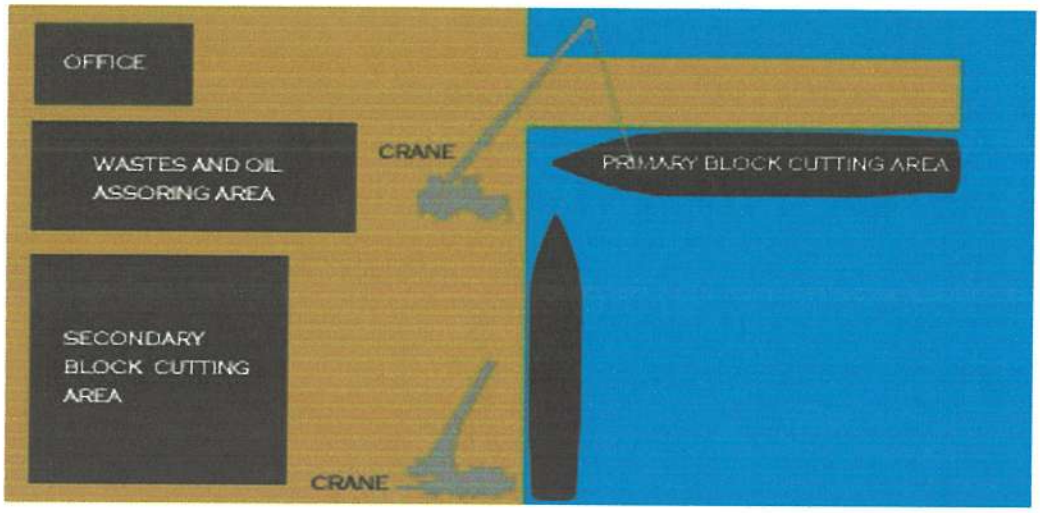


Figure 8 Buoy Method

Source: Adopted and simplified from "Final Report on Ship Recycling in Korea according to The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships", Korea Coast Guard, 2009, p.103

4.1.4 Slipway method

Slipway method is similar to the beaching method in the way that ships are stranded both on the land and the sea. A critical difference between them is that slipway recycling is typified by no tide, which enables to predict and control the contaminants by ships. Similar to the beaching method but without the help of tides. The ships are beached against the shore and then pulled with the use of a concrete slipway about 400-700 feet long. Turkey & a few locations in the UK and US. This method prevents accidental oil spillages preventing such materials to get mixed with sea water. The steel pieces are removed from the ship by mobile crane on the shore. As the ship becomes light, it is dragged up to the shore to continue further processes.

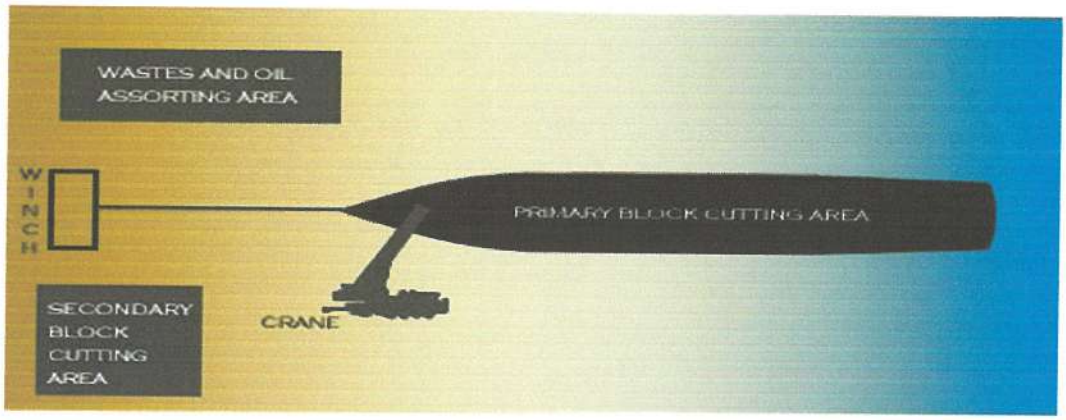


Figure 9 Slipway Method

Source: Adopted and simplified from "Final Report on Ship Recycling in Korea according to The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships", Korea Coast Guard, 2009, p.103

4.1.5 Reefing-

Reefing ships refers to the partial stripping of ships and removing of the majority of contaminants before sinking the ships at near-shore locations where they can serve as artificial reefs. These artificial reefs are beneficial because they stimulate fish populations by serving as a shelter and by providing a good surface for food sources to grow. In addition, artificial reefs are popular diving sites and can increase revenue and jobs. The downside to artificial reefing is that it is unnatural for these ships to be deposited into existing ocean ecosystems and the amount of space available for ship reefing is finite so this practice is unsustainable. Such a study could help to understand the environmental and economic impacts of decommissioning options including artificial reefing.

It is seen that in ship recycling general three methods are used beaching, Buoy and Dry dock Method. So in order to find the best available method for ship recycling, we have to compare this method by AHP.

4.2 Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making and may assist the decision maker to set priorities and make the best decision. By reducing complex decisions

to a small part of pairwise comparisons, and then generating the results, the AHP helps to capture both practical and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the conflict in the decision-making process.

In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from feasible measurement, or from practical opinions such as satisfaction feelings and preference. AHP allows checking the consistency. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value.

❖ Strengths of AHP:

In this AHP is broadly spread in distinctive fields like Engineering, Medicine and other sciences. The qualities incorporate

- It's usability
- It is an effortlessly reasonable system
- It disentangles a troublesome issue by separating it into little steps.
- It does not require authentic information sets.

The structure of AHP yields a simple route for a scholastic individual to take care of complex issues.

❖ Weaknesses:

AHP utilizations accurate qualities for judgments. i.e., in useful cases, the human emotions are obscure and the chiefs may be not able to fix the careful numerical qualities to the examination judgments.

❖ Steps for AHP-

Creating the hierarchy. Building the hierarchy is often the most challenging steps in the AHP. Creating the hierarchy requires an intuitive feel for the various factors and sub factors that directly influence the overall goal as well as an ability to identify alternatives suitable for accomplishing the goal. The hierarchy must be designed so that these alternatives are accurately evaluated on their ability to satisfy the overall goal. Both of these tasks require the DM to be extremely knowledgeable

and familiar with all facets of the problem. The hierarchy starts at the top by clearly stating the goal of the problem. Directly beneath this goal are the primary criteria to be considered when making the decision.

Using AHP to determine the relative importance of the criteria.

To evaluate the alternatives using AHP we most use the Fundamental Scale as shown in table 2. The usage of the above scales in a questionnaire is shown in Using AHP to determine the relative importance of the criteria. Using pairwise comparisons, the relative importance of one criterion over another was computed. A total number of pairwise comparisons were made to calculate the AHP's eigenvector values. Pairwise comparisons were also computed for the sub criteria to determine the relative importance of the sub-criteria relative to the criteria. After this, all alternative is ranked.

Table II AHP Fundamental Scales

Intensity of Importance	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one activity over another
5	Strong Importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent scale values	Compromise is needed between two levels

Reciprocals of above	If activity I has one of the above nonzero numbers assigned to it when compared to j, then j has the reciprocal value when compared with I	A reasonable assumption

4.3 Ranking for green ship recycling

As we know there are three main methods for the obsoleting vessel but in order to compare this method it is difficult as some have less pollution but handling capacity is small, some have large handling capacity but the weak policy for pollution and safety. So in order to compare such and various direct and indirect criteria we need the Analytic Hierarchy Process.

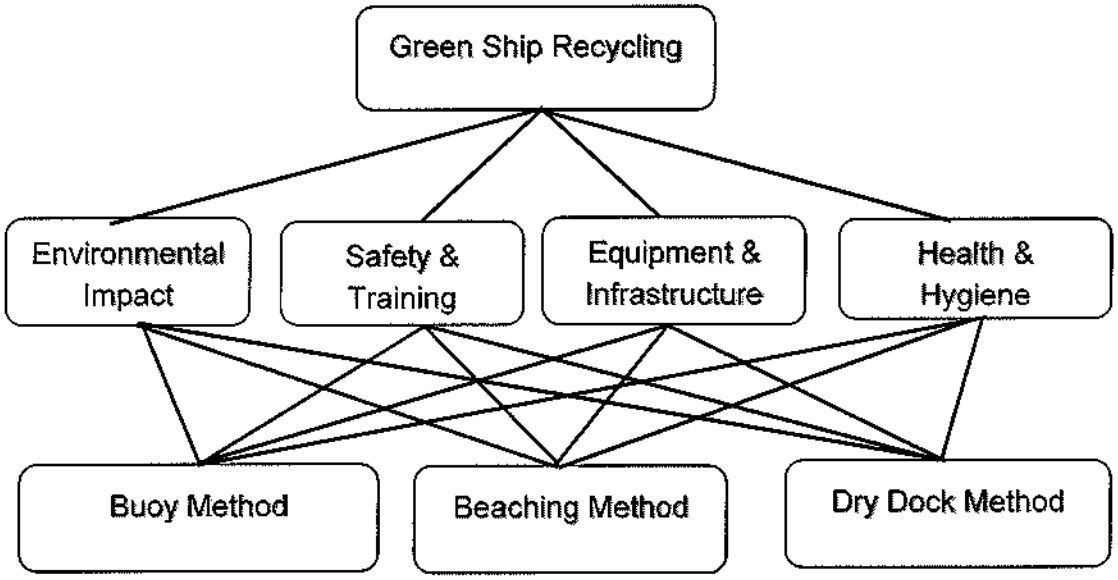


Figure 10 Analytic Hierarchy Process

In this direct result is shown in step the calculation of excel are shown in appendix-A

❖ STEP-1

Setting up Goal, Identify all the direct and indirect criteria and alternating process for the obsoleting vessel.

Goal- to identify the best method for the obsoleting ship.

Criteria- Theses are the main factor on which ship cutting depends, so here all the criteria are identified and there weighted are identified.

These are the following criteria which affect the ship recycling-

- Environment

This is a hot topic of IMO, most of the rules and regulation are implemented for reducing the impact of ship recycling on the environment and evolve ship recycling to green ship recycling.

- Health and hygiene

It is the health of human and marine are protected by either reducing hazardous material or reducing the exposure in hazardous material.

- Safety & Training

It is also the growing concern as many labours are killed during ship cutting due to lack of safety equipment and training.

- Equipment and infrastructure

These are the basic need for ship recycling as these are needed for breaking of the ship, handling material before disposal. These include (crane, office, storage yard).

Alternative process- there are only three processes which are chosen as an alternative as these are most dominant among others. Whereas others practiced by a small group.

❖ STEP-2

In this, we will find which is the most import criteria which are dominant and affect the selection. For this, we will set a Matrix of **n x n**.

n = Number of criteria affect the decision.

This matrix was formed after consulting with shipping expert, chief engineers, surveyor, ship recyclers. And the method was solved with reference to book Introduction to the analytic hierarchy process by Matteo Brunelli.

Where,

Finding dominat criteria for green ship recycling

A \ B	environment	health and hygiene	safety & training	equipment & infrastructure
environment	1.00	3.00	0.50	0.50
health and hygiene	0.33	1.00	0.33	0.50
safety & training	2.00	3.00	1.00	0.50
equipment & infrastructure	2.00	2.00	2.00	1.00
SUM	5.33	9.00	3.83	2.50

	upper triangle
	lower triangle
	digonal

Figure 11 Finding Dominant Criteria for Green Ship Recycling

This is the matrix which is generated in excel, in which **A** show row filled with criteria, **B** shows a column filled with criteria. In this triangle upper and lower is the inverse of each other.

Now in order to fill this matrix, we will use AHP fundamental scale mentioned in Table number-2. For example-

- ✓ A first row is an environment whereas in B first column is the environment, so in this, we see A and B is equal importance so the value is given is 1.
- ✓ Now we move further A's first-row environment and B's second column health & hygiene we see that is an environment which is moderately important and hence we will fill 3/1= 3
- ✓ In this way, we will fill this first row and rest left column.
- ✓ Now when we come to the second row that is health & hygiene and first row that is environment now the value is 1 and B value is 3 and hence we fill 1/3=0.33.

- ✓ In this way, we complete our matrix.

❖ STEP-3

As a result of step-2 criteria comparison matrix is prepared. In which we prepared a pairwise comparison. The matrix produced is given as

$$C=\begin{bmatrix} 1 & 3 & 0.5 & 0.5 \\ 0.33 & 1 & 0.33 & 0.5 \\ 2 & 3 & 1 & 0.5 \\ 2 & 2 & 2 & 1 \end{bmatrix}$$

❖ STEP-4

- ✓ We have to sum up the element of each column then we will normalize the matrix that means we will divide each element with the sum of their each column sum.
- ✓ Once we normalize the matrix we find each column sum becomes 1, now to find criteria weight we will take the average of each row.
- ✓ After this, the highest criteria weightage is ranked 1 as said to be the most dominant criteria.
- ✓ n = Number of criteria affect the decision.

NORMALIZE MATRIX

B / A	environment	health and hygiene	safety & training	equipment & infrastructure	CRITERIA WEIGHT {W}
environment	0.19	0.33	0.13	0.20	0.21
health and hygiene	0.06	0.11	0.09	0.20	0.12
safety & training	0.38	0.33	0.26	0.20	0.29
equipment & infrastructure	0.38	0.22	0.52	0.40	0.38
SUM	1.00	1.00	1.00	1.00	

Figure 12 Normalize Matrix

❖ STEP-5

Now we will check the consistency of the matrix, as human tendency can cause an error and it might be seen that due to his bias nature the result is affected so now checking the consistency.

The procedure for consistency matrix-

- Determining weight sum vector, $\mathbf{W_S}$ –

$$\{\mathbf{Ws}\} = [\mathrm{C}]\{\mathrm{W}\}$$

$$= \begin{bmatrix} 1 & 3 & 0.5 & 0.5 \\ 0.33 & 1 & 0.33 & 0.5 \\ 2 & 3 & 1 & 0.5 \\ 2 & 2 & 2 & 1 \end{bmatrix} \begin{Bmatrix} 0.21 \\ 0.12 \\ 0.29 \\ 0.38 \end{Bmatrix}$$

$$W_S = \begin{Bmatrix} 0.91 \\ 0.48 \\ 1.26 \\ 1.62 \end{Bmatrix}$$

- To find consistency vector-

Dot product= {Ws} .$\{\frac{1}{W}\}$

$$= \begin{Bmatrix} 4.31 \\ 3.97 \\ 4.34 \\ 4.26 \end{Bmatrix}$$

- To determine λ, we take the average of consistency vector

Therefore, λ= 4.22

- Now, calculating consistency Index-

$$CI = \frac{(\lambda - n)}{(n-1)}$$

Therefore,
CI= 0.074144293

- Random index for n=4, Is 0.90.

Therefore,
Consistency ratio (CR)

$$CR = {}^{CI}/_{RI}$$

As per the rule of consistency ratio,

CR< 0.1, the ranking is consistent.
CR=>0.1, the comparisons should be recalculated.

As per my result, **CR=0.08238.** Hence, the most dominating character is equipment and infrastructure.

❖ STEP-6

✓ Now we form a new matrix taking our alternative as an option and we will analyze for one criterion that is the environment.

✓ Now we will again from a **C** matrix then normalize it but this time sum weight is called alternative priorities and check the consistency and will repeat the process for 3 other criteria (health & hygiene, safety & training, equipment, and infrastructure)

Priorities of different matrix-

- For environment criteria-

$$\begin{pmatrix} 0.08 \\ 0.20 \\ 0.72 \end{pmatrix}$$

- For Health and hygiene-

$$\begin{pmatrix} 0.11 \\ 0.26 \\ 0.63 \end{pmatrix}$$

- For safety and training-

$$\begin{pmatrix} 0.33 \\ 0.33 \\ 0.33 \end{pmatrix}$$

- For equipment and infrastructure-

$$\begin{pmatrix} 0.11 \\ 0.26 \\ 0.63 \end{pmatrix}$$

❖ STEP-7

Selection matrix-

Now with the help of priorities matrix of all four criteria and alternative, we will generate a selection matrix.

	BEACHING METHOD	BUOY	DRY DOCK
	0.08	0.20	0.72
environment			
health and hygiene	0.11	0.26	0.63
safety & training	0.33	0.33	0.33
equipment & infrastructure	0.11	0.26	0.63

❖ STEP-8

Final rate matrix-

Now, taking the transpose of selection matrix and multiplying with weighted sum

	environment	health and hygiene	safety & training	equipment & infrastructure
BEACHING METHOD	0.08	0.11	0.33	0.11
BUOY	0.20	0.26	0.33	0.26
DRY DOCK	0.72	0.63	0.33	0.63

Weighted sum matrix of the criteria which shows weightage on selection-

weighted sum
0.23
0.10
0.30
0.33

Multiplying this matrix we get a final rate matrix

Method	weight
BEACHING METHOD	0.1675
BUOY	0.2677
DRY DOCK	0.5619

Now, the most weighted method is ranked high as to a result

Table III Final Rate and Rank

Final Rate Matrix		
method	weight	Rank
BEACHING METHOD	0.1911	3
BUOY	0.3426	2
DRY DOCK	0.7401	1

- STEP-9

Result-

Hence, for green ship recycling and criteria for selection, we come to the conclusion that DRY DOCK is the best method for ship recycling.

CHAPTER-5

INVENTORY OF HAZARDOUS MATERIAL

5.1 Inventory Of Hazardous Material (IHM)

An IHM is a document made mandatory by IMO in 2015 for all existing and new vessel. In this, all potentially hazardous material or hazardous material present on a vessel that can pose a risk to health and safety of the human or to the environment is located, identified and quantified.

Table IV Estimated Quantity of Hazardous and Non- Hazardous Waste Generated Per 350 Ships During 2001-2002

Description of waste	Quantity in tonnes per 350 ships per year	Category Hazardous (H) or Non-Hazardous (NH) waste
Asbestos-containing waste	175	H
Glass-wool and Thermocol	2,000-3,000	H
Sludge residues and contaminated materials	400	H
Plastics and cable pieces (with paint chips)	20	H
Rubber	49	NH
Fibre glass pieces	40	NH
Rexene pieces	50	NH
Iron Scale	900	H
Chicken mess	175	NH
Cardboard and packaging materials	35	NH
Glass pieces	175	NH
Municipal solid waste	5,000	NH
Cement tile pieces	10,000	NH
Bilgewater	10,500 kilolitres	H

5.2 Objective

The objectives of the Inventory are to provide specific information on the actual hazardous materials present on a vessel, in order to protect health and safety and to prevent environmental pollution at ship recycling facilities. This data shared by the ship owner will be used by the ship recycling facilities to decide how to manage the types and amounts of hazardous materials identified in the Inventory of Hazardous Materials.

5.3 INVENTORY LIST

Following information about hazardous and non-hazardous material present on a ship are shared which are to be listed in IHM-

- Each item in as per the guidelines is classified under tables 5, 6, 7 and 8, according to its properties.
- ✓ table 5 comprises the materials listed in table A of appendix 1 of the IMO IHM Convention.
- ✓ table 6 comprises the materials listed in table B of appendix 2 of the IMO IHM Convention.
- ✓ table 7 comprises goods which are not integral to a ship and are unlikely to be dismantled or treated at a ship recycling facility.
- ✓ table 8 goods which are potentially hazardous to the environment and human health at ship recycling facilities are mentions in the table.
- Tables 5 and 6 correspond to the part I of the Inventory that is hazardous which is present in ship structure. Table 8 corresponds to parts II and III which are at the storage of the ship and table 7 corresponds to part III of IMO IHM convention.

- For loosely fitted equipment, there is no need to list this in part I of the Inventory. Some equipment which remains on the ship is recycled should be listed in part III on IMO IHM Convention

- The batteries which contain lead-acid or other potentially hazardous or hazardous materials that are fixed in place should be listed in part I of the Ihm. Batteries which are fitted such as consumer batteries and batteries in store should be listed in part III of the IHM list.

- Exemptions – Materials which are not to be listed in the IHM

Materials listed in Table 6 that are inherent in solid metals or metal alloys, like steels, aluminum, brasses, bronzes, plating which are used in general construction, like hull, super-structure, pipes for equipment and machinery, are exempted from IHM.

- Revision to threshold values-

Revised threshold values in tables 5 and 6 should be used for Inventory development or updated after the approval of the revised values and not to be applied to the existing Inventory list and also in under developing inventory list. However, when materials are added to the list, like maintenance, the revised threshold values should be applied and recorded in the Inventory list.

Table V The Materials Listed In Table A of Appendix 1 of The IMO IHM Convention

No.	MATERIAL		Inventory			Threshold value
			Part I	Part II	Part III	
A-1	Asbestos		x			0.1%[4]
A-2	Polychlorinated biphenyls (PCBs)		x			50 mg/kg[5]
A-3	Ozone depleting substances	CFCs	x			no threshold value [6]
		Halons	x			
		Other fully halogenated CFCs	x			
		Carbon tetrachloride	x			
		1,1,1-Trichloroethane (Methyl chloroform)	x			
		Hydrochlorofluorocarbons	x			
		Hydrobromofluorocarbons	x			
		Methyl bromide	x			
		Bromochloromethane	x			
A-4	Anti-fouling systems containing organotin compounds as a biocide		x			2,500 mg total tin/kg[7]

Table VI The Materials Listed In Table B of Appendix 2 of The IMO IHM Convention

No.	Material	Inventory			Threshold value
		Part I	Part II	Part III	
B-1	Cadmium and cadmium compounds	x			100 mg/kg[8]
B-2	Hexavalent chromium and hexavalent chromium compounds	x			1,000 mg/kg[8]
B-3	Lead and lead compounds	x			1,000 mg/kg[8]
B-4	Mercury and mercury compounds	x			1,000 mg/kg[8]
B-5	Polybrominated biphenyl (PBBs)	x			50 mg/kg[9]
B-6	Polybrominated diphenyl ethers (PBDEs)	x			1,000 mg/kg[8]
B-7	Polychlorinated naphthalenes (more than 3 chlorine atoms)	x			50mg/kg[10]
B-8	Radioactive substances	x			no threshold value[11]
B-9	Certain shortchain chlorinated paraffin (Alkanes, C10-C13, chloro)	x			1%[12]

Table VII Regular Consumable Goods Potentially Containing Hazardous Materials

No.	Properties	Example	Inventory		
			Part I	Part II	Part III
D-1	Electrical and electronic equipment	Computers, refrigerators, printers, scanners, television sets, radio sets, video cameras, video recorders, telephones, consumer batteries, fluorescent lamps, filament bulbs, lamps			x
D-2	Lighting equipment	Fluorescent lamps, filament bulbs, lamps			x

D-3	Non ship-specific furniture, interior and similar equipment	Chairs, sofas, tables, beds, curtains, carpets, garbage bins, bed-linen, pillows, towels, mattresses, storage racks, decoration, bathroom installations, toys, not structurally relevant or integrated artwork			x

Table VIII Potentially Hazardous Items

No.	Properties		Goods	Inventory		
				Part I	Part II	Part III
C-1	Liquid	Oiliness	Kerosene			x
C-2			White spirit			x
C-3			Lubricating oil			x
C-4			Hydraulic oil			x
C-5			Anti-seize compounds			x
C-6			Fuel additive			x
C-7			Engine coolant additives			x
C-8			Antifreeze fluids			x
C-9			Boiler and feed water treatment and test reagents			x
C-10			De-ioniser regenerating chemicals			x
C-11			Evaporator dosing and descaling acids			x
C-12			Paint stabilizers/rust stabilizers			x
C-13			Solvents/thinners			x
C-14			Paints			x
C-15			Chemical refrigerants			x
C-16			Battery electrolyte			x
C-17			Alcohol, methylated spirits			x
C-18	Gas	Explosives/ inflammables	Acetylene			x
C-19			Propane			x
C-20			Butane			x
C-21			Oxygen			x

No.	Properties		Goods	Inventory		
				Part I	Part II	Part III
C-22		Green House Gases	CO_2			x
C-23			Perfluorocarbons (PFCs)			x
C-24			Methane			x
C-25			Hydrofluorocarbon (HFCs)			x
C-27			Nitrous oxide (N_2O)			x
C-28			Sulfur hexafluoride (SF_6)			x
C-29	Liquid	Oiliness	Bunkers: fuel oil			x
C-30			Grease			x
C-31			Waste oil (sludge)		x	
C-32			Bilge and/or waste water generated by the after-treatment systems fitted on machinery		x	
C-33			Oily liquid cargo tank residues		x	
C-34			Ballast water		x	
C-35			Raw sewage		x	
C-36			Treated sewage		x	
C-37			Non-oily liquid cargo residues		x	
C-38	Gas	Explosibility/ inflammability	Fuel gas			x
C-39			Dry cargo residues		x	
C-40			Medical waste/infectious waste		x	
C-41			Incinerator ash[13]		x	
C-42			Garbage		x	
C-43			Fuel tank residues		x	

No.	Properties	Goods	Inventory		
			Part I	Part II	Part III
C-44		Oily solid cargo tank residues		x	
C-45		Oily or chemical contaminated rags		x	
C-46		Batteries (incl. lead-acid batteries)			x
C-47		Pesticides/insecticide sprays			x
C-48		Chemical cleaner (incl. electrical equipment cleaner, carbon remover)			
C-49		Detergent/bleacher (could be a liquid)			
C-50		Miscellaneous medicines			
C-51		Fire clothing and Personal protective equipment			
C-52		Dry tank residues			
C-53		Cargo residues			
C-54		Spare parts which contain materials listed in Table A or Table B			
C-55		Chemical cleaner (incl. electrical equipment cleaner, carbon remover)			

No.	Properties	Goods	Inventory		
			Part I	Part II	Part III
C-39	solid	Dry cargo residues		x	
C-40		Medical waste/infectious waste		x	
C-41		Incinerator ash[13]		x	
C-42		Garbage		x	
C-43		Fuel tank residues		x	

No.	Properties	Goods	Inventory		
			Part I	Part II	Part III
C-44		Oily solid cargo tank residues		x	
C-45		Oily or chemical contaminated rags		x	
C-46		Batteries (incl. lead-acid batteries)			x
C-47		Pesticides/insecticide sprays			x
C-48		Extinguishers			x
C-49		Chemical cleaner (incl. electrical equipment cleaner, carbon remover)			x
C-50		Detergent/bleacher (could be a liquid)			x
C-51		Miscellaneous medicines			x
C-52		Fire fighting clothing and Personal protective equipment			x
C-53		Dry tank residues		x	
C-54		Cargo residues		x	
C-55		Spare parts which contain materials listed in Table A or Table B			x

5.4 How to prepare IHM?

5.4.1 Development of part I of the Inventory for new ships

Part I of the IHM convention for new ships should be developed at the design and construction stage.

- Checking of materials listed in table A of appendix-1 of IHM convention

During the development of the IHM (part I), the listed materials of table A of appendix 1 of IHM should be checked and confirmed, the quantity and location of table A materials should be listed in part I of the IHM. If such materials are used in with the Convention, they should be listed in part I of the IHM list. Any spare parts

containing listed material of table A are required to be listed in part III of the IHM list.

- Checking of materials listed in table B of appendix-2 of IHM convention

If materials listed in table B of appendix 1 of IHM are present in products above the threshold values provided in table B, the quantity and location of the products and the contents of the materials present in them should be listed in part I of the IHM list. Any spare parts containing materials listed in table B of Inventory are required to be listed in part III of the IHM.

- Process for checking of materials

The checking of materials as provided above should be based on the Material Declaration given by the suppliers in the shipbuilding supply chain (like equipment suppliers, parts suppliers, material suppliers).

5.4.2 Development of part I of the Inventory for existing ships

In order to achieve comparable results for existing ships with respect to the part I of the Inventory, the following procedure should be followed:

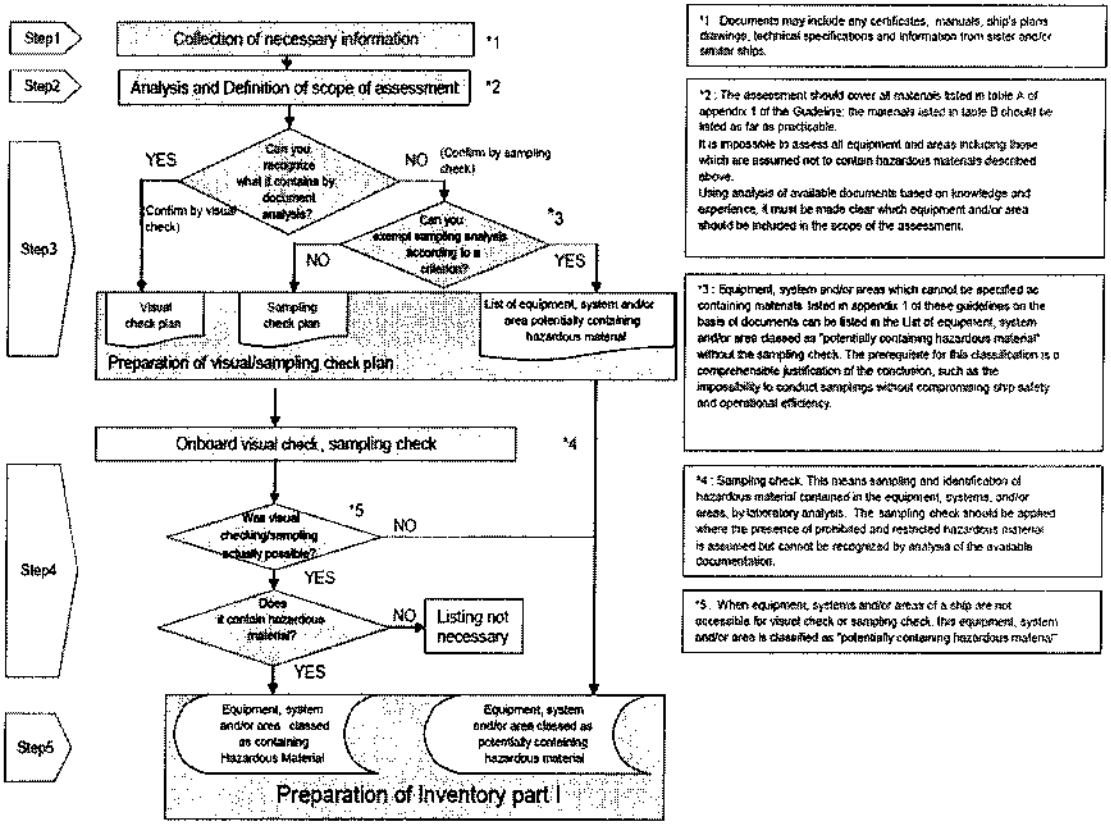


Figure 13 Flow Diagram for Developing Part I of the Inventory for Existing Ships

Source- ANNEX 17, RESOLUTION MEPC.269(68),(adopted on 15 May 2015) IHM convention, appendix-4.

1 collection of necessary information;

The ship-owner should identify, research, request and procure all reasonably available documentation regarding the ship. Data that will be useful should be taken from sister ships. Main sources of these data could be found from previous surveys, classification society records and ship recycling facilities who have experience working with similar ships

2 assessment of collected information;

The information collected in step 1 above should be assessed. The assessment should cover all materials listed in table A of appendix 1 of IHM, materials listed in table B should be assessed. The results of the assessment should be reflected in the check plan.

3 preparation of visual/sampling check plan-

- To specify the materials listed in appendix 1 of IHM, a visual/sampling check plan should be prepared taking in the to the guideline of the collected information and expertise. The check plan should be based on the following lists:

✓ List of equipment, system, an area for visual check should be entered in the List as per IHM rule.

✓ List of equipment, system, and area for sampling check. In this, a sampling check is done by taking of samples to identify the presence or absence of hazardous material contained in the equipment, systems, and/or areas, by suitable and generally accepted methods such as laboratory analysis as it is difficult to identify without these process.

✓ List of equipment, system and/or area classed as "potentially containing hazardous material" any equipment, system, and the area which cannot be specified as hazardous material can be directly put in potentially containing hazardous material without the sampling check.

- Visual/sampling checkpoints should be all points where:

✓ The presence of materials to be considered for the IHM list.

✓ The documentation is not specific.

✓ Materials of uncertain composition were used.

4 onboard visual check and sampling check

✓ The visual/sampling on a vessel check should be carried out in accordance with the visual/sampling check plan. When a sampling check is carried out, samples should be taken and the sample's origin area should be clearly marked on the ship plan and the same type of area should check to ensure that they are of the same kind. Then sampling check should be carried under expert assistance.

✓ Any doubt regarding the presence of hazardous materials should be clarified by a visual/sampling check. Checkpoints should be marked in the ship's plan.

- ✓ If the equipment, system and/or area of the ship is not accessible for a visual check or sampling check, they should be classified as potentially containing hazardous material.

5 preparation of part I of the Inventory and related documentation.

- ✓ If any equipment, system and/or area is classed as either "hazardous material" or "potentially hazardous material", their approximate quantity and location should be listed in part I of the IHM. These two categories should be indicated separately in the "Remarks" column of the Inventory.
- ✓ The procedures described in this section should be carried out by the ship owner, who may draw upon expert assistance.

EXAMPLE-

Example of the development process for the part I of the inventory for existing ships

INTRODUCTION

In order to develop part, I of the IHM for existing ships, documents of the individual ship as well as the knowledge and experience of marine is required. An example of the development process for Part I of the Inventory of Hazardous Materials for existing ships is useful to understand the basic steps as laid out in the guidelines and to ensure a unified application. However, attention should be paid to variations in different types of ships.

Compilation of part I of the Inventory of Hazardous Material for existing ships involves the following five steps –

Step 1: Collection of necessary information-

- ❖ Sighting of available documents

the first step is to collect detailed of the ship. The shipowner should try to collate documents normally retained on board the ship or by the shipping company as well as relevant documents that the shipyard, manufacturers, or classification society may have. The following documents should be used when available:

- ✓ Ship's specification
- ✓ General Arrangement

- ✓ Machinery Arrangement
- ✓ Spare Parts and Tools List
- ✓ Piping Arrangement
- ✓ Accommodation Plan
- ✓ Fire Control Plan
- ✓ Fire Protection Plan
- ✓ Insulation Plan (Hull and Machinery)
- ✓ International Anti-Fouling System Certificate
- ✓ Related manuals and drawings

If the ship has undergone conversions or major repair work, it is necessary to identify as far as possible the modifications from the initial design and specification of the ship.

- ❖ Indicative list

It is difficult to check all equipment, systems, areas to determine the presence or absence of hazardous materials. The total number of parts on a ship may be in several thousand. In order to take a practical approach, an indicative list should be prepared that identifies the equipment that may contain hazardous materials. Field interviews with the experts and suppliers may be necessary to prepare such lists. A typical example of an indicative list is shown below.

Materials to be checked and documented

Hazardous Materials, as identified in Appendix 1 of these IHM guidelines, should be listed in part I of the Inventory for existing ships. Appendix 1 of the IHM guidelines contain all the materials concerned. Table A shows those which are required to be listed and table B shows those which should be listed as far as practicable.

Materials listed in table A

Table A lists the following four materials:

1 Asbestos

Field interviews were conducted with over 200 Japanese experts and suppliers regarding the use of asbestos in production. Indicative lists for asbestos developed on the basis of this research are shown below-

Table IX Indicative List for Asbestos

Structure and/or equipment	**Component**
Propeller shafting	Packing with low-pressure hydraulic piping flange
	Packing with casing
	Clutch
	Brake lining
	Synthetic stern tubes
Diesel engine	Packing with piping flange
	Lagging material for fuel pipe
	Lagging material for exhaust pipe
	Lagging material turbocharger
Turbine engine	Lagging material for casing
	Packing with the flange of piping and valve for steam line, exhaust line and drain line
	Lagging material for piping and valve of steam line, exhaust line and drain line

Structure and/or equipment	Component
Boiler	Insulation in the combustion chamber
	Packing for casing door
	Lagging material for exhaust pipe
	Gasket for manhole
	Gasket for hand hole
	Gas shield packing for soot blower and another hole
	Packing with the flange of piping and valve for steam line, exhaust line, fuel line, and drain line
	Lagging material for piping and valve of steam line, exhaust line, fuel line, and drain line
Exhaust gas economizer	Packing for casing door
	Packing with manhole
	Packing with hand hole
	Gas shield packing for soot blower

Structure and/or equipment	Component
	Packing with the flange of piping and valve for steam line, exhaust line, fuel line, and drain line
	Lagging material for piping and valve of steam line, exhaust line, fuel line, and drain line
Incinerator	Packing for casing door
	Packing with manhole
	Packing with hand hole
	Lagging material for exhaust pipe
Auxiliary machinery (pump, compressor, oil purifier, crane)	Packing for casing door and valve
	Gland Packing
	Brake lining
Heat exchanger	Packing with casing
	Gland packing for valve
	Lagging material and insulation
Valve	Gland packing with valve, sheet packing with piping flange
	Gasket with the flange of high pressure and/or high temperature
Pipe, duct	Lagging material and insulation
Tank (fuel tank, hot water, tank, condenser), other equipment (fuel strainer, lubricant oil strainer)	Lagging material and insulation
Electric equipment	Insulation material
Airborne asbestos	Wall, ceiling
Ceiling, floor, and wall in the accommodation area	Ceiling, floor, wall
Fire door	Packing, construction, and insulation of the fire door
Inert gas system	Packing for the casing, etc.
Air-conditioning system	Sheet packing, lagging material for piping and flexible joint
Miscellaneous	Ropes

Structure and/or equipment	Component
	Thermal insulating materials
	Fire shields/fire proofing
	Space/duct insulation
	Electrical cable materials
	Brake linings
	Floor tiles/deck underlay
	Steam/water/vent flange gaskets
	Adhesives/mastics/fillers
	Sound Damping
	Molded plastic products
	Sealing putty
	Shaft/valve packing
	Electrical bulkhead penetration packing
	Circuit breaker arc chutes
	Pipe hanger inserts
	Weld shop protectors/burn covers
	Fire-fighting blankets/clothing/equipment
	Concrete ballast

2 Polychlorinated biphenyls (PCBs)

The indicative list of PCBs has been developed as shown below-

Table X indicative list for PCB

Equipment	**Component of equipment**
Transformer	Insulating oil
Condenser	Insulating oil
Fuel heater	Heating medium
Electric cable	Covering, insulating tape
Lubricating oil	

Heat oil	Thermometers, sensors, indicators
Rubber/felt gaskets	
Rubber hose	
Plastic foam insulation	
Thermal insulating materials	
Voltage regulators	
Switches/reclosers/bushings	
Electromagnets	
Adhesives/tapes	
Surface contamination of machinery	
Oil-based paint	
Caulking	
Rubber isolation mounts	
Pipe hangers	
Light ballasts (component within fluorescent light fixtures)	
Plasticizers	
Felt under septum plates on top of the hull bottom	

Similarly the list of ozone-depleting substance, antifouling paint is prepared.

Step 2: Assessment of collected information-

Preparation of a checklist is the right method for developing the Inventory for existing ships in order to clarify the results of each step, Based on collected information including the indicative list mentioned in step 1, all equipment, systems, and areas on a vessel assumed to contain hazardous materials listed in tables A and B should be included in the checklist. Each listed equipment, system, and area on a vessel should be analyzed and checked for its hazardous materials content.

The existence and volume of hazardous materials may be judged and calculated from the Spare parts and tools list and the maker's drawings. The existence of asbestos contained in floors, ceilings and walls may be identified from Fire Protection Plans, while the existence of TBT in coatings can be identified from the

International Anti-Fouling System Certificate, Coating scheme and the History of Paint

Table XI Example of Weight Calculation

No.	Hazardous Materials	Location/equipment/ component	Reference	Calculation
1.1-2	TBT	Flat bottom/paint	History of coatings	
1.2-1	Asbestos	Main engine/ exh. pipe packing	Spare parts and tools list	250 g x 14 sheet = 3.50 kg
1.2-3	HCFC	Ref. provision plant	Maker's drawings	20 kg x 1 cylinder = 20 kg
1.2-4	Lead	Batteries	Maker's drawings	6kg x 16 unit = 96 kg
1.3-1	Asbestos	Engine-room ceiling	Accommodation plan	

When a component or coating is determined to contain hazardous materials, a "Y" should be entered in the column for "Result of document analysis" in the checklist, to denote "Contained". Likewise, when an item is determined not to contain Hazardous Materials, the entry "N" should be made in the column to denote "Not contained". When a decision cannot be made about the hazardous materials content, the column should be completed with the entry "Unknown"

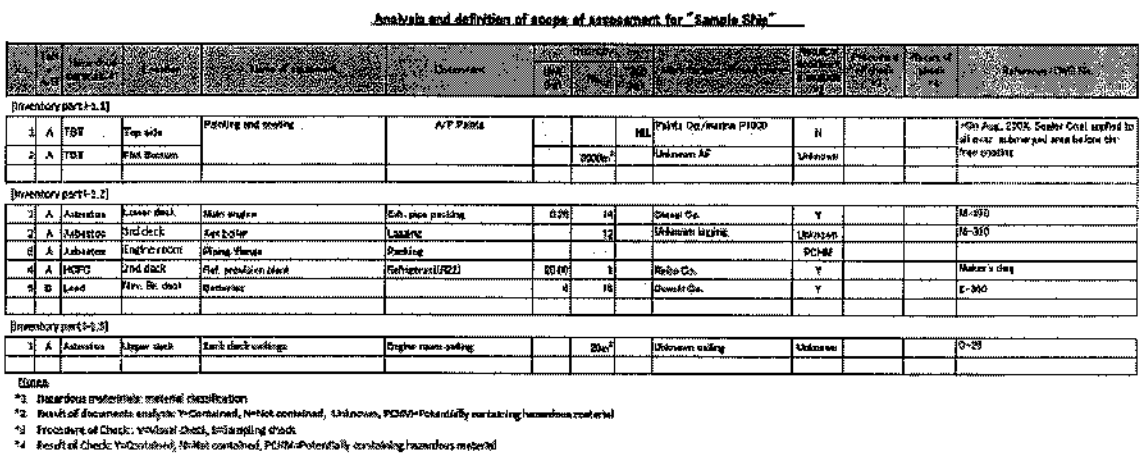

Analysis and definition of scope of assessment for "Sample Ship"

Figure 14 Checklist of a Sample Ship for Step-2

Source- ANNEX 17, RESOLUTION MEPC.269(68),(adopted on 15 May 2015)
IHM convention, appendix-5, step-2

Step 3 Preparation of visual/sampling check plan-

Each item classified as "Contained" or "Not contained" in step 2 should be subjected to a visual check on board, and the entry "V" should be made in the "Check procedure" column to denote "Visual check".

For each item categorized as "unknown", a decision should be made as to whether to classed as "potentially containing hazardous material" provided comprehensive justification is given, or if it can be conveyed that there will be little or no effect on disassembly as a unit and later ship recycling and disposal operations. The costs of this check are significantly higher than the later disposal costs at a ship recycling facility.

Before any visual/sampling check on board is conducted, a "visual/sampling check plan" should be prepared.

To prevent any incidents during the check, a schedule should be made to eliminate clashes with other ongoing work on the ship. To prevent exposure to Hazardous Materials during the check, safety precautions should be kept. For example, sampling of potential asbestos containing materials could release fibers into the atmosphere. Therefore, appropriate personnel safety procedures should be done.

Items listed in the check should be arranged in sequence so that the check is conducted in a structured manner from a lower level to an upper level and from a fore part to an aft part.

Analysis and definition of scope of assessment for "Sample Ship"

[illegible]	[illegible]	[illegible] *1	[illegible]	Name of equipment	Components	Quantity: Unit	[illegible]	[illegible]	[illegible]	[illegible] *2	[illegible] *3	[illegible] *4	Reference DWG No.
[Inventory part I-1.1]													
1	A	TBT	Top side	Painting & Coating	A/F Paints			NIL	Paints Co./marine P900	N	V		*On Aug. 200X Sealer Coat applied to all over submerged area before the final coating.
2	A	TBT	Flat bottom				3000m²		Unknown AF	Unknown	S		
[Inventory Part I-1.2]													
1	A	Asbestos	Lower deck	Main engine	Exh. pipe packing	0.25	54		Diesel Co.	Y	V		M-100
2	A	Asbestos	3rd deck	Aux.boiler	Lagging		58		Unknown lagging	Unknown	S		M-300
3	A	Asbestos	Engine room	Pipe/flange	Packing					PCHM	V		
4	A	HCFC	2nd deck	Ref. provision plant	Refrigerant(R22)	2020	1		Reiko Co.	Y	V		Maker's dwg
5	B	Lead	Nav. Br. deck	Batteries		6	14		Denchi Co.	Y	V		E-300
[Inventory Part I-1.3]													
1	A	Asbestos	Upper deck	Back deck ceilings	Engine room ceiling		20m²		Unknown ceiling	Unknown	S		G-23

Notes

*1 Hazardous materials: material classification

*2 Result of documents analysis: Y=Contained, N=Not contained, Unknown, PCHM=Potentially containing hazardous material

*3 Procedure of check: V=Visual check, S=Sampling check

*4 Result of check: Y=Contained, N=Not contained, PCHM=Potentially containing hazardous material

Figure 15 Checklist of Sample Ship for Step-3.

Source- ANNEX 17, RESOLUTION MEPC.269(68),(adopted on 15 May 2015) IHM convention, appendix-5, step-3

Step 4 Onboard visual/sampling check-

The visual/sampling check should be conducted according to the plan. Checkpoints should be marked in the ship's plan or recorded with photographs.

Human taking samples should be protected by the proper safety equipment relevant to the suspected type of hazardous materials encountered. Appropriate safety precautions should also be in place for passengers, crew members, and other persons.

The results of checks should be recorded in the plan and checklist. Any equipment, systems and/or areas of the ship that cannot be accessed for checks should be classified as "potentially containing hazardous material". In this case, the entry in the "Result of check" column should be "PCHM".

Step 5: Preparation of part I of the Inventory and related documentation.

- ✓ Development of part I of the Inventory

The results of the check and the estimated quantity of hazardous materials should be recorded on the checklist. Part I of the Inventory should be developed with reference to the checklist.

✓ Development of location diagram of hazardous materials

With respect to the part I of the Inventory, the development of a location diagram of hazardous materials is recommended in order to help the ship recycling facility gain a visual understanding of the Inventory.

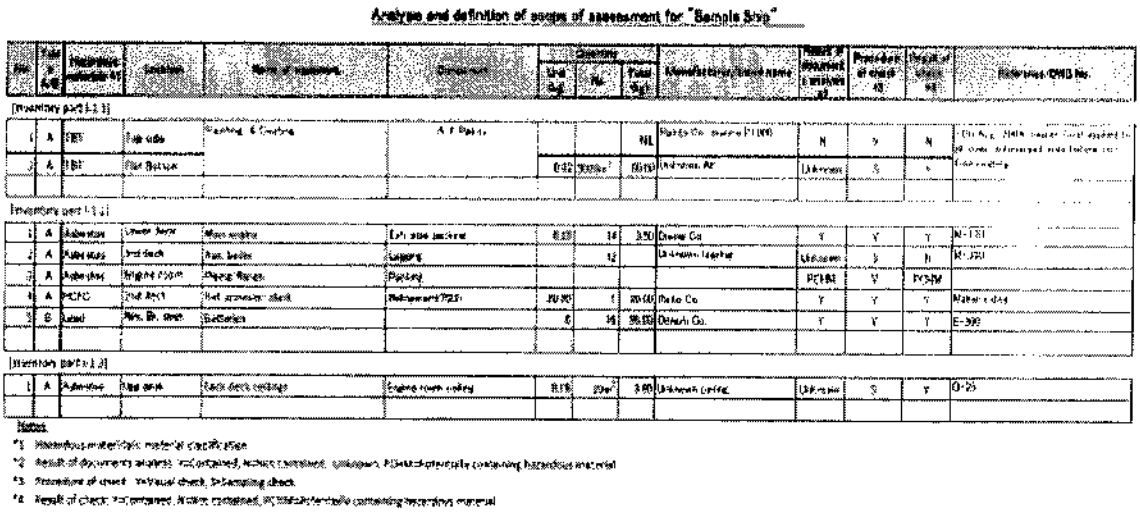


Figure 16 Checklist of Sample Ship for Step-5.

Source- ANNEX 17, RESOLUTION MEPC.269(68),(adopted on 15 May 2015) IHM convention, appendix-5, step-5.

Example of the Inventory for existing ships

Inventory of Hazardous Materials for "Sample Ship"

Particulars of the "Sample Ship"

Distinctive number or letters	XXXXNNN
Port of registry	Port of World
Type of vessel	Bulk carrier
Gross Tonnage	28,000 GT
IMO number	NNNNNNN
Name of shipbuilder	xx Shipbuilding Co. Ltd
Name of shipowner	yy Maritime SA
Date of delivery	MM/DD/1988

This inventory was developed in accordance with the guidelines for the development of the Inventory of Hazardous Materials.

Attachment:

1: Inventory of Hazardous Materials

2: Assessment of collected information

3: Location diagram of Hazardous Materials

Prepared by XYZ (Name & address) (dd/mm/20XX)

Figure 17 Sample Ship for Inventory of Existing Ship

Source- ANNEX 17, RESOLUTION MEPC.269(68),(adopted on 15 May 2015) IHM convention, appendix-5, step-5.

Sample table for an inventory of existing sample ship is given-

- ❖ Inventory of Hazardous Materials: "Sample Ship"

  - ✓ Part I – hazardous materials contained in the ship's structure and equipment

Table XII Paints and Coating Systems Containing Materials Listed In Table A and Table B of Appendix 1 Of The Guidelines

No.	Application of paint	Name of paint	Location*	Materials (classification in appendix 1)	Approximate quantity		Remarks
1	AF paint	Unknown paints	Flat bottom	TBT		kg	Confirmed by sampling

Table XIII Equipment and Machinery Containing Materials Listed In Table A And Table B of Appendix 1 of The Guidelines

No.	Name of equipment and machinery	Location *1	Materials (classification in appendix 1)	Parts where used	Approximate quantity		Remarks
1	Main engine	Lower floor	Asbestos	Exh. pipe packing	3.60	kg	
2	Aux. boiler	3rd deck	Asbestos	Unknown packing	11.00	kg	PCHM (potentially containing

							Hazardous Material)
3	Piping/flange	Engine-room	Asbestos	Packing	55.00	kg	PCHM
4	Ref. provision plant	3rd deck	HCFC	Refrigerant (R22)	10.00	kg	
5	Batteries	Bridge deck	Lead		97.00	kg	

Table XIV Structure and Hull Containing Materials Listed In Table A and Table B Of Appendix 1 Of The Guideline

No.	**Name of the structural element**	**Location *1**	**Materials (classification in appendix 1)**	**Parts where used**	**Approximate quantity**		**Remarks**
1	Back deck ceiling	Upper deck	Asbestos	Engine-room ceiling(A class)	3.80	kg	Confirmed by sampling

Each item should be entered in order based on its location, from a lower level to an upper level and from a fore part to an aft part.

5.5 Guideline & Standards for Ship Recycling-

- ISO 31000

ISO 31000 deal with the risk management which is applicable to all organization, regardless of types, activity and location and cover all types of risk.

It is applicable to all organization and to a wide range activity like process, function, operation, services and strategies.

Framework-

This frame work ensure that information about derived from this is used as a basis for decision making at all organizational level.

This is divided into 4 parts-

- Design of framework for managing risk
  - Understanding of the company structure
  - Establishing risk management policy
  - accontability
  - Integrating with company processes
  - Resources
  - Establishing communication and reporting mechanisms
- Implementing risk management
  - Implementing the framework
  - Implementing the risk management process
- Monitoring and review
- Continual improvement

Risk management process-

This process is a inter link between risk monitoring, communication and consulting, risk assessment (risk identification, risk analysis, risk evaluation) and risk treatment.

Now according to this frame work, the frame work was design for ship Recycling yard.

- For design of framework-

  STEP-1 In this all the external and internal causes are evaluated which directly affect the objective of the organization. Such as policy, cost, time, competitiveness.

  Step-2 all the guideline and standards such as IMO convention are adopted for reaching their goal

  STEP-3 risk management policy is set according as per rule the link between ship recycling, objective green ship recycling and risk management is set, and resources are made available like for green ship recycling we need to train the worker and give them best infrastructure and equipment for there work. After this policy is set performance is checked and was found applicable.

  Step-4 accountability, in this a ship recycling yard managers where, taken into account and authority was given to them.

Step-5 Integration to company policy, in this policy was integrated with the organization for green ship recycling.

STEP-6 resources all the training, documentation is set for green ship recycling and reporting procedure was set.

- ❖ Implementing risk management-

  Step-1 in this timing and strategy are set that is before the ship recycling one should know about most hazardous material, rules and regulation should be set.

  Step-2 implementing the risk management process.

- ❖ Monitoring and review-

  In this the policy and implementation was checked and was found effective.

- ❖ Continuous improvement-

  In this if needed than policy, frame work and plan are improved continuously.

- ISO 14000

It is a multi-face approach which deals with environmental protection, this approach is applicable to all the government and private organization.

This help to meet environmental challenges of climate change like standards for greenhouse gas accounting, verification and emissions trading, and for measuring the carbon emission products, standards for sampling and test methods to deal with specific environmental challenges. It has developed IS for the monitoring of such aspects as the quality of air, water and the soil, as well as noise, radiation, and for controlling the transport of dangerous goods.

This covers a family of environmental standards from 14001, 14020, 14004,14031,14065, 14064-1,2,3,14040, 14063.

Benefits of ISO 14000-

- ✓ Reduce raw material
- ✓ Reduce cost
- ✓ Improve efficiency
- ✓ Reduce waste

5.6 Classification of IHM For Green Ship Recycling-

Once the inventory of hazardous material is prepared from the shipowner, it handed to ship recycling company via captain of the ship. Now as soon as it is received it checked by the ship recycler. This list help ship breaking yard to know potential hazardous location and quantity, Now if someone now the quality of hazardous material that they may determine the effect on the environment, the cost for storage of hazardous material and time taken to remove it from the ship recycling storage yard. Following two things can be concluded-

- Forecasting of the most potential hazard for reducing the haphazard effect by JIT Removal.

- Selection of best ship recycling technique based on an inventory of hazardous material.

5.5.1 Selection of best ship recycling technique based on an inventory of hazardous material.

The selection of best ship recycling technique, In this with the help of quality and environmental effect one can predict which environmental area is getting more polluted or affected. As a result, one can give a solution as best suitable recycling technique.

For this, we will collect the data from the inventory of hazardous material in which the quantity of material is mentioned, after this, we find the percentage of the type of waste produced by the ship then we will decide which ship recycling yard is good and if it becomes difficult to decide then we will find the percentage to waste generated part wise.

❖ Step-1

All the data such as name, quantity, location is collected and the sum of total waste is calculated.

❖ Step-2

Now, this data is classified into two ways-

- First, the data is classified into following-

- ✓ Hazardous waste
- ✓ Solid potential hazardous waste
- ✓ Liquid potential hazardous waste
- ✓ Gas potential hazardous waste
- ✓ Radioactive waste

- Now this percentage of these classified is calculated

- Second, now again the main source of data is classified based on location-

  - ✓ Storage
  - ✓ Hull and structure of the ship
  - ✓ Equipment and machinery

- Now after this classification, the percentage of each type of waste mention in the first classification is calculated.

❖ Step-3

- Now based on step-2 a result is generated which is analyzed and the decision is taken that is either ship have to be sent to a dry dock or beaching or buoy method or to the combination of these method.
- Decision table Is made based on consultation with the expert, chief engineers, ship recyclers.

Table XV Criteria A for Partial Decision 1

Sno	Criteria A	Criteria step A	Partial decision 1
A	Hazardous waste% > all other waste%	1	If the criteria step A 1 is correct than prefer dry docking or buoy method
B	Solid potential hazardous waste% > all other waste%	2	If criteria step A 2 is correct than prefer any of three method

C	Liquid potential hazardous Waste% > all other waste%	3	If criteria step A 3 is correct than prefer dry docking
D	Gas potential hazardous waste% > all other waste%	4	If criteria step A 4 is correct than prefer buoy method

Table XVI Criteria B for Partial Decision 2

Sno	Criteria B	Criteria step B	Partial decision 2
A	Waste% at storage location > waste% of other location	1	If criteria step B 1 is correct then the ship can be recycled at any method
B	Waste% at hull and structure of the ship > waste% of other location	2	If criteria step B 2 is correct then ship should be cut by dry docking
C	Waste% at equipment and machinery > waste% of other location	3	If criteria step B 3 is correct then the ship can be recycled at the dry dock or buoy method.

Table XVII Final Decision

s. no	Step criteria A	Step criteria B	code	decision
A	1	1	11	If these criteria are true than ship should be recycled at Buoy method

B	1	2	12	If these criteria are true than ship should be recycled at dry dock OR by a combination of the buoy and dry dock
C	1	3	13	If these criteria are true than ship should be recycled at dry dock
D	2	1	21	If these criteria are true than ship should be recycled at beaching
E	2	2	22	If these criteria are true than ship should be recycled at buoy method
F	2	3	23	If these criteria are true than ship should be recycled at buoy method
G	3	1	31	If these criteria are true than ship should be recycled at dry dock
H	3	2	32	If these criteria are true than ship should be recycled at dry dock
I	3	3	33	If these criteria are true than ship should be recycled at dry dock
J	4	1	41	If these criteria are true than ship should be recycled at beaching
K	4	2	42	If these criteria are true than ship should be recycled at buoy method
L	4	3	43	If these criteria are true than ship should be recycled at beaching or buoy method

Example- classification is explained with the help of illustration in which data is collected ship recycling yard.

Step -1 data collection and classification-

CLASSIFICATION			
S. NO	**Material**	**weight in tons**	**percentage**
	Hazardous waste	1.740	0.027323778
1	Asbestos	0.458	0.007194188
2	Polychlorinated biphenyls (PCBs)	0.600	0.009424701
3	CFC	0.000	0
4	HAlons	0.100	0.001570783
5	Other fully halogenated cfc	0.000	0
6	Carbon tetrachloride	0.005	7.85392E-05
7	1,1,1-Trichloroethane (Methyl chloroform)	0.001	7.85392E-06
8	Hydrochlorofluorocarbons	0.100	0.001570783
9	Hydrobromofluorocarbons	0.100	0.001570783
10	Methyl bromide	0.000	0
11	Bromochloromethane	0.000	0
12	Anti-fouling systems containing organotin compounds as a biocide	0.200	0.003141567
13	Cadmium and cadmium compounds	0.050	0.000785392
14	Hexavalent chromium and hexavalent chromium compounds	0.000	0
15	Lead and lead compounds	0.100	0.001570783
16	Mercury and mercury compounds	0.001	1.57078E-05
17	Polybrominated biphenyl (PBBs)	0.000	0
18	Polybrominated diphenyl ethers (PBDEs)	0.000	0
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	0.000	0
20	Radioactive substances	0.000	0
21	Certain shortchain chlorinated paraffins (Alkanes, C10-C13, chloro)	0.025	0.000392696

Figure 18 Classification for Criteria Step A

Table XVIII Result of Step Criteria A

MATERIAL	PERCENTAGE	CRTERIA STEP-A
HAZARDOUS WASTE	0.027323778	1
POTENTIAL LIQUID WASTE	0.945250344	3
POTENTIAL GAS WASTE	0.000628313	4
POTENTIAL SOLID WASTE	0.026797565	2

RESULT 1	0.945250344	3

Step-2

Fore criteria step-B

step criteria B

CLASSIFICATION			
S. NO	Material	weight in tons	percentage
	STORAGE LOCATION	0.889	0.014357235
	Hazardous waste	0.436	0.121212121
1	Asbestos	0.050	
2	Polychlorinated biphenyls (PCBs)	0.050	
3	CFC	0.070	
4	HAlons	0.000	
5	Other fully halogenated cfc	0.000	
6	Carbon tetrachloride	0.005	
7	1,1,1-Trichloroethane (Methyl chloroform)	0.000	
8	Hydrochlorofluorocarbons	0.004	
9	Hydrobromofluorocarbons	0.070	
10	Methyl bromide	0.005	
11	Bromochloromethane	0.035	
12	Anti-fouling systems containing organotin compounds as a biocide	0.053	
13	Cadmium and cadmium compounds	0.070	
14	Hexavalent chromium and hexavalent chromium compounds	0.000	
15	Lead and lead compounds	0.019	
16	Mercury and mercury compounds	0.005	

Figure 19 classification for criteria Step –B

Table XIX Result of Step Criteria A

WASTE	%
TOTAL HAZARDOUS WASTE	0.06
TOTAL POTENTIAL LIQUID WASTE	0.89
TOTAL POTENTIAL GAS WASTE	0.01
TOTAL POTENTIAL SOLID WASTE	0.04

MATERIAL	PERCENTAGE	CRTERIA STEP-B
STORAGE LOCATION	0.014357235	1
HULL AND STRUCTURE OF THE SHIP	0.108510982	2
EQUIPMENT AND MACHINERY	0.877131783	3

RESULT 2	0.877131783	3

Step-3 Result-

After the criteria step A and Criteria step B we form the code from the result of A and B criteria which is compared with the decision table and result is produced.

Table XX Decision Table

		code formed
RESULT 1	3	33
RESULT 2	3	

s. no	Step criteria A	Step criteria B	code	decision
A	1	1	11	If these criteria are true than ship should be recycled at Buoy method
B	1	2	12	If these criteria are true than ship should be recycled at dry dock OR by a combination of the buoy and dry dock
C	1	3	13	If these criteria are true than ship should be recycled at dry dock
D	2	1	21	If these criteria are true than ship should be recycled at beaching
E	2	2	22	If these criteria are true than ship should be recycled at buoy method
F	2	3	23	If these criteria are true than ship should be recycled at buoy method
G	3	1	31	If these criteria are true than ship should be recycled at dry dock
H	3	2	32	If these criteria are true than ship should be recycled at dry dock
I	3	3	33	If these criteria are true than ship should be recycled at dry dock
J	4	1	41	If these criteria are true than ship should be recycled at beaching
K	4	2	42	If these criteria are true than ship should be recycled at buoy method
L	4	3	43	If these criteria are true than ship should be recycled at beaching or buoy method

Result	If these criteria are true than ship should be recycled at dry dock

5.5.2 Forecasting of the most potential hazard for reducing the haphazard effect by JIT Removal.

Forecasting of a most potential hazard, classifying this hazardous material on these three criteria and combining the three classifications will help us to know most hazardous material. Once this material is determined one can arrange the solution and help to reduce the pollution generated by hazardous waste.

- JUST IN TIME-

The just-in-time (JIT) inventory system is a management strategy that aligns raw material orders from suppliers directly with production schedules. Companies use this inventory strategy to increase efficiency and decrease waste by receiving goods only as they need them for the production process, which reduces inventory costs. This method requires producers to forecast demand accurately.

- ON THE BASIS OF FSN ANALYSIS

Before we classify material we must know about FNS analysis

FNS Analysis-

Item can be classified as fast moving, slow moving or non-moving based on the pattern of an issue for disposal. This denotes how soon a material is removed from the site. This classification helps in controlling obsolescence.

An item that is very fast moving to get disposed of recycling site in the least time (1-2 week) are classified as "F". Item which is disposed in more time as compared to Fast moving but less time as compared to non- moving (2-3 month) from the site are called slow moving "S" and item which take more time than this are non- moving "N".These non-moving items block the place which creates a storage problem.

- ON THE BASIS OF ENVIRONMENTAL & HEALTH IMPACT

This classification is the same as Inventory of Hazardous material (IHM) given by IMO as IMO have classified inventory into a different table- A, B, C and D based on properties. In This table A and B contain Material which is classified as inventory to be mention in the list and contain threshold value as per given in different rule, this shows that these are most hazardous material having an impact on health like (cancer, asthma, etc) and also a huge impact on the environment.

Whereas Table – C contains potential hazardous material, that is material having a property to affect the environment and human but still stable as compared to the material of Table-A and B.

Table-D contains regular good that contains a hazardous substance. The further checklist is also prepared to justify classification based on the research paper.

- Death or deadly diseases (D)
- Lifetime Injury (LI)
- Injury (I)

❖ ON THE BASIS OF HML Analysis for (COST OF STORAGE and Removing)

Cost is the main factor for any industry to run or stop, coming to ship recycling industry one can see that a part of capital is needed to store, remove and dispose the hazardous inventory from the ship. So before getting into the process, one can anticipate cost needed storage, removal, and disposal.

Factor affecting cost in hazardous waste of ship recycling yard is-

- Cost of inventory
- Cost of transportation
- Cost of disposal

✓ Cost of inventory-

In this making and maintenance cost of storage, the place is calculated with this cost of special equipment or special material needed for storage is also calculated. In some ship yard, a special person is contacted for removal of hazardous material and for loading theses material labour are used, whereas in most of the country

where labour is cheap they are only used with an arrangement of material for removal.

- ✓ Cost of transport-

It is that cost which a ship recycling yard has to pay to transport hazardous material to disposal yard.

- ✓ Cost of disposal-

It is that cost which ship recycling yard have to pay to the certified company responsible for disposal of material. Cost is based on per ton basis.

summation of these all cost gives capital needed an arrangement to be made which is further classified as HML analysis based on set criteria to range by company.

Item can be classified as high cost, medium cost or low cost based on the cost for storage, removing and disposal. This denotes how much a material cost for removing, storage and disposal. This classification helps in knowing capital blockage.

An item that is the high cost of storing and disposing of are classified as HIGH COST"H". Item which is disposed and stored between high and low are called as MEDIUM COST "M", and last material which cost least are called Low cost "L".

Table XXI Classification on Cost Basis

Classification	**Range**
High (H)	As per company policy
Medium(M)	As per company policy
LOW (L)	As per company policy

Now once the classification on this 3 basis is done, these analyses are given value as per table is given below-

Table XXII Value Given To Classification

Classification	**value**

N	D	H	3
S	LI	M	2
F	I	L	1

❖ Final classification-

Once the classification has been done, now a table is formed based on company objective and weights are given. Let weight given to goal be (p,q,r) for low cost, movement and effect respectively.

Where,

$$p + q + r = 1$$

Now a high value is given to classification based on its best suitable description for example cost is best described by HML analysis so the HML analysis gives the highest value and so on.

which is shown in below table-

Table XXIII Calculate Classification Weight

GOAL/AIM	**WEIGHT**	**FNS**	**HML**	**EFFECT**
LOW COST	As per policy(p)	2	3	1
MOVEMENT	As per policy(q)	3	2	1
EFFECT	As per policy(r)	2	1	3
CLASSIFICATION WEIGHT (Cw)		X	Y	Z

Where Cw (classification weight) is calculated as

$$Cw(\text{FNS analysis})\ (X) = 2 * p + 3 * q + 2 * r$$

$$\text{Cw(HML analysis) (Y)} = 3 * p + 2 * q + 1 * r$$

$$\text{Cw (Effect) (Z)} = 1 * p + 1 * q + 3 * r$$

They are combined by a simple weighted technique based on the objective to reduce the impact on human and environment (Let a,b are two different material)-

Table XXIV Example for Calculating Hazardous Material

Material	**Classification (FSN)**	**VALUE (FSN) Cv**	**Classification (HML)**	**VALUE (HML) Cv**	**Classification (effect)**	**VALUE (effect) Cv**	**Cw (FSN) X**	**Cw (HML) Y**	**Cw (effect) Z**	**Total**
a	Fast	3	Medium	2		3				I
b	Nonmoving	1	High	3		1				

Simple weight is calculated as,

$$Cni = \sum_{j=1}^{3} (Cwj\ X\ Cvi)$$

For example-

I= 3*X+2*Y+3*Z

Where (X, Y, Z) is the value of classification of Cw and (3,2,3) is the value of classification.

Now, this weightage is used to group the classification and identify the most hazardous, costly material to store, dispose and remove any material which takes

a long time to move. By this ship recycling yard, a person can arrange Just in time disposal facility and can reduce cost and environmental effect.

Example-

This classification will change as per recycling yard condition and cost and time for disposal. Below shown is an illustration for ship recycling yard situated at Kolkata port trust

The details about the ship breaking yard are mention in Appendix B and detail data of this analysis is given in Appendix C

FSN Analysis Criteria-

- F- 15 days
- S- 1 month
- N- 3 month

FSN ANALYSIS

S. NO	Material	days	analysis result	given value
28	Engine coolant additives	19	S	2
29	Antifreeze fluids	29	S	2
30	Boiler and feed water treatment and test re-agents	95	N	3
31	De-ioniser regenerating chemicals	90	N	3
32	Evaporator dosing and descaling acids	45	S	2
33	Paint stabilizers/rust stabilizers	60	S	2
34	Solvents/thinners	25	S	2
35	Paints	21	S	2
36	Chemical refrigerants	7	F	1
37	Battery electrolyte	13	F	1
38	Alcohol, methylated spirits	30	S	2

Figure 20 FSN Analysis

Environmental analysis Criteria-

The number shown here is total effect value

- D - 6
- LI -5
- I – 4

ENVIRONMENTAL & HEALTH IMPACT ANALYSIS						
S. NO	Material	analysis result	given value	health effect	environmental effect	total effect
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	L.I	2	2	3	5
20	Radioactive substances	D	3	3	3	6
21	Certain shortchain chlorinated paraffins (Alkanes, C10-C13, chloro)	L.I	2	2	3	5
22	Kerosene	I	1	1	3	4

Figure 21 Impact Analysis

HML analysis-

Criteria-

- **H-** above 100000
- **M-** between 10000 and 100000
- **L-** below 10000

HML ANALYSIS							
S. NO	Material	analysis result	given value	cost of inventory	cost of transportation	cost of disposal	total cost
22	Kerosene	M	2	7500	13950	13175	34625
23	White spirit	L	1	0	0	0	0
24	Lubricating oil	H	3	600000	1116000	1054000	2770000
25	Hydraulic oil	H	3	75000	139500	131750	346250
26	Anti-seize compounds	L	1	1500	2790	2635	6925
27	Fuel additive	M	2	7500	13950	13175	34625
28	Engine coolant additives	L	1	150	279	263.5	692.5
29	Antifreeze fluids	L	1	0	0	0	0
30	Boiler and feed water treatment and test re-agents	L	1	150	279	263.5	692.5
31	De-ioniser regenerating chemicals	L	1	300	558	527	1385
32	Evaporator dosing and descaling acids	L	1	900	1674	1581	4155
33	Paint stabilizers/rust stabilizers	L	1	750	1395	1317.5	3462.5

Figure 22 HML Analysis

Weightage table-

According to the goal of the project and ship recycling yard to reduce the hazardous material effect by JIT removal. The below table shows the criteria-

Table XXV Goal for Reducing Hazardous Effect by JIT

	WEIGHT	FNS	HML	EFFECT
LOW	0.5	2	3	1
MOVEMENT	0.2	3	2	1
EFFECT	0.3	2	1	3

[redacted]	1	2.2	2.2	1.6

Final table-

In this, the table is prepared and the final classification is done and grouping of material according to rule.

GROUPING CRITEIA

Table XXVI Group Criteria

GROUP	FINAL RANGE
G1	6 TO 7.3
G2	7.3 TO 8.6
G3	8.6 TO 10
G4	10 TO 11.3
G5	11.3 TO 12.6
G6	12.6 TO 14
G7	14 TO 15.3
G8	15.3 TO 16.6
G9	16.6 TO 18

Result-

B	C	D	E	F	G	H	I	J	K	L	M
	FINAL										
Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
	Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
Asbestos	N	3	M	2	D	3	6.6	4.4	4.8	15.8	G8
Polychlorinated biphenyls (PCBs)	N	3	M	2	D	3	6.6	4.4	4.8	15.8	G8
CFC	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
HAlons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Other fully halogenated cfc	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Carbon tetrachloride	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
1,1,1-Trichloroethane (Methyl chloroform)	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
Hydrochlorofluorocarbons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Hydrobromofluorocarbons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Methyl bromide	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
Bromochloromethane	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
Anti-fouling systems containing organotin compounds as a biocide	N	3	M	2	L.I	2	6.6	4.4	3.2	14.2	G7
Cadmium and cadmium compounds	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Hexavalent chromium and hexavalent chromium compounds	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
Lead and lead compounds	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
Mercury and mercury compounds	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5

Figure 23 Final Group Table

CHAPTER-6

RESULT, CONCLUSION AND FUTURE SCOPE

6.1 Result-

- Chapter -1, 2, 3, gives a basic idea of the process of ship recycling, problems, the reason for the project, previous work and its scenario across the world and also in India. It also gives the knowledge about Hazardous material present in ship, sources, effect, impact, rules & regulation and procedure for the safe removal of hazardous material.

- Chapter-4 In this I have explained the various procedure of obsoleting vessel, criteria which effect ship recycling and with the help of Analytical hierarchy process ranked the method based on multi-criteria. After this analysis, we come to result that is Dry dock is the best way for the obsoleting vessel followed by Buoy Method and then at the end Beaching Method as ranking is done based on criteria for less environmental and health impact.

- Chapter-5 it first describes the details of Inventory of Hazardous Material, a list which shows the material to be mention in IHM, Procedure to Prepare IHM for both existing and new ships. Further on Second part with the help of multi-criteria classification and simple weighted technique procedure is given to identify the most hazardous, most time taking to dispose and most capital blocking material which is further illustrated by a case study of Kolkata port trust ship breaking yard and it was found to be was asbestos and PCB where as its grade tell us about that these material are non moving ,medium valued and most environmental hazardous. In the third part, the IHM is used as base for the proposing appropriate method for the obsoleting vessel to reduce Environment, health effect in this an illustration is used too explain the process.

6.2 Conclusion-

- This project helps to understand what is ship recycling and what isa hazardous material and how they affect our ecosystem.

- This compares the 3 main vessels obsoleting technique and gives a way to how we can compare and also rank the best way for an obsoleting vessel with less environmental effect and as a result, it came to be Drydocking.

- Further, it gives knowledge and method to find about dominant hazardous material based on the condition of ship breaking yard for Just In Time removal of material for a safe and healthy environment.

- This also helps in proposing the best method for obsoleting vessel n based on IHM for reducing waste production.

This all point helps us to recycle a ship with minimum hazardous effect on the environment and health as a result problem of ship recycling will be reduced and need for the fixed type of method for the obsoleting ship can postpone as ship recycling yard becomes cable to know and handle most hazardous material. Which reduce the chance of accident and lead to safe and happy recycling.

6.3 Future Scope-

- ✓ One can find other ways to reduce the hazardous impact of ship recycling like changing the design of the ship
- ✓ Computerized system can be generated.
- ✓ One can do cost analysis that is amount to cost safe with this JIT of hazardous waste.
- ✓ One can use these AHP with all practical factor such as cost, area for dismantling and another factor to know the exact obsoleting method for dismantling.
- ✓ One can find a new way to cut ships such as the use of the sun for cutting metal in place of the gas cutter as it causes health and environmental issue.

APPENDIX A

Data related to the Analytic Hierarchy Process is shown-

Step-1

Finding dominate criteria for green ship recycling				
A \ B	environment	health and hygiene	safety & training	equipment & infrastructure
environment	1.00	3.00	0.50	0.50
health and hygiene	0.33	1.00	0.33	0.50
safety & training	2.00	3.00	1.00	0.50
equipment & infrastructure	2.00	2.00	2.00	1.00
SUM	5.33	9.00	3.83	2.50

	upper triangle
	lower triangle
	diagonal

Step-2 Normalize matrix-

NORMALIZE MATRIX					
A \ B	environment	health and hygiene	safety & training	equipment & infrastructure	CRITERIA WEIGHT {W}
environment	0.19	0.33	0.13	0.20	0.21
health and hygiene	0.06	0.11	0.09	0.20	0.12
safety & training	0.38	0.33	0.26	0.20	0.29
equipment & infrastructure	0.38	0.22	0.52	0.40	0.38
SUM	1.00	1.00	1.00	1.00	

STEP-3 CONSISTENT MATRIX FOR IDENTIFYING MOST DOMINANT CHARACTER AMONG DIFFERENT CRITERIA

Finding dominat criteria for green ship recycling

B / A	environment	health and hygiene	safety & training	equipment & infrastructure	CRITERIA WEIGHT (W)	CONSITENT (Ws)	consitency vector
environment	1.00	3.00	0.50	0.50	0.21	0.91	4.31
health and hygiene	0.33	1.00	0.33	0.50	0.12	0.48	3.97
safety & training	2.00	3.00	1.00	0.50	0.29	1.26	4.34
equipment & infrastructure	2.00	2.00	2.00	1.00	0.38	1.62	4.26
SUM	5.33	9.00	3.83	2.50			

A= 4.22

n= no.of criteria n=4 RI= Random index for n=4 is 0.90 CR=(CI/RI)

ci=CONSISTENCY INDEX CI=(A-n)/(n-1) 0.074144293 0.082382547

STEP-4 DIFFERENT CRITERIA EFFECT ON ALTERNATIVE OPTION ARE CHECKED-

FOR ENVIRONMENT-

ENVIRONMENT

C MATRIX

B / A	BEACHING METHOD	BUOY	DRY DOCK
BEACHING	1.00	0.25	0.17
BUOY	4.00	1.00	0.14
DRY DOCK	6.00	7.00	1.00
SUM	11.00	8.25	1.31

NORMALIZE MATRIX

B / A	BEACHING METHOD	BUOY	DRY DOCK	ALTERNATIVE priorities
BEACHING	0.09	0.03	0.13	0.08
BUOY	0.36	0.12	0.11	0.20
DRY DOCK	0.55	0.85	0.76	0.72
SUM	1.00	1.00	1.00	

CONSITENCY

Ws		dot vector
0.25		0.328437917
0.63		0.313242009
2.60		0.276397516
	A=	0.31

n=3				
RI=0.58			CONSISTENCY RATIO	
CI	-1.346987093		CR<0.1	accetpted
CR	-2.32239154		CR>=.1	not accetpted

FOR HEALTH AND HYGIENE-

HEALTH AND HYGIENE

C MATRIX

A \ B	BEACHING METHOD	BUOY	DRY DOCK
BEACHING	1.00	0.33	0.20
BUOY	3.00	1.00	0.33
DRY DOCK	5.00	3.00	1.00
SUM	9.00	4.33	1.53

NORMALIZE

A \ B	BEACHING METHOD	BUOY	DRY DOCK	ALTERNATIVE priorit
BEACHING METHO	0.11	0.08	0.13	0.11
BUOY	0.33	0.23	0.22	0.26
DRY DOCK	0.56	0.69	0.65	0.63
SUM	1.00	1.00	1.00	

CONSITENCY

Vs		dot vector
0.32		0.3320933
0.79		0.32971
1.95		0.3255237
	λ=	0.329109

n=3					
RI=0.58				CONSISTENCY RATIO	
CI	-1.3354			CR<0.1	accetpted
CR	-2.3025			CR>=.1	not accetpted

FOR SAFETY & TRAINING-

SAFETY & TRAINING

C MATRIX

A \ B	BEACHING METHOD	BUOY	DRY DOCK
BEACHING METH	1.00	1.00	1.00
BUOY	1.00	1.00	1.00
DRY DOCK	1.00	1.00	1.00
SUM	3.00	3.00	3.00

NORMALIZE

A \ B	BEACHING METHOD	BUOY	DRY DOCK	ALTERNATIVE priorities (AP)
BEACHING METH	0.33	0.33	0.33	0.33
BUOY	0.33	0.33	0.33	0.33
DRY DOCK	0.33	0.33	0.33	0.33
SUM	1.00	1.00	1.00	

CONSITENC

Vs		dot vector
1.00		0.3333333
1.00		0.3333333
1.00		0.3333333
	λ=	0.33333

n=3					
RI=0.58				CONSISTENCY RATIO	
CI	-1.33			CR<0.1	accetpted
CR	-2.3			CR>=.1	not accetpted

EQUIPMENT & INFRASTRUCTURE-

A \ B	BEACHING METH	BUOY	DRY DOCK
BEACHING METH	[illegible]	0.33	0.20
BUOY	3.00	[illegible]	0.33
DRY DOCK	5.00	3.00	[illegible]
SUM	9.00	4.33	1.53

NOR

A \ B	BEACHING METHOD	BUOY	DRY DOCK	ALTERNATIYE priorit
BEACHING METH	0.11	0.08	0.13	0.11
BUOY	0.33	0.23	0.22	0.26
DRY DOCK	0.56	0.69	0.65	0.63
SUM	1.00	1.00	1.00	

CONS

Vs	dot vecto
0.32	0.3321
0.79	0.3297
1.95	0.3255
λ=	0.3291

n=3
RI=0.58
CI -1.3354
CR -2.3025

CONSISTENCY RATIO
CR<0.1 accetpted
CR>=.1 not accetpted

STEP-5 SELECTION MATRIX-

matrix | selection matrix

A \ B	BEACHING METHOD	BUOY	DRY DOCK	weighted sum
environment	0.08	0.20	0.72	0.21
health and hygiene	0.11	0.26	0.63	0.12
safety & trainning	0.33	0.33	0.33	0.29
equipment & infrastructure	0.11	0.26	0.63	0.38

STEP-6 FINAL RATE MATRIX-

Final Rate Matrix		
method	**weight**	**Rank**
BEACHING METHOD	0.1675	3
BUOY	0.2677	2
DRY DOCK	0.5619	1

APPENDIX B

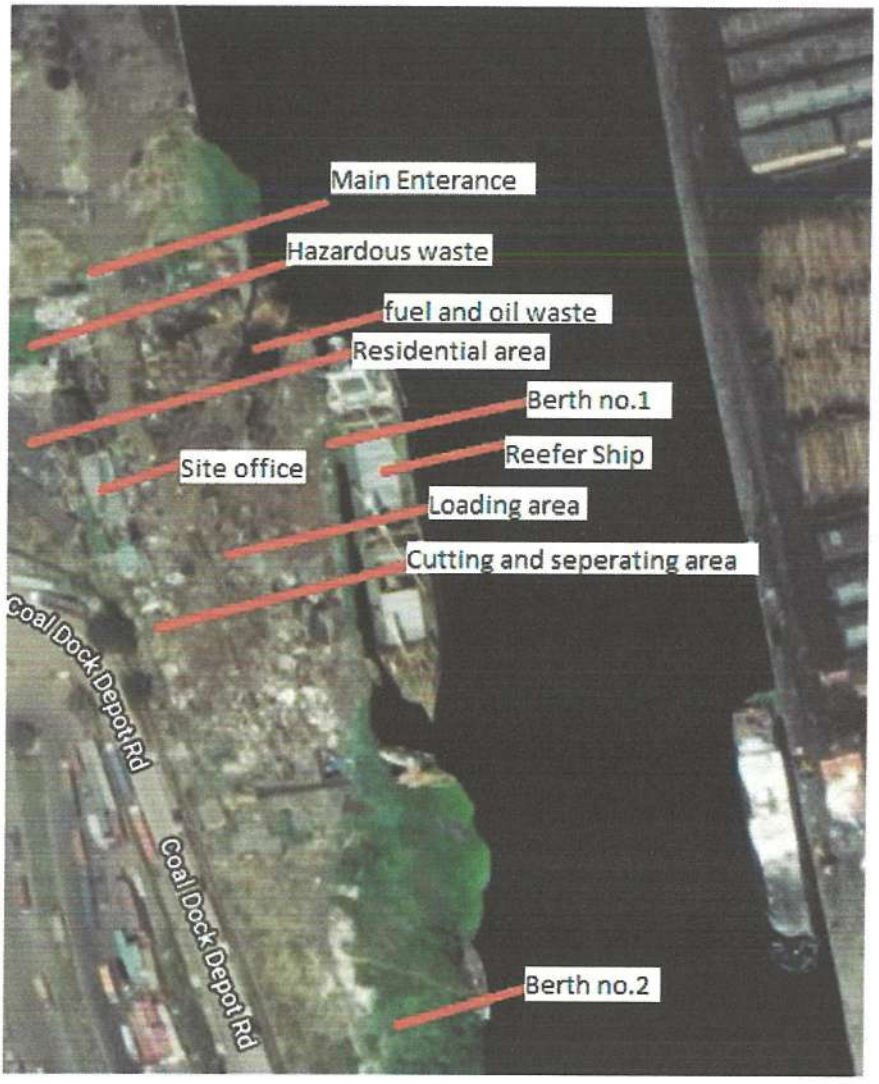
❖ SHIP RECYCLING YARD KOLKATA PORT TRUST-

- This ship recycling yard is a part of Kolkata port trust in which area is leased to a private company named Amar Iron Udyog Pvt. Ltd. for dismantling.
- It is situated at (22.529507, 88.311627) latitude and longitude.

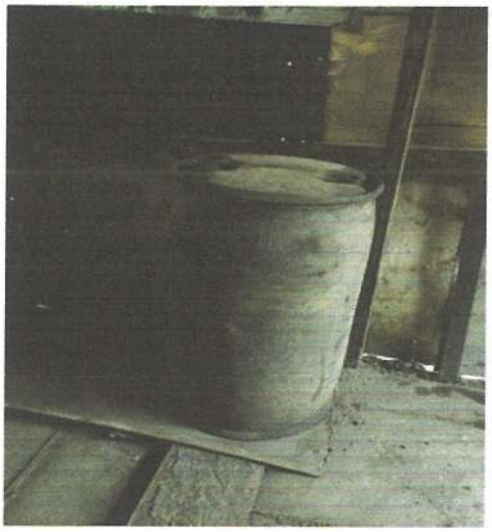
Features of ship recycling yard, Kolkata Port Trust-

Feature	Details
Type of obsoleting method	Buoy method
Number of berths	2
Safety measure	
✓ **Fire fighting**	Yes
✓ **Security**	Yes
✓ **Heath safety (first aid)**	Yes
✓ **PPE**	yes
✓ **Training**	yes
✓ **Hazardous material storage**	yes
✓ **Boom/oil spill equipment**	yes
Equipment	
Method for cutting	Gas cutting
Crane (for unloading from the ship)	1
loading in Truck	by labor
Waste produced	
Oil and fuel waste	Yes
Hazardous waste	Yes
Gas waste	yes

Satellite image of the ship recycling yard



Some glimpse of the hazardous waste which was found during the visit at the ship recycling yard.



✓

APPENDIX C

FSN ANALYSIS				
S. NO	**Material**	**days**	**analysis result**	**given value**
1	Asbestos	90	N	3
2	Polychlorinated biphenyls (PCBs)	120	N	3
3	CFC	100	N	3
4	HAlons	90	N	3
5	Other fully halogenated cfc	102	N	3
6	Carbon tetrachloride	106	N	3
7	1,1,1-Trichloroethane (Methyl chloroform)	111	N	3
8	Hydrochlorofluorocarbons	101	N	3
9	Hydrobromofluorocarbons	106	N	3
10	Methyl bromide	100	N	3
11	Bromochloromethane	90	N	3
12	Anti-fouling systems containing organotin compounds as a biocide	95	N	3
13	Cadmium and cadmium compounds	93	N	3
14	Hexavalent chromium and hexavalent chromium compounds	99	N	3
15	Lead and lead compounds	102	N	3
16	Mercury and mercury compounds	150	N	3
17	Polybrominated biphenyl (PBBs)	148	N	3
18	Polybrominated diphenyl ethers (PBDEs)	170	N	3
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	99	N	3
20	Radioactive substances	80	S	2
21	Certain short-chain chlorinated paraffin (Alkanes, C10-C13, chloro)	26	S	2
22	Kerosene	10	F	1
23	White spirit	12	F	1
24	Lubricating oil	13	F	1
25	Hydraulic oil	14	F	1
26	Anti-seize compounds	10	F	1
27	Fuel additive	22	S	2
28	Engine coolant additives	19	S	2
29	Antifreeze fluids	29	S	2
30	Boiler and feed water treatment and test reagents	95	N	3
31	De-ioniser regenerating chemicals	90	N	3
32	Evaporator dosing and descaling acids	45	S	2
33	Paint stabilizers/rust stabilizers	60	S	2

FSN ANALYSIS				
S. NO	**Material**	**days**	**analysis result**	**given value**
34	Solvents/thinners	25	S	2
35	Paints	21	S	2
36	Chemical refrigerants	7	F	1
37	Battery electrolyte	13	F	1
38	Alcohol, methylated spirits	30	S	2
39	Acetylene	28	S	2
40	Propane	27	S	2
41	Butane	40	S	2
42	Oxygen	2	F	1
43	CO2	6	F	1
44	Perfluorocarbons (PFCs)	9	F	1
45	Methane	7	F	1
46	Hydrofluorocarbon (HFCs)	7	F	1
47	Nitrous oxide (N2O)	7	F	1
48	Sulfur hexafluoride (SF6)	5	F	1
49	Bunkers: fuel oil	35	S	2
50	Grease	9	F	1
51	Waste oil (sludge)	12	F	1
52	Bilge and/or wastewater generated by the after-treatment systems fitted on machinery	12	F	1
53	Oily liquid cargo tank residues	12	F	1
54	Ballast water	15	F	1
55	Raw sewage	10	F	1
56	Treated sewage	12	F	1
57	Non-oily liquid cargo residues	10	F	1
58	Fuel gas	10	F	1
59	Dry cargo residues	10	F	1
60	Medical waste/infectious waste	10	F	1
61	Incinerator ash13	39	S	2
62	Garbage	10	F	1
63	Fuel tank residues	45	S	2
64	Oily solid cargo tank residues	43	S	2
65	Oily or chemical contaminated rags	32	S	2
66	Batteries (incl. lead acid batteries)	40	S	2
67	Pesticides/insecticide sprays	15	F	1
68	Extinguishers	45	S	2
69	Chemical cleaner (incl. electrical equipment cleaner, carbon remover)	45	S	2
70	Detergent/bleacher (could be a liquid)	45	S	2
71	Miscellaneous medicines	90	N	3
72	Fire fighting clothing and Personal protective equipment	60	S	2

FSN ANALYSIS				
S. NO	**Material**	**days**	**analysis result**	**given value**
73	Dry tank residues	40	S	2
74	Cargo residues	45	S	2
75	Spare parts which contain materials listed in Table A or Table B	30	S	2
76	Electrical and electronic equipment	30	S	2
77	Lighting equipment	45	S	2
78	Non ship-specific furniture, interior and similar equipment	15	F	1

Criteria for value for environmental analysis

effect	value given
health	
cancer/ mutation	3
lifetime injury	2
injury	1
environment	3

On the basis of the above table, impact analysis was done-

ENVIRONMENTAL & HEALTH IMPACT ANALYSIS						
S. NO	**Material**	**analysis result**	**given value**	**health effect**	**environmental effect**	**total effect**
1	Asbestos	D	3	3	3	6
2	Polychlorinated biphenyls (PCBs)	D	3	3	3	6
3	CFC	D	3	3	3	6
4	HAlons	D	3	3	3	6
5	Other fully halogenated cfc	D	3	3	3	6
6	Carbon tetrachloride	L.I	2	2	3	5
7	1,1,1-Trichloroethane (Methyl chloroform)	L.I	2	2	3	5
8	Hydrochlorofluorocarbons	D	3	3	3	6
9	Hydrobromofluorocarbons	D	3	3	3	6
10	Methyl bromide	L.I	2	2	3	5
11	Bromochloromethane	L.I	2	2	3	5
12	Anti-fouling systems containing organotin compounds as a biocide	L.I	2	2	3	5
13	Cadmium and cadmium compounds	D	3	3	3	6
14	Hexavalent chromium and hexavalent chromium compounds	D	3	3	3	6
15	Lead and lead compounds	L.I	2	2	3	5

ENVIRONMENTAL & HEALTH IMPACT ANALYSIS						
S. NO	**Material**	**analysis result**	**given value**	**health effect**	**environmental effect**	**total effect**
16	Mercury and mercury compounds	L.I	2	2	3	5
17	Polybrominated biphenyl (PBBs)	L.I	2	2	3	5
18	Polybrominated diphenyl ethers (PBDEs)	L.I	2	2	3	5
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	L.I	2	2	3	5
20	Radioactive substances	D	3	3	3	6
21	Certain short-chain chlorinated paraffin (Alkanes, C10-C13, chloro)	L.I	2	2	3	5
22	Kerosene	I	1	1	3	4
23	White spirit	I	1	1	3	4
24	Lubricating oil	I	1	1	3	4
25	Hydraulic oil	I	1	1	3	4
26	Anti-seize compounds	I	1	1	3	4
27	Fuel additive	I	1	1	3	4
28	Engine coolant additives	I	1	1	3	4
29	Antifreeze fluids	L.I	2	2	3	5
30	Boiler and feed water treatment and test reagents	I	1	1	3	4
31	De-ioniser regenerating chemicals	I	1	1	3	4
32	Evaporator dosing and descaling acids	I	1	1	3	4
33	Paint stabilizers/rust stabilizers	I	1	1	3	4
34	Solvents/thinners	I	1	1	3	4
35	Paints	I	1	1	3	4
36	Chemical refrigerants	L.I	2	2	3	5
37	Battery electrolyte	L.I	2	2	3	5
38	Alcohol, methylated spirits	I	1	1	3	4
39	Acetylene	L.I	2	2	3	5
40	Propane	L.I	2	2	3	5
41	Butane	I	1	1	3	4
42	Oxygen	I	1	1	3	4
43	CO2	I	1	1	3	4
44	Perfluorocarbons (PFCs)	I	1	1	3	4
45	Methane	I	1	1	3	4
46	Hydrofluorocarbon (HFCs)	I	1	1	3	4
47	Nitrous oxide (N2O)	I	1	1	3	4
48	Sulfur hexafluoride (SF6)	I	1	1	3	4
49	Bunkers: fuel oil	I	1	1	3	4
50	Grease	I	1	1	3	4
51	Waste oil (sludge)	I	1	1	3	4
52	Bilge and/or waste water generated by the after-treatment systems fitted on machinery	I	1	1	3	4
53	Oily liquid cargo tank residues	I	1	1	3	4

ENVIRONMENTAL & HEALTH IMPACT ANALYSIS						
S. NO	Material	analysis result	given value	health effect	environmental effect	total effect
54	Ballast water	I	1	1	3	4
55	Raw sewage	I	1	1	3	4
56	Treated sewage	I	1	1	3	4
57	Non-oily liquid cargo residues	I	1	1	3	4
58	Fuel gas	I	1	1	3	4
59	Dry cargo residues	I	1	1	3	4
60	Medical waste/infectious waste	L.I	2	2	3	5
61	Incinerator ash13	I	1	1	3	4
62	Garbage	I	1	1	3	4
63	Fuel tank residues	I	1	1	3	4
64	Oily solid cargo tank residues	I	1	1	3	4
65	Oily or chemical contaminated rags	L.I	2	2	3	5
66	Batteries (incl. lead acid batteries)	L.I	2	2	3	5
67	Pesticides/insecticide sprays	L.I	2	2	3	5
68	Extinguishers	L.I	2	2	3	5
69	Chemical cleaner (incl. electrical equipment cleaner, carbon remover)	L.I	2	2	3	5
70	Detergent/bleacher (could be a liquid)	L.I	2	2	3	5
71	Miscellaneous medicines	I	1	1	3	4
72	Fire fighting clothing and Personal protective equipment	I	1	1	3	4
73	Dry tank residues	I	1	1	3	4
74	Cargo residues	I	1	1	3	4
75	Spare parts which contain materials listed in Table A or Table B	I	1	1	3	4
76	Electrical and electronic equipment	I	1	1	3	4
77	Lighting equipment	I	1	1	3	4
78	Non ship-specific furniture, interior and similar equipment	I	1	1	3	4

HML criteria-

CRITERIA	LIMMIT
H	>100000
M	10000<=100000
L	<10000

HML analysis-

HML ANALYSIS							
S. NO	**Material**	**analysis result**	**given value**	**cost of inventory**	**cost of transportation**	**cost of disposal**	**total cost**
1	Asbestos	M	2	6870	12778.2	12068.3	31717
2	Polychlorinated biphenyls (PCBs)	M	2	9000	16740	15810	41550
3	CFC	L	1	0	0	0	0
4	HAlons	L	1	1500	2790	2635	6925
5	Other fully halogenated cfc	L	1	0	0	0	0
6	Carbon tetrachloride	L	1	75	139.5	131.75	346.25
7	1,1,1-Trichloroethane (Methyl chloroform)	L	1	7.5	13.95	13.175	34.625
8	Hydrochlorofluorocarbons	L	1	1500	2790	2635	6925
9	Hydrobromofluorocarbons	L	1	1500	2790	2635	6925
10	Methyl bromide	L	1	0	0	0	0
11	Bromochloromethane	L	1	0	0	0	0
12	Anti-fouling systems containing organotin compounds as a biocide	M	2	3000	5580	5270	13850
13	Cadmium and cadmium compounds	L	1	750	1395	1317.5	3462.5
14	Hexavalent chromium and hexavalent chromium compounds	L	1	0	0	0	0
15	Lead and lead compounds	L	1	1500	2790	2635	.6925
16	Mercury and mercury compounds	L	1	15	27.9	26.35	69.25
17	Polybrominated biphenyl (PBBs)	L	1	0	0	0	0
18	Polybrominated diphenyl ethers (PBDEs)	L	1	0	0	0	0
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	L	1	0	0	0	0
20	Radioactive substances	L	1	0	0	0	0
21	Certain shortchain chlorinated paraffins (Alkanes, C10-C13, chloro)	L	1	375	697.5	658.75	1731.3
22	Kerosene	M	2	7500	13950	13175	34625

HML ANALYSIS							
S. NO	**Material**	**analysis result**	**given value**	**cost of inventory**	**cost of transportation**	**cost of disposal**	**total cost**
23	White spirit	L	1	0	0	0	0
24	Lubricating oil	H	3	600000	1116000	1054000	3E+06
25	Hydraulic oil	H	3	75000	139500	131750	346250
26	Anti-seize compounds	L	1	1500	2790	2635	6925
27	Fuel additive	M	2	7500	13950	13175	34625
28	Engine coolant additives	L	1	150	279	263.5	692.5
29	Antifreeze fluids	L	1	0	0	0	0
30	Boiler and feed water treatment and test re-agents	L	1	150	279	263.5	692.5
31	De-ioniser regenerating chemicals	L	1	300	558	527	1385
32	Evaporator dosing and descaling acids	L	1	900	1674	1581	4155
33	Paint stabilizers/rust stabilizers	L	1	750	1395	1317.5	3462.5
34	Solvents/thinners	L	1	375	697.5	658.75	1731.3
35	Paints	H	3	75000	139500	131750	346250
36	Chemical refrigerants	L	1	0	0	0	0
37	Battery electrolyte	L	1	30	55.8	52.7	138.5
38	Alcohol, methylated spirits	L	1	0	0	0	0
39	Acetylene	H	3	30000	55800	52700	138500
40	Propane	M	2	3000	5580	5270	13850
41	Butane	H	3	60000	111600	105400	277000
42	Oxygen	M	2	15000	27900	26350	69250
43	CO2	L	1	0	0	0	0
44	Perfluorocarbons (PFCs)	M	2	15000	27900	26350	69250
45	Methane	M	2	7500	13950	13175	34625
46	Hydrofluorocarbon (HFCs)	M	2	3000	5580	5270	13850
47	Nitrous oxide (N2O)	L	1	0	0	0	0
48	Sulfur hexafluoride (SF6)	L	1	15	27.9	26.35	69.25
49	Bunkers: fuel oil	L	1	30	55.8	52.7	138.5

HML ANALYSIS							
S. NO	**Material**	**analysis result**	**given value**	**cost of inventory**	**cost of transportation**	**cost of disposal**	**total cost**
50	Grease	L	1	75	139.5	131.75	346.25
51	Waste oil (sludge)	L	1	90	167.4	158.1	415.5
52	Bilge and/or waste water generated by the after-treatment systems fitted on machineries	L	1	60	111.6	105.4	277
53	Oily liquid cargo tank residues	L	1	60	111.6	105.4	277
54	Ballast water	L	1	30	55.8	52.7	138.5
55	Raw sewage	L	1	105	195.3	184.45	484.75
56	Treated sewage	L	1	30	55.8	52.7	138.5
57	Non-oily liquid cargo residues	L	1	45	83.7	79.05	207.75
58	Fuel gas	L	1	60	111.6	105.4	277
59	Dry cargo residues	L	1	75	139.5	131.75	346.25
60	Medical waste/infectious waste	L	1	15	27.9	26.35	69.25
61	Incinerator ash13	L	1	1350	2511	2371.5	6232.5
62	Garbage	L	1	750	1395	1317.5	3462.5
63	Fuel tank residues	L	1	0	0	0	0
64	Oily solid cargo tank residues	L	1	0	0	0	0
65	Oily or chemical contaminated rags	L	1	0	0	0	0
66	Batteries (incl. lead acid batteries)	L	1	1200	2232	2108	5540
67	Pesticides/insecticide sprays	L	1	675	1255.5	1185.75	3116.3
68	Extinguishers	L	1	1500	2790	2635	6925
69	Chemical cleaner (incl. electrical equipment cleaner, carbon remover)	L	1	0	0	0	0
70	Detergent/bleacher (could be a liquid)	L	1	375	697.5	658.75	1731.3
71	Miscellaneous medicines	L	1	0	0	0	0
72	Fire fighting clothing and Personal protective equipment	L	1	150	279	263.5	692.5
73	Dry tank residues	L	1	0	0	0	0

HML ANALYSIS							
S. NO	Material	analysis result	given value	cost of inventory	cost of transportation	cost of disposal	total cost
74	Cargo residues	L	1	0	0	0	0
75	Spare parts which contain materials listed in Table A or Table B	L	1	0	0	0	0
76	Electrical and electronic equipment	M	2	10500	19530	18445	48475
77	Lighting equipment	L	1	1500	2790	2635	6925
78	Non ship-specific furniture, interior and similar equipment	M	2	7500	13950	13175	34625
78	Non ship-specific furniture, interior and similar equipment	L	1	0	0	0	0

FINAL RESULT-

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
1	Asbestos	N	3	M	2	D	3	6.6	4.4	4.8	15.8	
2	Polychlorinated biphenyls (PCBs)	N	3	M	2	D	3	6.6	4.4	4.8	15.8	G8
3	CFC	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
4	HAlons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
5	Other fully halogenated cfc	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
6	Carbon tetrachloride	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
7	1,1,1-Trichloroet	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5

FINAL												
S.NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
	hane (Methyl chloroform)											
8	Hydrochlorofluorocarbons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
9	Hydrobromofluorocarbons	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
10	Methyl bromide	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
11	Bromochloromethane	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
12	Anti-fouling systems containing organotin compounds as a biocide	N	3	M	2	L.I	2	6.6	4.4	3.2	14.2	G7
13	Cadmium and cadmium compounds	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
14	Hexavalent chromium and hexavalent chromium compounds	N	3	L	1	D	3	6.6	2.2	4.8	13.6	G6
15	Lead and lead compounds	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
16	Mercury and mercury compounds	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
17	Polybrominated biphenyl (PBBs)	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
18	Polybrominated diphenyl ethers (PBDEs)	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
19	Polychlorinated naphthalenes (more than 3 chlorine atoms)	N	3	L	1	L.I	2	6.6	2.2	3.2	12.0	G5
20	Radioactive substances	S	2	L	1	D	3	4.4	2.2	4.8	11.4	G5
21	Certain shortchain chlorinated paraffins (Alkanes, C10-C13, chloro)	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
22	Kerosene	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G2
23	White spirit	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G1
24	Lubricating oil	F	1	H	3	I	1	2.2	6.6	1.6	10.4	G4
25	Hydraulic oil	F	1	H	3	I	1	2.2	6.6	1.6	10.4	G4
26	Anti-seize compounds	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G1
27	Fuel additive	S	2	M	2	I	1	4.4	4.4	1.6	10.4	G4
28	Engine coolant additives	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G2
29	Antifreeze fluids	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
30	Boiler and feed water treatment	N	3	L	1	I	1	6.6	2.2	1.6	10.4	G4

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
	and test re-agents											
31	De-ioniser regeneratin g chemicals	N	3	L	1	I	1	6.6	2.2	1.6	10.4	G 4
32	Evaporator dosing and descaling acids	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
33	Paint stabilizers/r ust stabilizers	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
34	Solvents/thi nners	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
35	Paints	S	2	H	3	I	1	4.4	6.6	1.6	12.6	G 6
36	Chemical refrigerants	F	1	L	1	L.I	2	2.2	2.2	3.2	7.6	G 2
37	Battery electrolyte	F	1	L	1	L.I	2	2.2	2.2	3.2	7.6	G 2
38	Alcohol, methylated spirits	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
39	Acetylene	S	2	H	3	L.I	2	4.4	6.6	3.2	14.2	G 7
40	Propane	S	2	M	2	L.I	2	4.4	4.4	3.2	12.0	G 5
41	Butane	S	2	H	3	I	1	4.4	6.6	1.6	12.6	G 6
42	Oxygen	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2
43	CO2	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
44	Perfluoroca rbons (PFCs)	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2
45	Methane	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
46	Hydrofluorocarbon (HFCs)	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2
47	Nitrous oxide (N2O)	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
48	Sulfur hexafluoride (SF6)	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
49	Bunkers: fuel oil	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
50	Grease	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
51	Waste oil (sludge)	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
52	Bilge and/or waste water generated by the after-treatment systems fitted on machineries	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
53	Oily liquid cargo tank residues	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
54	Ballast water	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
55	Raw sewage	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
56	Treated sewage	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
57	Non-oily liquid cargo residues	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
58	Fuel gas	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1
59	Dry cargo residues	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G 1

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
60	Medical waste/infectious waste	F	1	L	1	L.I	2	2.2	2.2	3.2	7.6	G2
61	Incinerator ash13	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G2
62	Garbage	F	1	L	1	I	1	2.2	2.2	1.6	6.0	G1
63	Fuel tank residues	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G2
64	Oily solid cargo tank residues	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G2
65	Oily or chemical contaminated rags	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
66	Batteries (incl. lead acid batteries)	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
67	Pesticides/insecticide sprays	F	1	L	1	L.I	2	2.2	2.2	3.2	7.6	G2
68	Extinguishers	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
69	Chemical cleaner (incl. electrical equipment cleaner, carbon remover)	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
70	Detergent/bleacher (could be a liquid)	S	2	L	1	L.I	2	4.4	2.2	3.2	9.8	G3
71	Miscellaneous medicines	N	3	L	1	I	1	6.6	2.2	1.6	10.4	G4

FINAL												
S. NO	Material	FSN		HML		EFFECT		Cw (FSN)	Cw (HML)	Cw (EFFECT)	TOTAL	GROUP
		Analysis	VALUE	Analysis	VALUE	Analysis	VALUE	2.2	2.2	1.6		
72	Fire fighting clothing and Personal protective equipment	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
73	Dry tank residues	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
74	Cargo residues	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
75	Spare parts which contain materials listed in Table A or Table B	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
76	Electrical and electronic equipment	S	2	M	2	I	1	4.4	4.4	1.6	10.4	G 4
77	Lighting equipment	S	2	L	1	I	1	4.4	2.2	1.6	8.2	G 2
78	Non ship-specific furniture, interior and similar equipment	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2
78	Non ship-specific furniture, interior and similar equipment	F	1	M	2	I	1	2.2	4.4	1.6	8.2	G 2

REFERENCE

1. Silvia Pastorelli, "EU Ship Recycling Regulation: What's in it for South Asia?" European Institute for Asian Studies, 2014.

2. K. P. Jain, J. F. J. Pruyn, J. J. Hopman, "Critical Analysis of the Hong Kong International Convention on Ship Recycling", International Journal of Environmental, Ecological, Geological, and Mining Engineering Vol:7 No:10, 2013

3. N. M. Golam Zakaria and K. A. Hossain, "UNDERLYING PROBLEMS OF SHIP RECYCLING INDUSTRIES IN BANGLADESH AND WAY FORWARD", Journal of Mechanical Engineering, Vol. ME 42 No. 1, December 2012.

4. Yen-Chiang Chang, Nannan Wang, Onur Sabri Durak, "Ship recycling and marine pollution", Y.-C. Chang et al. / Marine Pollution Bulletin 60 (2010) 1390–1396.

5. Ramapati Kumar, *"Ship dismantling—a Status Report on South Asia"*, Euro consult Mott MacDonald and WWF-India, 2010.

6. Aslam Khan, Raisa Bashar, Gas U. Ahsan, Nazmul Ahsan Khan, "health risk assessment of the workers of shipbreaking industry: a case study from Chittagong", International Journal of Advances in Science Engineering and Technology, ISSN (p): 2321 –8991, ISSN (e): 2321 –9009, Vol-6, Iss-1, Spl. Issue-1 Feb.-2018.

7. Hasan Ruhan Rabbi, Aevelina Rahman, "Ship Breaking and Recycling Industry of Bangladesh; Issues and Challenges", 10th International Conference on Marine Technology, MARTEC 2016.

8. Mosabbir. Pasha, Aziz. HasanMahmood, Istiakur. Rahman, and Abul. Hasnat, "Assessment of Ship Breaking and Recycling Industries in Bangladesh - An Effective Step towards The Achievement Of Environmental Sustainability", International Conference on Agricultural, Environment and Biological Sciences (ICAEBS'2012) May 26-27, 2012 Phuket.

9. IMO, "GUIDELINES FOR THE DEVELOPMENT OF THE INVENTORY OF HAZARDOUS MATERIAL", 15 May 2015, MEPC 68/21/Add.1 Annex 17, page 1-55.

10. REGULATION (EU) No 1257/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ship recycling and amending Regulation, of 20 November 2013 (EC) No 1013/2006 and Directive 2009/16/EC, Official Journal of the European Union.

11. BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL, By Katharina Kummer Peiry (Executive Secretary of the Basel Executive Secretary of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal United Nations Environmental Programme),2010

12. Ministry of environment and forests government of India, "Technical EIA guidance manual for ship breaking yard, IL&FS SEPTEMBER 2009.

13. IMO, "HONG KONG INTERNATIONAL CONVENTION FOR THE SAFE AND ENVIRONMENTALLY SOUND RECYCLING OF SHIPS, 2009", 19 May 2009.

14. REGULATION (EC) No 1013/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on shipments of waste, of 14 June 2006

15. Jun-Ki Choia, Daniel Kelleya, Sean Murphyc, Dillip Thangamani, "Economic and environmental perspectives of end-of-life ship management",

Resources, Conservation and Recycling 107 (2016) 82–91, 14 December 2015.

16. K.P. Jain, J.F.J. Pruyn & J.J. Hopman, "Influence of ship design on ship recycling", Influence of ship design on ship recycling, OCTOBER-2014

17. Erdem Vardar, "Fate of Shipbreaking Wastes in Turkey", NGO Platform on Shipbreaking 2009

18. Manoj T Thomas," The Alang Ship-breaking Yard", Asian Case Res. J. 2007.11:327-346, 2007.

19. "Technologies and Management Strategies for Hazardous Waste Control", NTIS order #PB83-189241, March 1983

20. Yogesh Kumar, Rupesh Kumar Khaparde , Komal Dewangan, Gautam Kumar Dewangan, Jalam Singh Dhiwar,Devprakash Sahu, "FSN Analysis for Inventory Management – Case Study of Sponge Iron Plant", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue II, February 2017 IC Value: 45.98 ISSN: 2321-9653

21. Singh, G. and Ahuja, I.S. 'Just-in-time manufacturing: literature review and directions', Int. J. Business Continuity and Risk Management, (2012), Vol. 3, No. 1, pp.57–98.

22. Occupational Safety and HealthAdministration U.S. Department of Labor, "SafeWork Practices for Shipbreaking", OSHA 3375-03 2010.

23. Thanasis Karlis, Dionysios Polemis, Anastasios Georgakis," Ship demolition activity. An evaluation of the effect of currency exchange rates on ship scrap values", SPOUDAI Journal of Economics and Business, Vol.66 (2016), Issue 3, pp. 53-70.

24. Legaspi, Rolando D., "Ship recycling: analysis of the shipbreaking countries in Asia" (2000).World Maritime University Dissertations 384.

25. R. W. SAATY," THE ANALYTIC HIERARCHY PROCESS-WHAT IT IS AND HOW IT IS USED", Mat/d Modelling, Vol. 9, No. 3-5, pp. 161-176, 1987.

26. Dr Zahi Abu-Sarhan, "Application Of Analytic Hierarchy Process (AHP) In The Evaluation and Selection Of an Information System Reengineering Projects", IJCSNS International Journal of Computer Science and 1 Network Security, VOL.11 No.1, January 2011

27. Manisha Ketkara *, Omkarprasad S. Vaidya, "Developing ordering policy based on multiple inventory classification schemes" ICTMS-2013.

28. INTERNATIONAL STANDARD ORGANIZATION, "Risk management — Principles and guidelines", ISO 31000, 15/11/2009.

29. INTERNATIONAL STANDARD ORGANIZATION, "Environmental Management" ISO 14000.