BACHELOR THESIS – ME141502

Penilaian Resiko Peluncuran *Free Fall* Lifeboat Menggunakan Metode Failure Modes and Effects Analysis

Teuku Irmansyah
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DOUBLE DEGREE PROGRAM OF MARINE ENGINEERING
DEPARTMENT FACULTY OF MARINE TECHNOLOGY
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Free Fall Lifeboat Launching Risk Assessment Using Failure Modes and Effects Analysis Method

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This Bachelor Thesis is submitted as a partial fulfilment of the requirements for the Bachelor Engineering Degree on
Field study of Marine Reliability, Availability, Maintainability and Safety (RAMS)
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Sepuluh Nopember Institute of Technology

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APPROVAL FORM

FREE FALL LIFEBOAT LAUNCHING RISK ASSESSMENT USING FAILURE MODES AND EFFECT ANALYSIS METHOD

BACHELOR THESIS

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On
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ANALISA RISIKO PADA FREE FALL LIFEBOAT LAUNCHING DENGAN MENGUNAKAN METODE FMEA

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ABSTRAK

Sekoci adalah salah satu peralatan yang menyelamatkan jiwa yang paling penting onboard kapal, yang digunakan pada saat darurat ekstrim untuk meninggalkan kapal. Sekoci adalah kapal kecil yang kaku, dijamin onboard, ke davits sehingga dapat diluncurkan ke sisi kapal dengan sedikit waktu dan bantuan mekanik mungkin untuk melarikan diri awal kru dari kapal. Dalam dekade sejak itu menjadi persyaratan bahwa peralatan menyelamatkan nyawa tersedia untuk semua orang di kapal, banyak fitur desain sekoci dan sistem peluncuran mereka telah berubah. Ini biasanya telah dalam menanggapi tuntutan untuk kapasitas yang lebih besar sekoci, perlindungan yang lebih besar bagi mereka yang menggunakan mereka, kemudahan pengoperasian dan keselamatan ditingkatkan. Sebuah sekoci harus membawa semua peralatan yang diuraikan di bawah kode SOLAS dan LSA, yang lulus untuk kelangsungan hidup di laut. Ini termasuk jatah, air tawar, pertolongan pertama, kompas, distress peralatan sinyal seperti roket dll Sebuah kapal harus membawa satu perahu penyelamat untuk tujuan

penyelamatan, bersama dengan sekoci lainnya. Salah satu sekoci dapat ditunjuk sebagai perahu penyelamat, jika lebih dari dua atau lebih sekoci yang hadir onboard kapal a. sekoci adalah kerajinan air yang digunakan untuk membantu penumpang di perahu dan kapal dalam kesulitan. Ini adalah kerajinan kecil di atas kapal laut untuk memungkinkan melarikan diri darurat. Sebuah sekoci adalah jenis kapal yang digunakan untuk melarikan diri struktur tenggelamnya lebih besar seperti kapal pesiar, kapal komersial, atau pesawat yang telah mendarat di air. Sebuah sekoci adalah perahu kecil, kaku atau tiup dilakukan untuk evakuasi darurat dalam hal terjadi bencana di kapal. Penelitian ini bertujuan untuk memperoleh risiko yang dapat dihasilkan dari Lifeboat selama peluncuran dan operasi pemulihan menggunakan metode FMEA dan mendapatkan tingkat prioritas risiko siapa risiko yang dapat diterima, risiko ditolerir atau berisiko tinggi. Lalu bagaimana untuk meminimalkan kategori risiko tinggi untuk mencegah kecelakaan menggunakan Lopa. Menggunakan Mode Kegagalan dan Efek Metode Analisis (FMEA) untuk penilaian risiko.

Kata kunci : Analisa risiko, FMEA, *LOPA, peluncuran Free fall lifeboat*, *prioritas risiko*.

FREE FALL LIFEBOAT LAUNCHING RISK ASSESSMENT USING FAILURE MODES AND EFFECTS ANALYSIS METHOD

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ABSTRACT

Lifeboat is one of the most important life-saving equipment onboard a ship, which is used at the time of extreme emergencies for abandoning a ship. Lifeboat is a smaller rigid vessel, secured onboard into davits so that it can be launched over the side of the ship with least time and mechanical assistance possible for an early escape of the crew from the ship. In the decades since it became a requirement that lifesaving appliances are available for everyone on board a vessel, many design features of lifeboats and their launching systems have changed. These have usually been in response to the demands for larger lifeboat capacity, greater protection for those using them, ease of operation and enhanced safety. A lifeboat must carry all the equipment described under SOLAS and LSA codes, which are passed for the survival at sea. This includes rations, fresh water, first aid, compass, distress signaling equipment like rocket etc. A ship must carry one rescue boat for the rescuing purpose, along with other lifeboats. One of the lifeboats can be designated as a rescue boat, if more than two or more lifeboats are present onboard a ship. The lifeboat is a water craft used to help passengers on boats and ships in trouble. It is a small craft aboard a ship to allow for emergency escape. A lifeboat is a kind of boat that is used to escape a larger sinking structure such as a cruise ship, commercial vessel, or aircraft that has landed in the water. A lifeboat is a small, rigid or inflatable watercraft carried for emergency evacuation in the event of a disaster aboard ship.

Keywords : FMEA*, Free fall lifeboat launching*, risk assessment, , *risk priority, LOPA*.

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CHAPTER I
INTRODUCTION

1.1 Background

Since the beginning of the 20th century, an incredible improvement in safety at sea has taken place. Much of the improvement has to do with technical and operational improvements in ship and offshore technology and equipment, with the aim to avoid dangerous situations or limit the damage when a situation has occurred. Watertight bulkheads, fireproof materials, separated engine rooms etc. have been designed and developed to do just this; to prevent escalation of a dangerous situation.

Other systems aim to resolve dangerous situations or limit the damage by use of systems on board, such as firefighting systems, bilge pumps etc. However, in severe emergencies, these systems may not be sufficient to resolve the situation.

The initial incident, such as an explosion or a ship-to-ship collision, may escalate to a situation where it is no longer safe for the crew to stay on board the ship or installation. The only option is then to abandon ship, i.e. for the crew to leave the ship or installation and find a safe refuge in a lifeboat, another ship, offshore structure or on land. When the decision to abandon ship has been made, the crew members have to rely on the lifesaving equipment, which can consist of several different components.

This thesis will discuss the Risk Assessment on a Free-Fall Lifeboat with the purpose of determining whether an Free-Fall Lifeboat have a risk that is acceptable or not, create awareness about the dangers and risks obtained from the Free-Fall Lifeboat. It aims to reduce the possibility of danger by adding steps - necessary control measures and precautions. The assessment also prioritize hazards and help determine whether the existing control measures are adequate. A risk assessment carried out by the “FMEA (Failure Modes and Effect Annalysis)” method

1.2 Problem Formulation

Launching and retrieving a lifeboat are high-risk activities, but with proper training a ship’s personnel can attain the required level of familiarity to identify and overcome the potential risks. The MAIB (Marine Accident Investigation Branch) database accumulated over a ten-year period indicates that lifeboats and their launching systems have cost the lives of 12 professional seafarers, or 16% of the total lives lost on merchant ships. Eighty seven people have been injured. These accidents all occurred during training exercises or testing, with experienced and qualified seafarers either performing, or supervising, the operations. Based on the description above, presented several problems:

1. What are the risks and failures that can be generated on free-fall lifeboat?
2. How is the level of each step of process launching?
3. How to minimize risk and failure on free fall lifeboat launching?

1.3 Research Limitation

1. The analysis focuses only on the safety equipment aboard the lifeboat.
2. The method used to interpret the risk is FMEA (Failure Modes and Effect Annalysis) method.
3. Type of Lifeboat that free-fall Lifeboat

1.4 Objective

The objectives of this Thesis are:

1. Knowing the risks and failures that can be generated on a free-fall Lifeboat

2. Knowing the level of danger that can be generated from each step of launching and recovery process.
3. To obtain a way to eliminate the risk and failure.

1.5 Benefit

The final results of this Thesis is the form of safety recommendations for functional of an free-fall Lifeboat Launching to prevent and minimize accident.

1.6 Writing Structure

This thesis contains an introduction, literature review, methodology, analysis and discussion and conclusion with the following stages :

a. CHAPTER I (INTRODUCTION), contains the background, problem formulation, problem definition, research objectives, the benefits of research, and systematic writing.
b. CHAPTER II (LITERATURE REVIEW), contains introduction of lifeboat, launching process, risk analysis and FMEA method
c. CHAPTER III (METHODOLOGY), describes the methods used to solve the existing problems in this thesis.
d. CHAPTER IV (DISCUSSION AND ANALYSIS), discusses the risk analysis using FMEA method.
e. CHAPTER V (CONCLUSIONS AND RECOMMENDATIONS), contains the conclusions and recommendations of the analysis results to refine the results of this thesis and related issues.

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CHAPTER II
LITERATURE REVIEW

In this literature review section will describe the basic theory , such as risk assessment method, Free Fall lifeboat, FMEA worksheet, LOPA. that will support and build a base for conducting this research.

2.1 Evacuation

In the maritime industry, as in all other industries, various degrees of undesired events occur from time to time. Although much effort is put into avoiding situations which can be harmful to human health, the possibility of an emergency is always present. On petroleum installations, such as drilling rigs, drill ships, oil production platforms, etc., the presence of explosive and combustible substances increases the potential risk of fires and explosions. When a situation arises which is dangerous for the crew, the solution is often to move the entire crew to a safer location. This operation involves three phases :

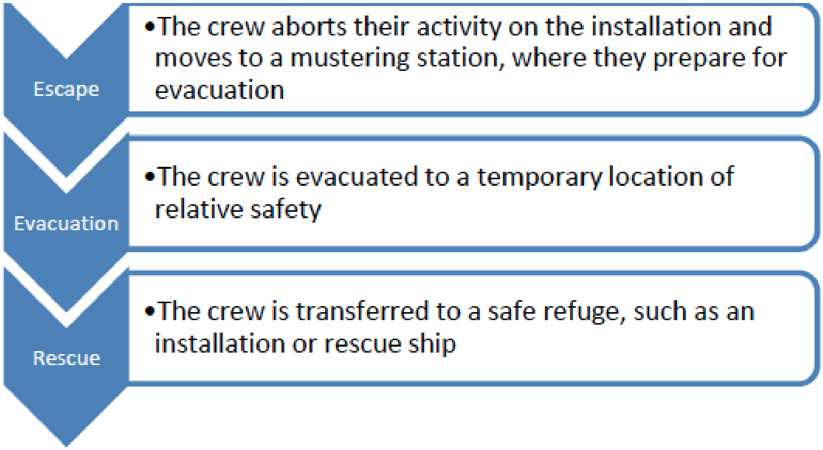


Figure 2.1 Escape, Evacuation and Rescue

Phase one is the evacuation phase, which consists of movement from one part of the installation to another. The crew moves to a lifeboat mustering station or a helicopter deck, where they board a lifeboat or a helicopter. The goal is to prepare for the next phase, which is evacuation.

Phase two is the evacuation phase. The goal of this phase is to move the crew away from immediate danger. Before the operation enters this phase, the situation has escalated to a level where it is no longer safe for the crew to stay on the installation. They must therefore be evacuated to location where they can stay in relative safety until they can be rescued to a more permanent refuge. The evacuation can be carried out by helicopter or by lifeboats. As helicopters are in daily use for transportation in the oil industry, they are preferred also for evacuation.

The operation can be performed as an ordinary transport operation, with a high degree of routine and a very low risk. The crew can be moved dry-shoed at a very high speed to another installation. However, due to the limited capacity of each helicopter, this type of evacuation is time consuming. It is also subject to weather limitations. Lifeboat evacuation is therefore preferred when time is of the essence and when the weather conditions do not allow helicopter evacuation. The lifeboat evacuates the crew from the installation to a location where they can wait for rescue in relative safety.

Phase three is the rescue phase. The goal is to transfer the crew from the temporary refuge reached in phase to, to a safe location. In practice, this involves transfer of the evacuees from life rafts and life boats to land, rescue vessels or other petroleum installations. The transfer can be performed directly or via helicopters and MOB boats.

2.2 SOLAS Chapter III (Life – saving appliances and arrangements)

SOLAS is the abbreviation for Safety of Life at Sea Treaty. It is an international treaty promoting the safety of life at sea. It is one of the most important of all international treaties affecting merchant shipping. This treaty represents a significant advance in the modernization of regulations for the shipping industry. Among other things it provides for traffic separation schemes and revisions to the International Regulations for Preventing Collisions at Sea.

The first SOLAS convention was adopted in 1914 as a result of the Titanic disaster, and was followed by the second in 1929, the third in 1948, and the fourth in 1960. In 1974, it was again amended to include all the amendments up to that time. The 1974 convention has also been amended several times.

2.2.1 Regulation 3

Definitions

- *Free –fall launching* is that method of launching a survival craft whereby the craft with its complement of persons and equipment on board is released and allowed to fall into the sea without any restraining apparatus.

- *International Life-Saving Appliance (LSA)* Code (referred to as "the Code" in this chapter) means the International Life-Saving Appliance (LSA) Code adopted by the Maritime Safety Committee of the Organization by resolution MSC.48(66), as it may be amended by the Organization, provided that such amendments are adopted, brought into force and take effect in accordance with the provisions of article VIII of the present Convention concerning the amendment procedures applicable to the annex other than chapter I.
- *Launching appliance or arrangement* is a means of transferring a survival craft or rescue boat from its stowed position safely to the water.

2.2.2 Regulation 11

Survival craft muster and embarkation arrangements

- Lifeboats and liferafts for which approved launching appliances are required shall be stowed as close to accommodation and service spaces as possible.
- Muster and embarkation stations shall be readily accessible from accommodation and work areas.
- Davit-launched and free-fall launched survival craft muster and embarkation stations shall be so arranged as to enable stretcher cases to be placed in survival craft.

2.2.3 Regulation 17

Rescue boat embarkation, launching, and recovery arrangements

- The rescue boat embarkation and launching arrangements shall be such that the rescue boat can be boarded and launched in the shortest possible time.
- Recovery time of the rescue boat shall be not more than 5 min in moderate sea conditions when loaded with its full complement of persons and equipment. If the rescue boat is also a lifeboat, this recovery time shall be possible when loaded with its lifeboat equipment and the approved rescue boat complement of at least six persons.
- Rescue boat embarkation and recovery arrangements shall allow for safe and efficient handling of a stretcher case. Foul weather recovery strops shall be provided for safety if heavy fall blocks constitute a danger.

2.2.4 Regulation 19

Emergency training and drills

- Familiarity with safety installations and practice musters
- Drills shall, as far as practicable, be conducted as if there were an actual emergency

2.2.5 Regulation 20

Operational readiness, maintenance and inspections

- Operational readiness
- Maintenance
- Maintenance of falls
- Spares and repair equipment
- Weekly inspection
- Monthly inspections
- Periodic servicing of launching appliances and on-load release gear

Measures to prevent accidents with Lifeboats, The Maritime Safety Committee (MSC), at its eighty-first session 10 to 19 May 2006, recalled that at its seventy-fifth session (15 to 24 May 2002), it had considered the issue of the unacceptably high number of accidents with lifeboats in which crew were being injured, sometimes fatally, while participating in lifeboat drills and/or inspections. Chapter III - Life-saving appliances and arrangements. The Chapter includes requirements for life-saving appliances and arrangements, including requirements for life boats, rescue boats and life jackets according to type of ship. The International Life-Saving Appliance (LSA) Code gives specific technical requirements for LSAs and is mandatory under Regulation 34, which states that all life-saving appliances and arrangements shall comply with the applicable requirements of the LSA Code.

2.3 Life Saving Appliances (LSA) Code

International Life-Saving Appliance (LSA) Code (referred to as "the Code" in this chapter) means the International Life-Saving Appliance (LSA) Code adopted by the Maritime Safety Committee of the Organization by resolution MSC.48(66), as it may be amended by the Organization, provided that such amendments are adopted, brought into force and take effect in accordance with the provisions of article VIII of the present Convention concerning the amendment procedures applicable to the Annex other than chapter I.

2.4 Lifeboats

There are different types of lifeboats used on board a ship on the basis of the type of ship and other special requirements. Not all the lifeboats have the same type of releasing mechanisms, for the launching of a lifeboat depends on several other factors.

2.4.1 Open Lifeboats

The open lifeboat was once, by far, the most common type of lifeboat. Due to SOLAS requirements, open lifeboats are no longer installed on ships or platforms.

2.4.2 Partially enclosed lifeboats

Partially enclosed lifeboats are, as the name suggests, lifeboats which are not totally enclosed. The superstructure of the lifeboat has large openings for efficient embarkation, and to allow pick-up of people from the sea. The openings can be covered by tarpaulins or similar arrangements to provide protection from the weather. Launching is performed by means of winches, wires and hooks by controlled lowering to sea level.

Figure 2.1 *Partially enclosed lifeboat*

One area of use for these boats is on passenger vessels, e.g. cruise ships, where lifeboats with a high capacity are required to evacuate a large number of passengers and crew with a relatively small number of lifeboats. Some partially enclosed lifeboats are multifunctional, i.e. they can be used in situations other than evacuation, such as transport of passengers between an anchored cruise ship and shore.

2.4.3 Totally enclosed lifeboats

Totally enclosed lifeboats, often referred to as TEMPSC (totally enclosed motor propelled survival crafts), protect the occupants from weather, waves and cold temperatures. All openings in the superstructure are in the form of hatches which can be closed. The lifeboats are stored in davits, connected to winches, wires and hooks for controlled lowering to sea level.

Figure 2.2 ***Totally enclosed lifeboats***

The lifeboat is boarded in the stored position or at an embarkation deck, and then lowered to the water surface with the occupants on board. The hooks are released when the lifeboat is fully lowered and is afloat, and the lifeboat then maneuvers away from the abandoned vessel or installation under its own power. The propulsion gear consists of a diesel engine, conventional propeller and a propeller nozzle for steering. The conning position is positioned in the stern. Totally enclosed lifeboats are used on ships, drilling rigs and offshore platforms. In general, they have lower weight than free fall lifeboats, which may be a significant argument for ships and floating installations where the deadweight is limited.

2.4.4 Free fall lifeboats

Free fall lifeboats are stored in davits, either hanging by wire and quick release hook or standing on sloping skids, held back by a retaining mechanism. The lifeboat is boarded in the stored position. When boarding is completed and all occupants are secured in their seats, the hook or retaining mechanism is released and the lifeboat falls freely to the surface.

Figure 2.3 *Free fall Lifeboats*

The energy from the fall is converted to a forward motion, securing that the lifeboat moves quickly away from the abandoned vessel. Free fall lifeboats are in wide use on oil platforms and on new drilling rigs. They are also required on certain ships, such as new ore carriers and tankers. The maximum approved launch height is up to 35 meters, depending on model and manufacturer. In full scale trials lifeboats have been dropped from 55 meters.

Some ships have freefall lifeboats, stored on a downward sloping slipway normally on stern of vessel. These free fall lifeboats drop into the water as holdback is released. Such lifeboats are considerably heavier as they are strongly constructed to survive the impact with water. Freefall lifeboats are used for their capability to launch nearly instantly and high reliability in any conditions, and since 2006 are required on bulk carriers that are in danger of sinking too rapidly for conventional lifeboats to be released. Seagoing oil rigs are also customarily equipped with this type of lifeboat

Freefall Lifeboats are designed as escape capsules for crew abandoning ship or a rig, and provide a safe and swift means of evacuation. They have been used for a number of years and have been responsible for saving many lives. For the safety of lives, the regulators have always considered the lifeboats to be the most important and the life rafts more as a supplement. Among seamen, however, for many years there has been a lack of confidence in lifeboats, which have been seen as rather difficult and dangerous to launch. There has been a need and a requirement for lifeboat exercises in which all members of the crew had to participate.

Figure 2.4 *Free fall lifeboat on davit*

The need for lifeboats as opposed to other lifesaving apparatus is based on the concept that the survival craft should be capable of being navigated independently. This stems from an era when communications were poor or even non-existent. There are numerous examples of survivors undertaking remarkable feats of seamanship in navigating lifeboats over long distances to a safe haven. It is almost inconceivable that this would be required in these days of Global Maritime Distress and Safety System (GMDSS) when a vessel in difficulty can quickly and automatically summon assistance

Free-fall lifeboats have a number of advantages when compared with conventional davit-launched lifeboats. These advantages include:

• faster and more efficient evacuation,

- a single stern-mounted lifeboat instead of port and starboard lifeboats,
- means for secondary launching,
- always stowed in the ready-to-launch position,
- boat is propelled clear of the vessel during the launch,
- fewer tasks required for launch,
- safer evacuation, particularly from vessels having a high freeboard, and
- improved economy over a 20-year period.

Since it was formed in 1989, the MAIB (Marine Accident Investigation Branch) has received a number of reports about seafarers being injured, and sometimes killed, in accidents involving lifeboats. Scrutiny of the data held by the MAIB (Marine Accident Investigation Branch) suggests that anyone using a lifeboat, be it in a drill or a genuine evacuation, runs a risk of being injured or even killed.

Recently, free-fall lifeboats are becoming popular due to the fact that many life threatening accidents have occurred with conventional lifeboat systems. Most of the accidents happened during launching and after lowering the boat into the rough seas in high wind. During launch, the lifeboat may hit the sides of the distressed vessel, become severely damaged and occupants may fall into the sea causing injury and even death. It is impossible to launch the lifeboat if the parent vessel is listing significantly or if the falling becomes tangled. After lowering the boat into the water, it may be unable to move away from the distressed vessel if high seas and winds continually push the lifeboat towards the parent vessels or due to the inability of the engine to start. These situations become even more dangerous during fire or when the potential for an explosion exists. Many of the risks associated with conventional lifeboat systems have been substantially reduced by the free-fall lifeboat system. These problems are minimized with the free-fall lifeboat because it is not lowered into the sea. The free-fall lifeboat falls freely into the sea, generating kinetic energy as it does so. The kinetic energy, which is developed, propels the lifeboat away from the distressed vessel during and immediately after water entry. The lifeboat moves away from the danger even if the engine does not operate.

2.5 General Description

A lifeboat is a kind of boat that is used to escape a larger sinking structure such as a cruise ship, commercial vessel, or aircraft that has landed in the water. A lifeboat is intended only for use in case of an emergency. Lifeboats may also be used if the larger structure is not sinking but is experiencing some other sort of disaster such as a fire that has become out of control. Lifeboats are almost always intended for use solely in the event of an emergency.

Lifeboats have traditionally been made out of wood, and some still are. However, these days, it is very common for a lifeboat to be made out of durable plastic or water-resistant tarp. A plastic lifeboat is usually inflatable. Furthermore, they are often referred to as life rafts. Most airplanes, especially commercial airplanes, come equipped with life rafts which are to be used in the event of an emergency water landing.

Free fall lifeboats are totally enclosed lifeboats, and is similar to the enclosed lifeboats in some ways. Openings for embarkation etc. are covered by watertight hatches which must be closed before launch. Propulsion is provided by an inboard diesel engine and a conventional propeller, and steering is provided by a propeller nozzle. Navigation is performed from the conning position, which on most free fall lifeboats is positioned in the aft of the boat.

Free-fall lifeboats are stored and boarded in the davit. They are stored on sloping longitudinal skids which are approximately the same length as the craft, with locking devices which hold it in position. When the boat is released it slides longitudinally off the skids and falls freely to the water surface without any ropes or wires connecting it to the ship or installation from which it is launched. Some models have an alternative arrangement without skids, where the lifeboat is released in a direct vertical direction, and enters the water with no initial forward velocity. In both alternatives, the lifeboat hits the water with the bow first at a forward heeling angle, which causes it to move forward and away from the ship or installation. The launching process is illustrated in Figure 18, which shows a full size life boat trial performed by launching the lifeboat from a steel frame which acts as the davit. For the trial, the steel frame is suspended in a floating crane.

Figure 2.5 ***Full scale free fall lifeboat trial***

Compared to conventional lifeboats, free-fall lifeboats provide a very quick escape, and the launching method involves a low risk for incidents during the launch which may occur for conventional lifeboats. Free fall lifeboats are therefore in use on many oil rigs, platforms, bulk carriers and ships which carry dangerous cargo.

Free fall lifeboat davits are purpose built for each lifeboat model, and are able to launch the lifeboat both by the free-fall method and a secondary launching method involving wires, winches and a lifting frame. They are also capable of recovering the lifeboat to the stored position. A wide variety of lifeboat models is available with different sizes and specifications, depending on the needs of the vessel in question and the applicable rules and regulations.

Figure 2.6 ***Water entry phase***

Figure 2.7 *Water exit phase*

2.6 Free-Fall Lifeboats Stowage Plan for Equipment :

It is important that a lifeboat be quite durable, as the passengers sometimes have to wait quite a while before they are rescued. Many of the boats come equipped with materials that allow passengers to protect themselves from the elements until help arrives. Some even come with a package of materials which may include a first aid kit, oars, flares, mirrors which can be used for signaling, food, potable water, tools to catch drinkable rainwater, and fishing equipment. Some lifeboats are prepared for self-rescue. This means that they have supplies such as navigational equipment and a small engine or sail.

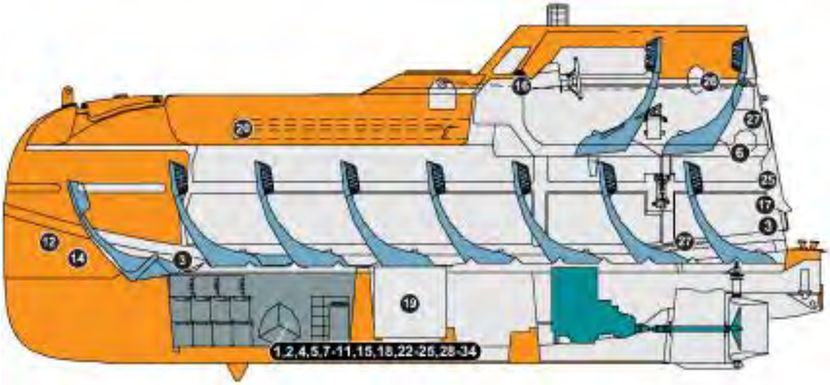


Figure 2.8 *Stowage Plan of Free fall lifeboats*

1) BUOYANT BAILER
2) BUCKETS
3) HATCHETS
4) CONTEINER WITH DISTRESS SIGNAL AS :
   HAND FIARES
   ROCKET PARACHUTE FIARES
   BUOYANT SMOKE SIGNALES ORANGE
   DAYLIGHT SIGNAL MIRROR
   JACKKNIFE WITH TIN OPENER AND
   MARLING, SPIKE
   ELECTR. TORCH WITH 1 SPARE BULB AND 2
   SPARE BATTERIES
5) TIN OPENER
6) FIRE EXTINGUISHER
7) FISHING TACKLE
8) WHISTLE
9) ITRS. CONTAINERS WITH DRINK WATER
10) LIFEBOAT FOOD RATION
11) DRINK CUPS

12) SEA ANCHOR TOWING AND MORING LINE
13) PAINTERS
14) BUOYANT LINES
15) FIRST AID KIT FOR LIFEBOATS WITH SEATHICKNESS
16) LIFEBOAT COMPASS
17) MANUAL BILGE PUMP
18) RADAR REFLECTOR
19) DIESEL-FUEL
20) BOAT HOOKS
21) SEARCH LIGHT
22) THERMAL PROTECTIVE AIDS
23) SURVIVAL-MANUAL
24) EMBARKATION LADDER LOOSE EQUIPMENT
25) KEY FOR SEALTS/FUEL TANK
26) SET LIFTING SLINGS
27) EMERGENCY TILLER
28) STRAPS FOR STRETCHER

SPARE PARTS FOR THE ENGINE :

29) VEE-BELT
30) FUEL FILTER
31) PUMP IMPELLER
32) OIL FILTER
33) SET OF COMMON TOOLS
34) OIL DRAIN PUMP

2.7 Risk Assessment

Risk assessment is typically applied as an aid to the decision-making process. As options are evaluated, it is critical to analyze the level of risk introduced with each option. The analysis can address financial risks, health risks, safety risks, environmental risks and other types of business risks. An appropriate analysis of these risks will provide information which is critical to good decision making, and will often clarify the decision to be made. The information generated through risk assessment can often be communicated to the organization to help impacted parties understand the factors which influenced the decision.

Risk assessment is not a new field. Formal risk assessment techniques have their origins in the insurance industry. As the industrial age progressed, and businesses began to make large capital investments, it became a business necessity to understand the risks associated with the enterprises being undertaken and to be able to manage the risk using control measures and insurance. For insurance companies to survive, it became imperative that they be able to calculate the risks associated with the insured activities. Risk assessment is the process of gathering data and synthesizing information to develop an understanding of the risk of a particular enterprise. To gain an understanding of the risk of an operation, one must answer the following three questions:

i) What can go wrong?

ii) How likely is it?

iii) What are the impacts?

To use a systematic method to determine risk levels, the Risk Assessment Process is applied. This
process consists of four basic steps:

i) *Hazard Identification*

ii) *Frequency Analysis*

iii) *Consequence Analysis, and*

iv) *Risk Evaluation*

The level of information needed to make a decision varies widely. In some cases, after identifying the hazards, qualitative methods of assessing frequency and consequence are satisfactory to enable the risk evaluation. In other cases, a more detailed quantitative analysis is required. The Risk Assessment Process is illustrated in Figure 11, and the results possible from qualitative and quantitative approaches are described.

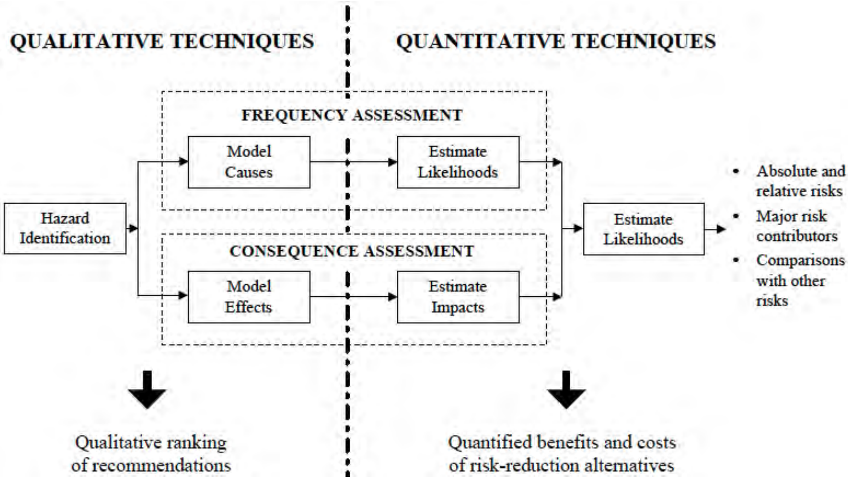


Figure 2.9 *The risk assessment process*

There are many different analysis techniques and models that have been developed to aid in conducting risk assessments A key to any successful risk analysis is choosing the right method (or combination of methods) for the situation at hand. For each step of the Risk Assessment Process, this Chapter provides a brief introduction to some of the analysis methods available and suggests risk analysis approaches to support different types of decision making within the maritime and offshore industries. For more information on applying a particular method or tool, consult the references noted.

2.7.1 Hazards or Threats

Hazards or threats are conditions which exist which may potentially lead to an undesirable event.

2.7.2 Controls

Controls are the measures taken to prevent hazards from causing undesirable events. Controls can be physical (safety shutdowns, redundant controls, conservative designs, etc.), procedural (written operating procedures), and can address human factors (employee selection, training, supervision).

2.7.3 Event

An event is an occurrence that has an associated outcome. There are typically a number of potential outcomes from any one initial event which may range in severity from trivial to catastrophic, depending upon other conditions and add-on events.

2.7.4 Risk

Now we are ready to provide a technical definition of the term risk. Risk is composed of two elements, frequency and consequence. Risk is defined as the product of the frequency with which an event is anticipated to occur and the consequence of the event's outcome.

Risk = Frequency x Consequence

2.7.5 Frequency

The frequency of a potential undesirable event is expressed as events per unit time, usually per year. The frequency should be determined from historical data if a significant number of events have occurred in the past. Often, however, risk analyses focus on events with more severe consequences (and low frequencies) for which little historical data exist. In such cases, the event frequency is calculated using risk assessment models.

2.7.6 Consequence

Consequence can be expressed as the number of people affected (injured or killed), property damaged, amount of spill, area affected, outage time, mission delay, dollars lost, etc. Regardless of the measure chosen, the consequences are expressed “per event”. Thus the above equation has the units “events/year” times “consequences/event”, which equals “consequences/year”, the most typical quantitative risk measure.

2.7.7 Overview of Risk Assessment Methods

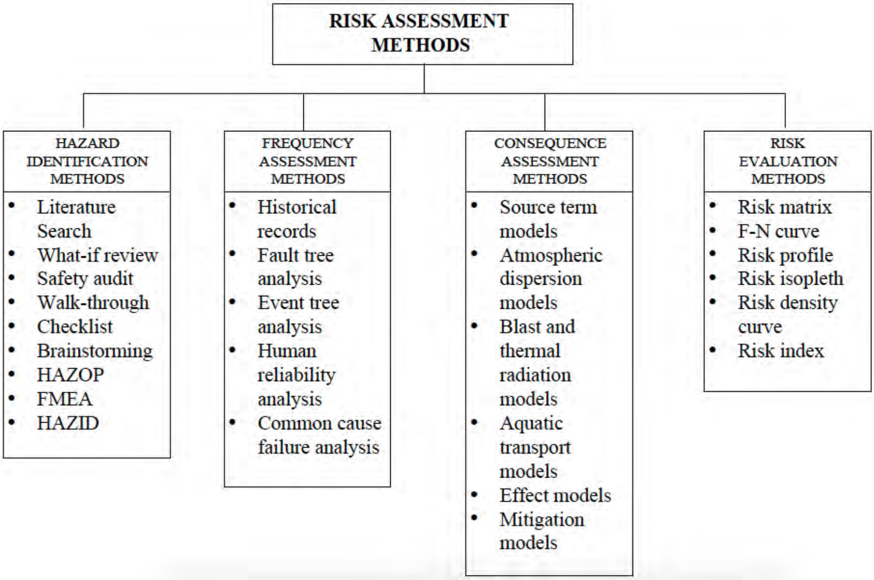


Figure 2.10 *Overview of risk assessment*

2.8 Failure Modes and Effects Analysis (FMEA) Method

FMEA is an inductive reasoning approach that is best suited for reviews of mechanical and electrical hardware systems. This technique is not appropriate to broader marine issues such as harbor transit or overall vessel safety. The FMEA technique, considers how the failure mode of each system component can result in system performance problems and ensures that appropriate safeguards against such problems are in place. This technique is applicable to any well-defined system, but the primary use is for reviews of mechanical and electrical systems (e.g., fire suppression systems, vessel steering/propulsion systems). It also is used as the basis for defining and optimizing planned maintenance for equipment because the method systematically focuses directly and individually on equipment failure modes. FMEA generates qualitative descriptions of potential performance problems (failure modes, root causes, effects, and safeguards) and can be expanded to include quantitative failure frequency and/or consequence estimates.

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service. “Failure modes” means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual. “Effects analysis” refers to studying the consequences of those failures. Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones. Failure modes and effects analysis also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during design to prevent failures. Later it’s used for control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.

FMEA method was conducted to analyze the potential for errors or failures in the system and the potential identified will be classified according to the magnitude of potential failure and its effect on the process.

2.8.1 Failure Modes and Effects Analysis (FMEA) Worksheet

The FMEA (Failure Mode and Effects Analysis) Worksheet is a tool to help you systematically plan for possible problems with a product or process.

Item	Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Design Controls (Prevention)	Current Design Controls (Detection)	Detection	RPN	Recommended Action(s)	Responsible Person	Actions Taken	Revised Rankings			
												Target Completion Date	Effective Completion Date	Severity	Occurrence	Detection	RPN
1	2	3	4	5	6	7	8	8	9	10	11		12				

Figure 2.11 *FMEA Worksheet*

1. An “item” is the focus of the FMEA project.

2. A “function” is what the item or process is intended to do, usually to a given standard of performance or requirement.

3. A “failure mode” is the manner in which the item or operation potentially fails to meet or deliver the intended function and associated requirements.

4. An “effect” is the consequence of the failure on the system or end user.
5. “Severity” is a ranking number associated with the most serious effect for a given failure mode

6. A “cause” is the specific reason for the failure, preferably found by asking “why” until the root cause is determined.

7. “Occurrence” is a ranking number associated with the likelihood that the failure mode and its associated cause will be present in the item being analyzed.

8. “Controls” are the methods or actions currently planned, or are already in place, to reduce or

eliminate the risk associated with each potential cause.

9. “Detection” is a ranking number associated with the best control from the list of detection-type controls, based on the criteria from the detection scale.

10. “RPN” is a numerical ranking of the risk of each potential failure mode/cause, made up of the arithmetic product of the three elements: severity of the effect, likelihood of occurrence of the cause, likelihood of detection of the cause.

11. “Recommended actions” are the tasks recommended by the FMEA team to reduce or eliminate the risk associated with potential causes of failure. They should consider

12. “Action Taken” is the specific action that is implemented to reduce risk to an acceptable level.

For this bachelor thesis will be use FMEA worksheet by IEC 60812 standard.

Indenture level: Sheet no: Operating mode:			Design by: Item: Revision:					Prepared by: Approved by:				FMEA
Item ref.	Item description-function	Failure entry code	Failure mode	Possible failure causes	Symptom detected by	Local effect	Effect on unit output	Compensating provision against failure	Severity class	Failure rate F/Mhr	Data source	Recommendations and actions taken

Figure 2.12 *IEC 60812 FMEA Worksheet Standard*

2.8.2 Severity Criteria

In general, severity assesses how serious the effects would be should the potential risk occur. Ranking Guidelines based on International Marine Contractors Association (IMCA) M 166 2002.

Table 2.1 ***Severity criteria***

Category	Degree	Description
I	Minor	Functional failure of part of a machine or process with no potential for injury, damage or pollution
II	Critical	Failure will probably occur without major damage to system, pollution or serious injury
III	Major	Major damage to system with a potential for serious injury to personnel and minor pollution
IV	Catastrophic	Failure causes complete system loss with a high potential for fatal injury and major pollution.

2.8.3 Probability of Occurrence Criteria

In general, the probability of occurrence evaluates the frequency that potential risk(s) will occur for a given system or situation. The probability score is rated against the probability that the effect occurs as a result of a failure mode.

Table 2.1 ***Occurence criteria***

Level	Probability	Description
A	10^{-1}	Likely to occur frequently
B	10^{-2}	Probable – may occur several times in the life of an item
C	10^{-3}	Occasional – may occur sometime in the life of an item
D	10^{-4}	Remote – unlikely to occur but possible
E	10^{-5}	Improbable – unlikely to occur at all

2.8.4 Detectability Criteria

In general, detectability is the probability of the failure being detected before the impact of the failure to the system or process being evaluated is detected. The detectability score is rated against the ability to detect the effect of the failure mode or the ability to detect the failure mode itself.

2.9 Frequency Analysis Method

After the hazards of a system or process have been identified, the next step in performing a risk assessment is to estimate the frequency at which the hazardous events may occur. The following are some of the techniques and tools available for frequency assessment.

2.9.1 Event Tree Analysis (ETA)

Event tree analysis utilizes decision trees to graphically model the possible outcomes of an initiating event capable of producing an end event of interest. This type of analysis can provide qualitative descriptions of potential problems (combinations of events producing various types of problems from initiating events) and quantitative estimates of event frequencies or likelihoods, which assist in demonstrating the relative importance of various failure sequences. Event tree analysis may be used to analyze almost any sequence of events, but is most effectively used to address possible outcomes of initiating events for which multiple safeguards are in line as protective features.

2.9.2 Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is a deductive analysis that graphically models (using Boolean logic) how logical relationships among equipment failures, human errors and external events can combine to cause specific mishaps of interest. Similar to event tree analysis, this type of analysis can provide, qualitative descriptions of potential problems (combinations of events causing specific problems of interest) and quantitative estimates of failure frequencies/likelihoods and the relative importance of various failure sequences/contributing events. This methodology can also be applied to many types of applications, but is most effectively used to analyze system failures caused by relatively complex combinations of events. The logical structure of a fault tree can be expressed in terms of Boolean algebraic equa- tions. Boolean algebra is used to reduce equations composed of variables that can take on only two values. It is commonly used to describe the operations of power switching grids, computer memories, or logic diagrams.

The benefits of FTA include :

- *Identify failures deductively*, Using the logic of a detailed failure analysis and tools like 5 whys, FTA helps the team focus on the causes of each event in a logical sequence that leads to the failure.

- *Highlight the important elements of system related to system failure,* The FTA process may lead to a single component or material that causes many paths to failure, thus improving that one element may minimize the possibly of many failures.

- *Create a graphical aid for system analysis and management,* Apparently managers like graphics, and for complex systems it helps to focus the team on critical elements.

- *Provides an alternatively way to analysis the system,* FMEA, RBD and other tools permit a way to explore system reliability, FTA provide a tool that focuses on failure modes one at a time. Sometimes a shift in the frame of reference illuminates new and important elements of the system.

- *Focus on one fault at a time,* The FTA can start with an overall failure mode, like the car not starting, or it can focus on one element of the vehicle failing, like the airbag not inflating as expected within a vehicle. The team chooses the area for focus at the start of the analysis.

- *Expose system behavior and possible interactions,* FTA allows the examination of the many ways a fault may occur and may expose non-obvious paths to failure that other analysis approaches miss.

- *Account for human error,* FTA includes hardware, software, and human factors in the analysis as needed. The FTA approach includes the full range of causes for a failure.

The steps of FTA by Hank Marquis (2006) include :

- Select a top level event for analysis.

- Identify faults that could lead to the top level event.

- For each fault, list as many causes as possible in boxes below the related fault

- Draw a diagram of the "fault tree."

- Continue identifying causes for each fault until you reach a root cause, or one that you can do something about.

- Consider countermeasures.

2.9.3 Analysis of Historical Data

The best way to assign a frequency to an event is to research industry databases and locate good historical frequency data which relates to the event being analyzed. Before applying historical frequency data, a thoughtful analysis of the data should be performed to determine its applicability to the event being evaluated. The analyst needs to consider the source of the data, the statistical quality of the data (reporting accuracy, size of data set, etc.) and the relevance of the data to the event being analyzed. For example, transportation data relating to helicopter crashes in the North Sea may not be directly applicable to Gulf of Mexico operations due to significant differences in atmospheric conditions and the nature of helicopter operating practices. In another case, frequency data for a certain type of vessel navigation equipment failure may be found to be based on a very small sample of reported failures, resulting in a number which is not statistically valid.

2.10 Risk Matrix

Another method to characterize risk is categorization. In this case, the analyst must define the likelihood and consequence categories to be used in evaluating each scenario and define the level of risk associated with likelihood/consequence category combination. Frequency and consequence categories can be developed in a qualitative or quantitative manner. Qualitative schemes (i.e., low, medium, or high) typically use qualitative criteria and examples of each category to ensure consistent event classification. Multiple consequence classification criteria may be required to address safety, environmental, operability and other types of consequences.

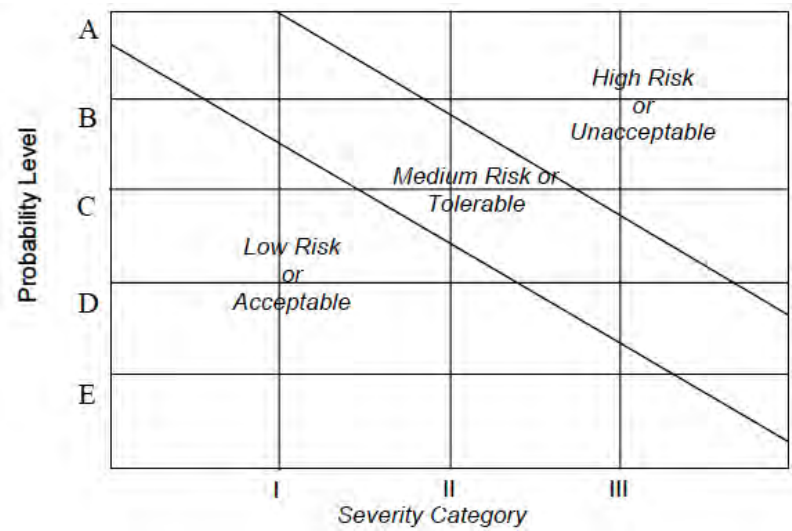


Figure 2.13 ***IMCA M 166 2002***

CHAPTER III
METHODOLOGY

This thesis will discuss the Risk Assessment on a Free-Fall Lifeboat with the purpose of determining whether an Free-Fall Lifeboat have a risk that is acceptable or not, create awareness about the dangers and risks obtained from the Free-Fall Lifeboat. It aims to reduce the possibility of danger by adding steps - necessary control measures and precautions. The assessment also prioritize hazards and help determine whether the existing control measures are adequate. A risk assessment carried out by the "FMEA (Failure Modes and Effect Annalysis)" method. Here is a schematic of the research methodology to be done:

3.1 Background and Problem Identification

The first stage is to identify and formulate the problem. In this thesis is to analyze problems taken risks in the process of lifeboat Free-fall launching. However, the extent to which these risks will occur and of whether the consequences that would arise. Hence the need for a measurement of risk, namely the risk assessment method FMEA (Failure Modes and Effects Analysis) which is based on data that have been obtained as well as the standards used to certify whether the risk is acceptable or not and then if it can not be accepted we need some mitigation of the consequences of risk.

3.2 Study Literatures

The literature study was done by collecting various references to support the work and writing of this bachelor thesis. References required regarding Launching operation, Manufacture of Free-fall Lifeboat, some Journal, book, paper, internet and the data that is required in order to support the work of bachelor thesis.

3.3 Data Collection

Collecting data is done in order to support the thesis progress. The collection of data that are needed include informations the process of Free-fall lifeboat launching, General Arrangement, Launching Introduction and the data is that is required in order to support the work of the bachelor thesis.

3.4 Identify Process of Free-fall Launching and Recovery

At this stage the understanding of the process Free-fall lifeboat launching consisting of Launch Behavior of Free-fall Lifeboat, Launch Simulation of a Free-fall Lifeboat

Figure 3.1 *Scope of process*

3.5 Data Analyze Using FMEA Worksheet

Potential cause of failure describes how a process failure could occur, in terms of something that can be controlled or corrected. The goal is to describe the direct relationship that exists between the cause and resulting process failure mode. The data in order from PT. Surya Segara and based on DNV – OS – E406. Also the standard of FMEA Worksheet is based on International Electrotechnical Commission (IEC) 60812 Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA).

3.6 Frequency Analysis, Consequence Analysis and Detection Analysis

Analysis of the data in order to determine the levels of risk. The standards for frequency analysis, consequence analysis, and detection analysis is based on International Marine Contractors Association (IMCA M 166). Also the number of frequency are generated from Basis Event from several source such as DNV Technica 1983, ANNEX III: FSA/LSA/BC: FREE-FALL LIFEBOAT AS RCO, and UK HSE RR599 2007.

3.7 Risk Evaluation

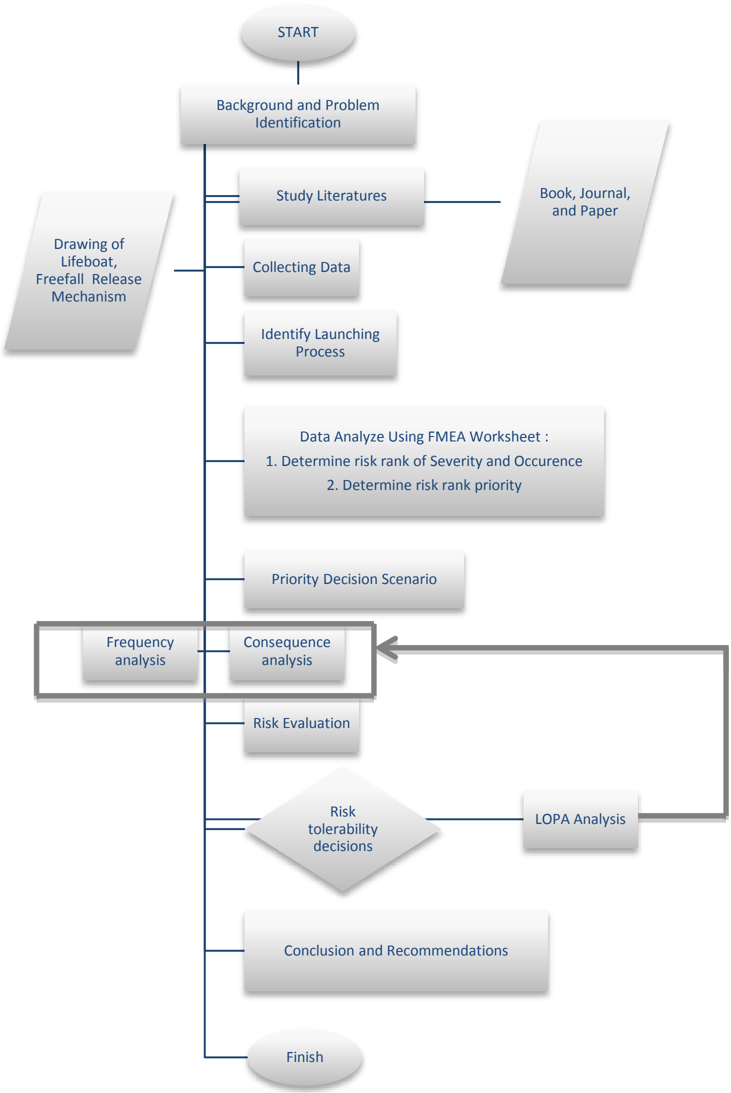
Analysis of the data in order to determine the levels of danger posed using the results of risk priority. By using Table Occurance, FTA and ETA for frequency analysis and severity from IMCA for consequence analysis.

3.8 Mitigation

If there are any intolerable risk after the risk evaluation, then will be do a mitigation act to minimize those risk by using LOPA method.

3.9 Conclusion and Recommendation

Make conclusions based on the results obtained and suggestions for further research development.


START
Background and Problem Identification
Study Literatures
Book, Journal, and Paper
Drawing of Lifeboat, Freefall Release Mechanism
Collecting Data
Identify Launching Process
Data Analyze Using FMEA Worksheet :
1. Determine risk rank of Severity and Occurence
2. Determine risk rank priority
Priority Decision Scenario
Frequency analysis
Consequence analysis
Risk Evaluation
Risk tolerability decisions
LOPA Analysis
Conclusion and Recommendations
Finish

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CHAPTER IV
DATA ANALYSIS AND FINDINGS

4.1 Data Analysis

On this chapter will be discussed further on about all data that required. Analyze data will be appropriated to the scope of problems which had determined.

4.1.2 General Arrangement of Free-Fall Davit :

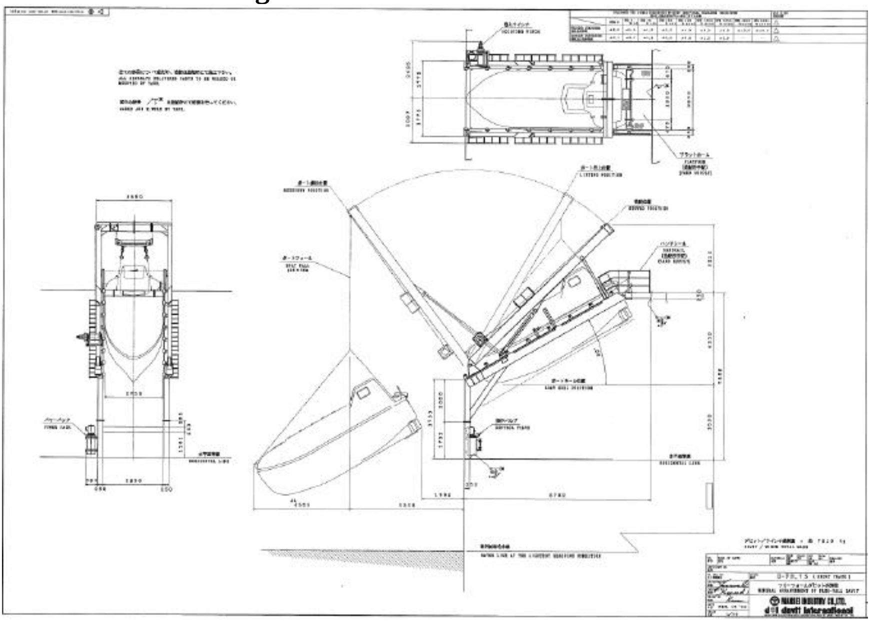


Figure 4.1 *General Arrangement*

4.1.3 Launching Operation

Analyzing by overview step for launching operation will be shown as figure 4.2 below

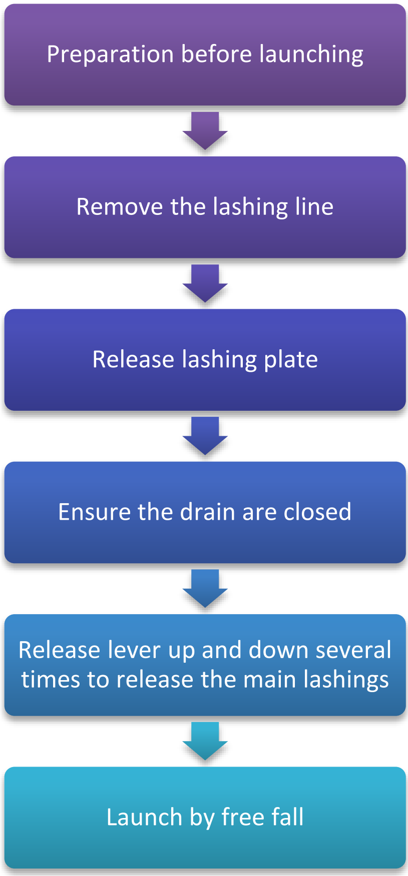


Figure 4.2 ***Launching operation***

4.1.4 Retrieval Operation

Analyzing by overview step for retrieval operation will be shown as figure 4.3 below

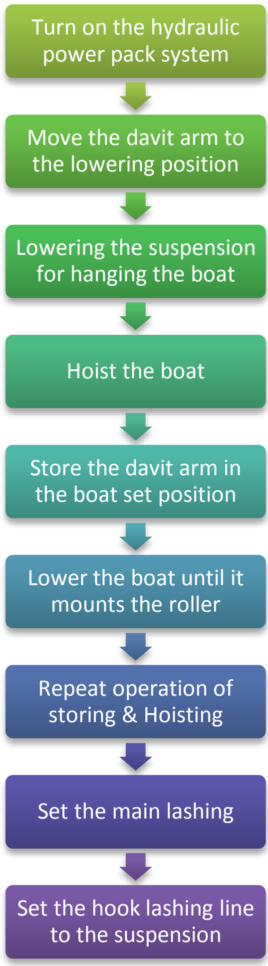


Figure 4.3 ***Retrieval operation***

4.1.5 Launch Behavior of Free-Fall Lifeboats :

The configuration of a free-fall lifeboat at the beginning of a launch is shown in figure 6 The free-fall height is measured from the water surface to the lowest point on the lifeboat when the lifeboat is in its launch position. The primary factors that affect the launch performance of a free-fall lifeboat are its mass and mass distribution, the length and angle of the launch ramp, and the free-fall height. These parameters interact to affect the orientation and velocity of the lifeboat at the time of water impact, the acceleration forces experienced by the occupants, and the headway of the lifeboat immediately after water entry.

The launch of a free-fall lifeboat can be divided into four distinct phases. These are the ramp phase, the rotation phase, the free-fall phase, and the water entry phase. The ramp phase is that part of the launch when the lifeboat is sliding along the launch ramp. The ramp phase ends when the center-of-gravity (CG) passes the end of launch ramp and the lifeboat begins to rotate; this rotation marks the beginning of the rotation phase. The rotation phase ends when the lifeboat is no longer in contact with the launch ramp. This is the beginning of the free-fall phase; the lifeboat is falling freely through the air. The water entry phase begins when the lifeboat first contacts the surface of the water and continues until the lifeboat has returned to the surface and is behaving as a boat.

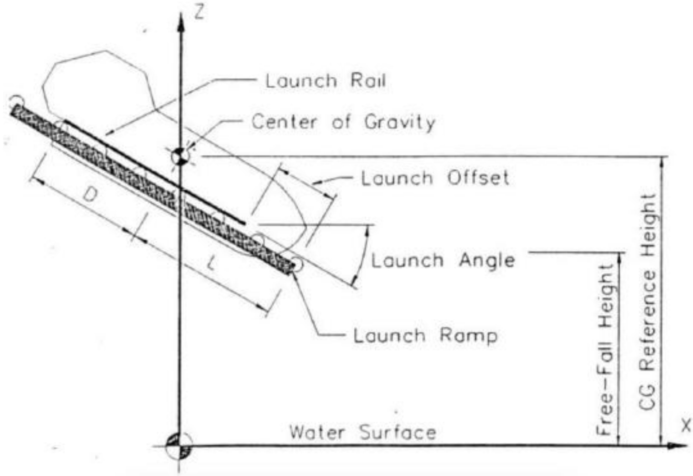


Figure 4.4 *Launch behavior of free-fall lifeboats*

4.1.6 Launch Simulation of a Free-fall Lifeboat :

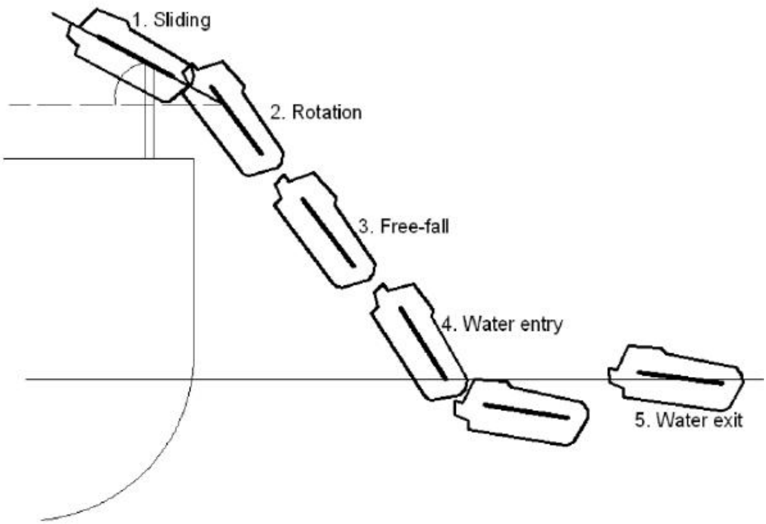


Figure 4.5 *Different phases of a free-fall lifeboat*

4.1.6.1 Sliding Phase
Sliding of boat begins when it is released and ends when the center of gravity (**G**) is crossing a point close to the end of the launch skid. During this phase the lifeboat is constrained to slide along the skid, so it cannot rotate. The velocity of the lifeboat at the end of the launch skid is mostly dependent upon the length of the launch skid in front of the lifeboat.

4.1.6.2 Rotation Phase
This rotation phase of the free-fall launch begins as the sliding ends and it continues until the boat is no longer in contact with the launch skid

4.1.6.3 Free-fall Phase
The free-fall phase of the launch begins at the end of the rotation phase and continues until the boat touches the water surface.

4.1.6.4 Water Entry Phase
The water entry of the free-fall lifeboat begins at the end of the free fall phase. During the water entry phase, the boat is acted upon by hydrostatic and hydrodynamic forces. When the lifeboat first hit the water surface, high accelerations are experienced by the bow of the boat, this is bow impact. At that time, couple formed by the fluid forces and the weight of the lifeboat causes the angular momentum induced during the rotation phase to be reversed and the boat to return to even keel and this is stern impact.

4.1.7 Launching and Recovery Operation

Preparation Before Launching :

1. Check to ensure that there is no obstacle in the boat Fall path

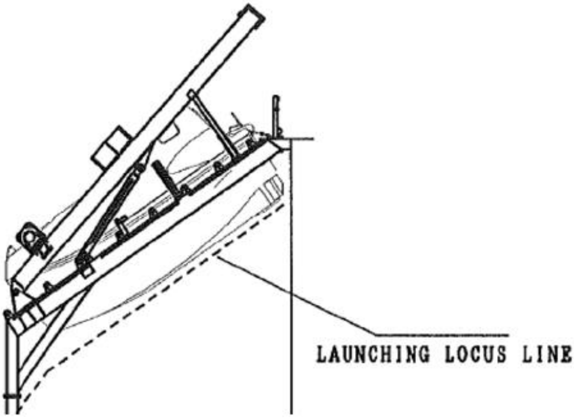


Figure 4.6 *Preparation before launching*

2. Remove the Lasing Line

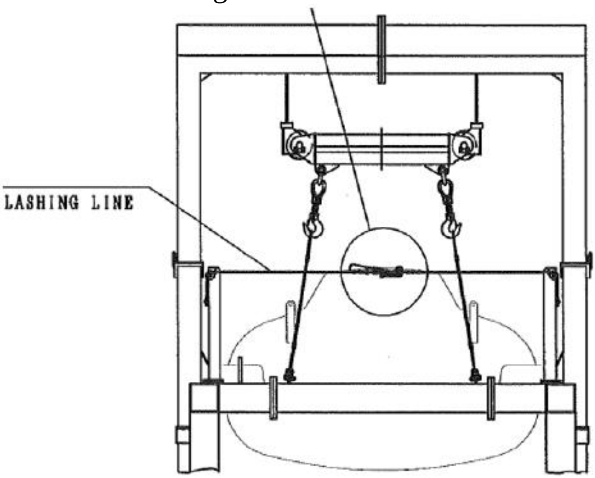


Figure 4.7 *Preparation before launching*

3. Check to Ensure that the lashing plate has been released
4. Check to ensure that the drain of the boat is closed

Launch by Free Fall :

1. The operator checks to ensure that preparation of the boat launching has been made without fault.
2. The crew members board the boat from the rear hatch.
3. The operator boards the boat last, and will closed the hatch from within.

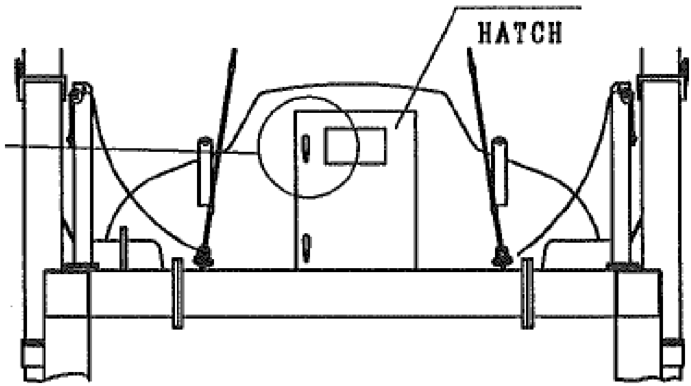


Figure 4.8 *Hatch*

4. The operator checks to ensure that crew members are wearing seat belt securely.
5. The operator takes a seat in the control compartment and wears a seat belt.
6. The operator starts the engine in accordance with the boat operation manual.
7. The procedures to start the engine are described on the side of the control compartment.
8. The operator releases a pin with which the release lever has been secured.
9. The operator operates the release lever up and down several times to release the main lashing.

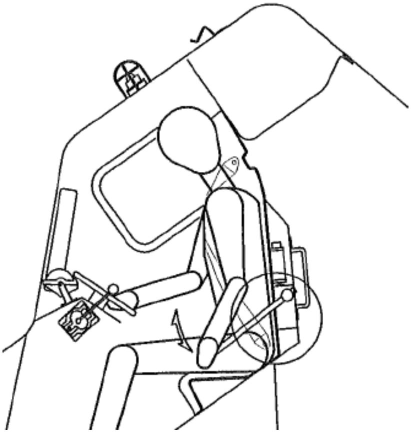


Figure 4.9 *Release lever*

10. Releasing of the main lashings allows the boat to be launched by a free fall.

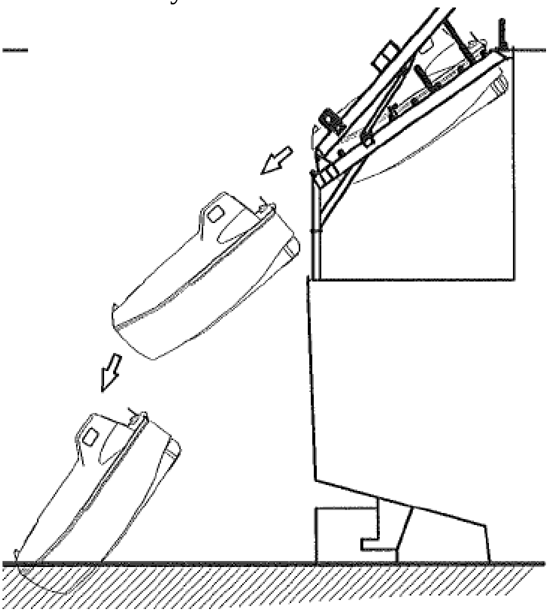


Figure 4.10 *Launch by Free fall*

Recovery Operation :

1. Turn the main switch of the ship "on".

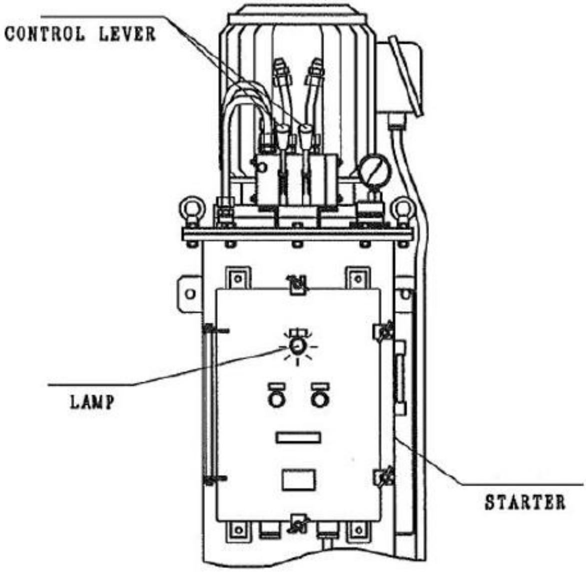


Figure 4.11 *Hydraulic power pack*

2. The operator operates the control lever to move the davit arm outboard to the boat lowering position.
3. The operator operates the control lever to lower the suspension to a position which allows the wire rope for hanging boat to be set.

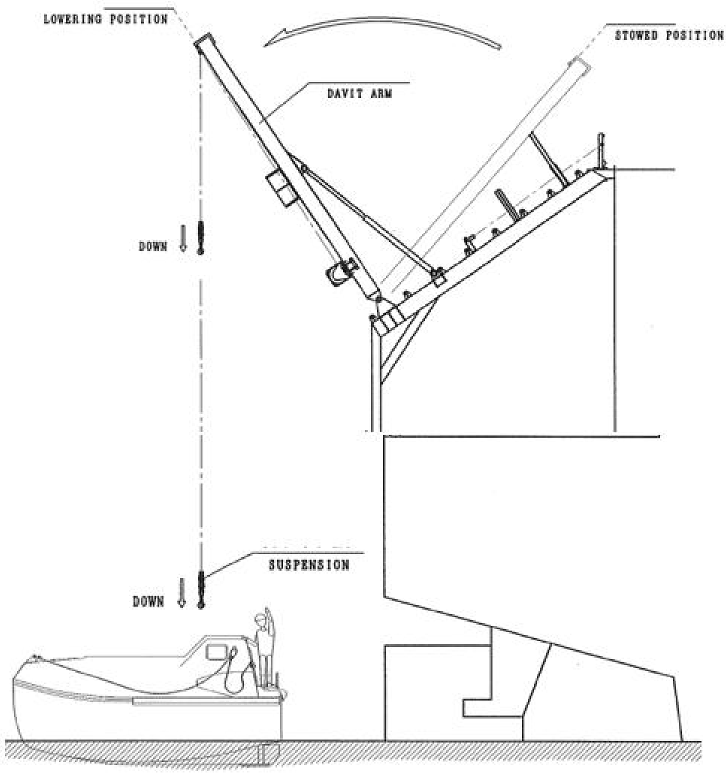


Figure 4.12 *Recovery operation*

4. The operator in the boat sets the wire rope for hanging boat to the suspension, after giving a signal to the operator on the depot ship, the operator in the boat takes a seat in the control compartment and wears a seat belt. Stop the engine in accordance with the boat operation manual.
5. The operation hoist the boat after ensuring that the engine of the boat has come to a stop. Stop the hoisting 100mm before the position where the traverse will hit against the hinge block and the wire rope supporter.

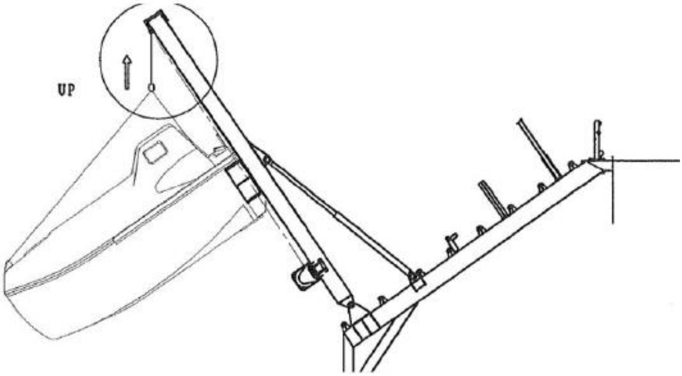


Figure 4.13 *Lifting position*

6. The operator operates the control lever to store the davit arm in the boat set position.
7. Assign the operator to the platform and stop the boat in a position where the boat will not touch the davit rear span.
8. The operator operates the control lever to lower the boat until it mounts the roller.
9. The operator operates the control lever to repeat operation of storing and hoisting. The boat will be moved to a position which allows the boat to be set to the main lashing.

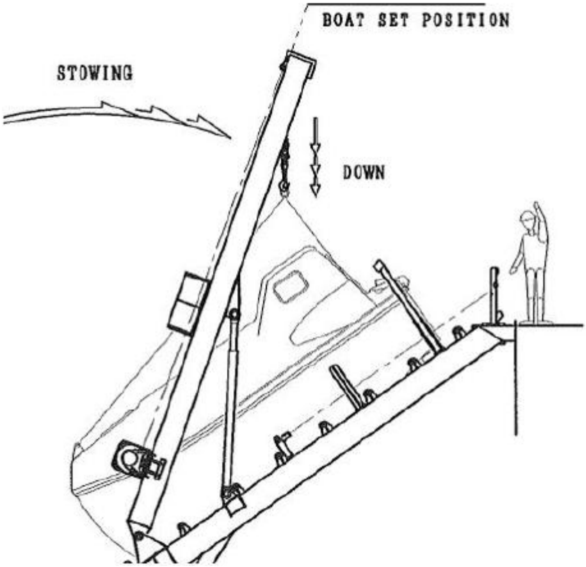


Figure 4.14 *Stowed position*

10. Set the main lashing in accordance with the boat operation manual. The operation checks to ensure that the main lashing have been set.

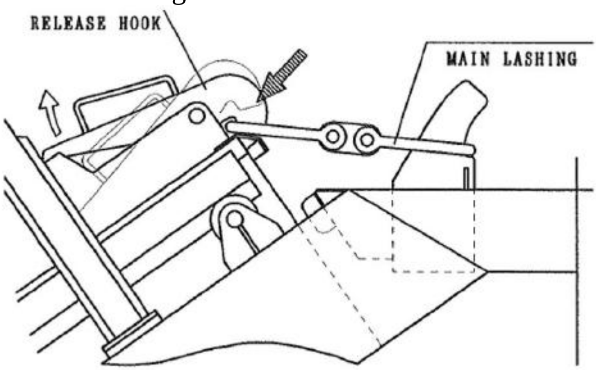


Figure 4.15 *Main lashing*

11. The crew members board from the boat to the depot ship from the rear hatch.
12. Lower the suspension until the wire rope for hanging boat comes fully loose.

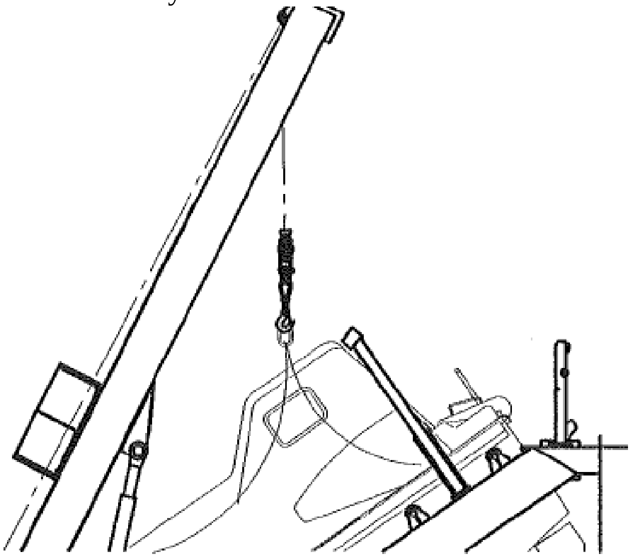


Figure 4.16 *Release the suspension*

13. Release the wire rope for hanging boat to set it to the set plate.
14. The operator operates the control lever to move the davit arm to the stowed position. The davit arms will hit against the arm support and stop automatically, but ensure to operate the lever by visual check.
15. Set the hook lashing line to the suspension.
16. Set the lashing line
17. Set of the lashing plate to the lashing lines allows the automatic setting.
18. The main power of the power pack is turned “off”
19. Turn the main switch of the ship “off”.

4.2 Risk Identification

The FMEA Worksheet is laid out in the logical progression of an FMEA investigation and analysis. The objective of worksheet is to ensure that all steps in the study have been addressed.

Risk identification on this Bachelor Thesis do by understanding function of process launching which will be analyze. The result from risk identification is scenario of all failure modes. Example of failure modes list on FMEA worksheet has attached below.

For the example is the risk identification of Retrieval Arrangement (RVL) which refer to Operation Manual of free fall lifeboat.

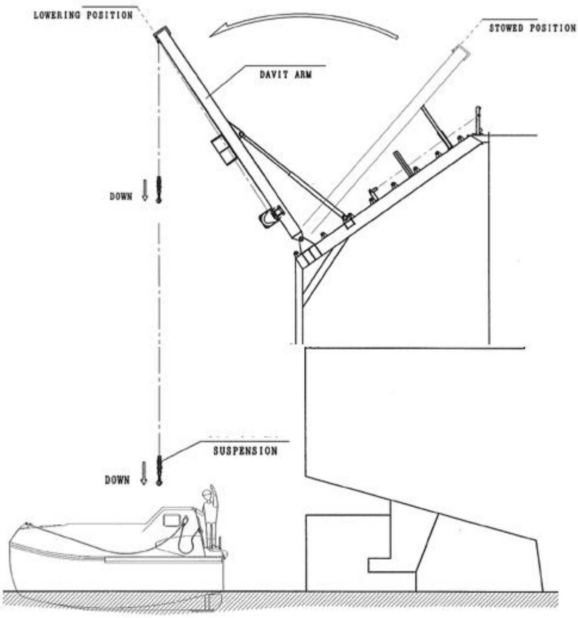


Figure 4.17 *Lifting position*

The next step is identify every single step in retrieval arrangement, what can go wrong in retrieval arrangement.

After obtaining possible of failure which can be generated, the next step is investigate cause, consequence and protection. For the consequence which has possibility of failure will use IMCA standard to determine the number of consequence.

Sheet no : 01				Item : Retrieval arrangement				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Retrieve lifeboat back to platform/ship	Overload of lifting arrangement	Loss of Lifeboat	Jerk in wire because of dynamic affects (due to waves)	IMCA M 166					
	Retrieve lifeboat back to platform/ship	Man overboard	Rescue operation	Climbing on top of lifeboat while connecting lifting hook	IMCA M 166					
2	Hydraulic power pack system	Failure on electric motor	Unsuccessful Recovery operation	loss of power	IMCA M 166					
		Failure on pressure gauge	Error calibration	Error judgement	IMCA M 166					
		Failure on starter	Can't start hydraulic power pack system	Hydraulic power pack system can't work	IMCA M 166					
		Failure on control valve	Can't control and adjust hydraulic power pack	Stuck on panel	IMCA M 166					

Figure 4.18 *Risk Identify on FMEA Worksheet*

4.3 Risk Analysis

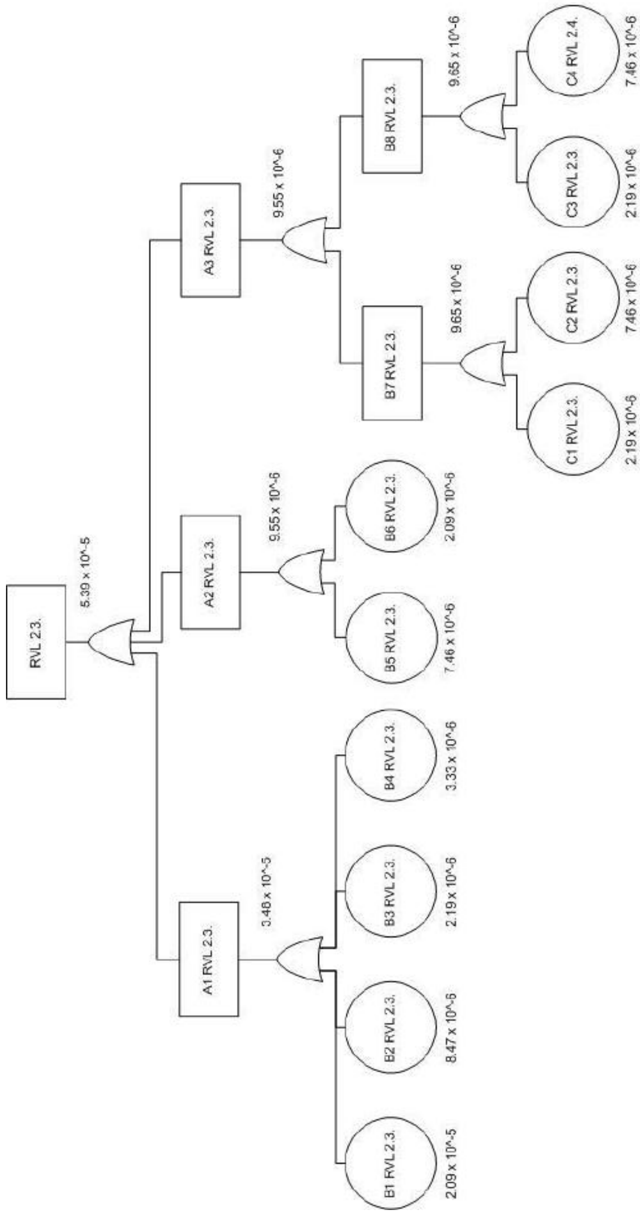
After finished on risk identification step for lifeboat free fall launching, the next step is risk analysis to determine level of Frequency and Consequence which will be used as an input data for the risk analysis result from FMEA Worksheet Retrieval Arrangement (RVL).

Frequency value for each causes are decided from FTA method which had explained on sub-chapter 2.9. Failure Mode and Effect Analysis. For value of Basic Event are generated from several source such as OREDA 2002, DNV Technica 1983, ANNEX III: FSA/LSA/BC: FREE-FALL LIFEBOAT AS RCO, and UK HSE RR599 2007. After obtained the value of Failure Rates and Probability of Failure, the value will be matched to that several source, depend on Probability Description.

The FTA method will start from top event which refer to Possible Causes from FMEA worksheet. For each causes will be given a code to simplify the process. For example, failure on Hydraulic power pack system cannot work

A1 RVL 2.3.

A	: First level contributor (It will following alphabet for the next level)
1	: First contribution (It will following numerical order for the next causes)
RVL	: System which have to identify from FMEA worksheet
2	: Failure mode’s number, based on FMEA worksheet
3	: Potential cause order


RVL 2.3.
5.39 x 10^-5
A1 RVL 2.3.
3.48 x 10^-5
A2 RVL 2.3.
9.55 x 10^-6
A3 RVL 2.3.
9.55 x 10^-6
B1 RVL 2.3.
2.09 x 10^-5
B2 RVL 2.3.
8.47 x 10^-6
B3 RVL 2.3.
2.19 x 10^-6
B4 RVL 2.3.
3.33 x 10^-6
B5 RVL 2.3.
7.46 x 10^-6
B6 RVL 2.3.
2.09 x 10^-6
B7 RVL 2.3.
9.65 x 10^-6
B8 RVL 2.3.
9.65 x 10^-6
C1 RVL 2.3.
2.19 x 10^-6
C2 RVL 2.3.
7.46 x 10^-6
C3 RVL 2.3.
2.19 x 10^-6
C4 RVL 2.4.
7.46 x 10^-6

A1 RVL 2.3. (RVL 2.3)

Causes of Hydraulic power pack system can’t work

A1: Loss of power
A2: Internal leakage on hydraulic motor
A3 : Short circuit
B1 : Fail to start on demand
B2 : Breakdown
B3 : Overheating
B4 : Parameter deviation
B5 : Structural deficiency
B6 : Fail to start on demand
B7 : High voltage inlet
B8 : low voltage inlet
C1 : Overheating
C2 : Structural deficiency
C3 : Overheating
C4 : Structural deficiency
The value of each event are decided based on gate type. Failure Probability for Basic Event will obtained from Failure Rates value.

Boolean expression

T = B1+B2+B3+B4+B5+B6+C1+C2+C3+C4

P(T) = P(B1+B2+B3+B4+B5+B6+C1+C2+C3+C4)
=P(B1)+P(B2)+P(B3)+P(B4)+P(B5)+P(B6)+P(B7)+P(B8)
=P(B1)+P(B2)+P(B3)+P(B4)+P(B5)+P(B6)+P(C1)+P(C2)+P(C3)+P(C4)
=P(B1)+P(B2)+P(B3)+P(B4)+P(B5)+P(B6)+P(C1)+P(C2)+P(C3)+P(C4) −
P(B1)+P(B2)+P(B3)+P(B4)+P(B5)+P(B6)+P(C1)+P(C2)+P(C3)+P(C4)

$= (2.09 \times 10^{-5} + 8.47 \times 10^{-6} + 2.19 \times 10^{-6} + 3.33 \times 10^{-6} + 7.46 \times 10^{-6} + 2.09 \times 10^{-6} + 2.19 \times 10^{-6} + 7.46 \times 10^{-6} + 2.19 \times 10^{-6} + 7.46 \times 10^{-6}) - (2.09 \times 10^{-5} \times 8.47 \times 10^{-6} \times 2.19 \times 10^{-6} \times 3.33 \times 10^{-6} \times 7.46 \times 10^{-6} \times 2.09 \times 10^{-6} \times 2.19 \times 10^{-6} \times 7.46 \times 10^{-6} \times 2.19 \times 10^{-6} \times 7.46 \times 10^{-6})$
$= 5.39 \times 10^{-5}$

Or other solution

- C1 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002 : 0.53×10^{-6})
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{C1} = 1 - e^{-(0.53 \times 10^{-6}) \times 4.3894} = 2.19 \times 10^{-6}$

- C2 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002 : 1.70×10^{-6})
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{C2} = 1 - e^{-(1.70 \times 10^{-6}) \times 4.3894} = 7.46 \times 10^{-6}$

- C3 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

P : Failure Probability
γ : Failure Rate (OREDA 2002 : 0.53×10^{-6})
T : Exposure Interval (OREDA 2002 : 4.3894)

$P_{C3} = 1 - e^{-(0.53\times10^{-6})\times4.3894} = 2.19 \times 10^{-6}$

- C4 RVL 2.3.

$P = 1 - e^{-\gamma T}$

P : Failure Probability
γ : Failure Rate (OREDA 2002 : 1.70×10^{-6})
T : Exposure Interval (OREDA 2002 : 4.3894)

$P_{C4} = 1 - e^{-(1.70\times10^{-6})\times4.3894} = 7.46 \times 10^{-6}$

- B1 RVL 2.3.

$P = 1 - e^{-\gamma T}$

P : Failure Probability
γ : Failure Rate (OREDA 2002 : 4.77×10^{-6})
T : Exposure Interval (OREDA 2002 : 4.3894)

$P_{B1} = 1 - e^{-(4.77\times10^{-6})\times4.3894} = 2.09 \times 10^{-5}$

- B2 RVL 2.3.

$P = 1 - e^{-\gamma T}$

P : Failure Probability
γ : Failure Rate (OREDA 2002 : 1.93×10^{-6})
T : Exposure Interval (OREDA 2002 : 4.3894)

$P_{B2} = 1\text{-}e^{-(1.93\times10^{-6})\times4.3894} = 8.47 \times 10^{-6}$

- B3 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002 : 0.53×10^{-6})
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{B3} = 1\text{-}e^{-(0.53\times10^{-6})\times4.3894} = 2.19 \times 10^{-6}$

- B4 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002 : 0.76×10^{-6})
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{B4} = 1\text{-}e^{-(0.76\times10^{-6})\times4.3894} = 3.33 \times 10^{-6}$

- B5 RVL 2.3.

  $P = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002 : 0.76×10^{-6})
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{B5} = 1\text{-}e^{-(1.70\times10^{-6})\times4.3894} = 7.46 \times 10^{-6}$

- B6 RVL 2.3.

$\mathrm{P} = 1 - e^{-\gamma T}$

P : Failure Probability
γ : Failure Rate (OREDA 2002 : 4.77×10^{-6})
T : Exposure Interval (OREDA 2002 : 4.3894)

$P_{B6} = 1\text{-}e^{-(4.77\times10^{-6})\times4.3894} = 2.09 \times 10^{-6}$

- B7 RVL 2.3.

  $\mathrm{P} = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002)
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{B7} = (2.19 \times 10^{-6}) + (7.46 \times 10^{-6}) = 9.65 \times 10^{-6}$

- B8 RVL 2.3.

  $\mathrm{P} = 1 - e^{-\gamma T}$

  P : Failure Probability
  γ : Failure Rate (OREDA 2002)
  T : Exposure Interval (OREDA 2002 : 4.3894)

  $P_{B8} = (2.19 \times 10^{-6}) + (7.46 \times 10^{-6}) = 9.65 \times 10^{-6}$

After finish with all basic event, then calculate the top event based on the gate.

Because there is an OR Gate then,

$P_{A1} = P_{B1} + P_{B2} + P_{B3} + P_{B4}$

$P_{A1} = 2.09 \times 10^{-5} + 8.47 \times 10^{-6} + 2.19 \times 10^{-6} + 3.33 \times 10^{-6} =$ $\mathbf{3.48 \times 10^{-5}}$

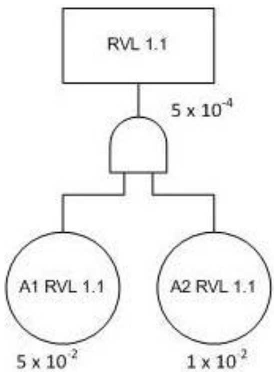
$P_{A2} = P_{B5} + P_{B6}$
$P_{A2} = 7.46 \times 10^{-6} + 2.09 \times 10^{-6} =$ $\mathbf{9.55 \times 10^{-6}}$

$P_{A3} = P_{B7} (P_{C1} + P_{C2}) + P_{B8} (P_{C3} + P_{C4})$
$P_{A3} = P_{B7} (2.19 \times 10^{-6} + 7.46 \times 10^{-6}) + P_{B8} (2.19 \times 10^{-6} + 7.46 \times 10^{-6})$
$P_{A3} = 9.65 \times 10^{-6} + 9.65 \times 10^{-6} =$ $\mathbf{9.55 \times 10^{-6}}$

RVL 2.3. = $P_{A1} + P_{A2} + P_{A3}$
RVL 2.3. = $3.48 \times 10^{-5} + 9.55 \times 10^{-6} + 9.55 \times 10^{-6} =$ $\mathbf{5.39 \times 10^{-5}}$

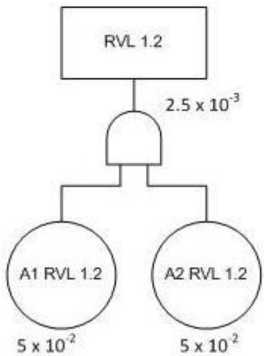
Causes of Jerk in wire because of dynamic affects (RVL 1.1.)

A1: Bad weather conditions
A2: Overload of lifting arrangement



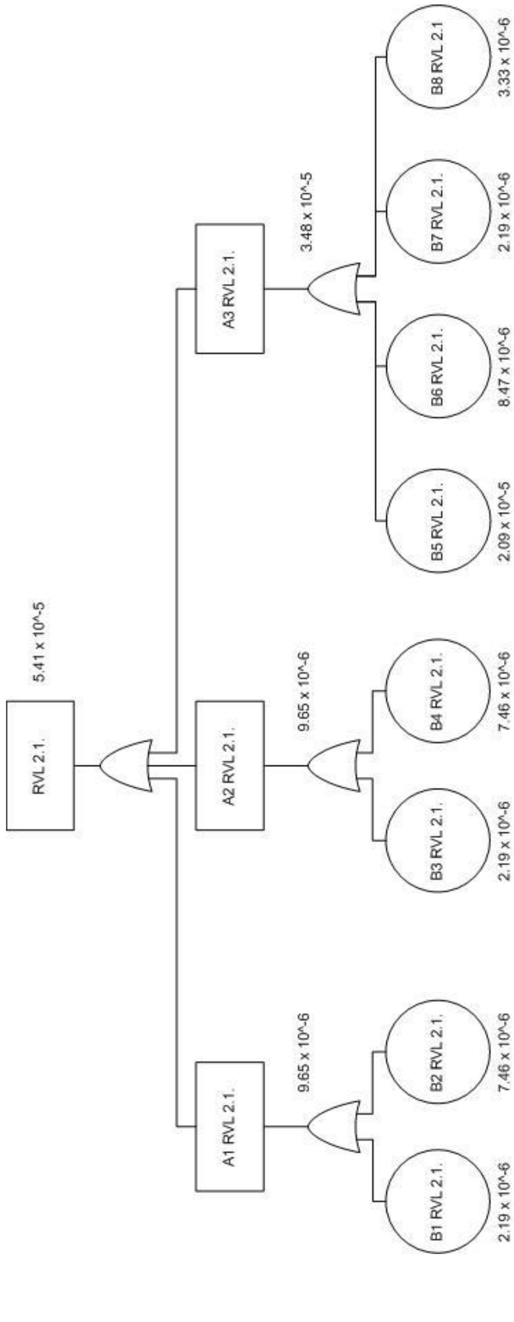
Causes of Climbing on top of lifeboat while connecting lifting hook (RVL 1.2.)

A1: Bad weather conditions
A2: Training



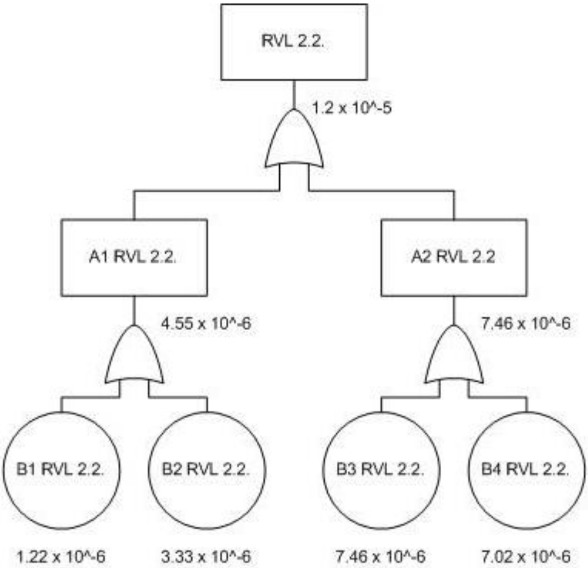
Causes of Loss of power (RVL 2.1.)

A1: Higher voltage inlet
A2: Lower voltage inlet
A3 : Loss of power
B1 : Overheating
B2 : Structural deficiency
B3 : Overheating
B4 : Structural deficiency
B5 : Fail to start on demand
B6 : Breakdown
B7 : Overheating
B8 : Parameter deviation


RVL 2.1.
5.41 x 10^-5
A1 RVL 2.1.
9.65 x 10^-6
A2 RVL 2.1.
9.65 x 10^-6
A3 RVL 2.1.
3.48 x 10^-5
B1 RVL 2.1.
2.19 x 10^-6
B2 RVL 2.1.
7.46 x 10^-6
B3 RVL 2.1.
2.19 x 10^-6
B4 RVL 2.1.
7.46 x 10^-6
B5 RVL 2.1.
2.09 x 10^-5
B6 RVL 2.1.
8.47 x 10^-6
B7 RVL 2.1.
2.19 x 10^-6
B8 RVL 2.1
3.33 x 10^-6

Causes of Error judgement (RVL 2.2.)

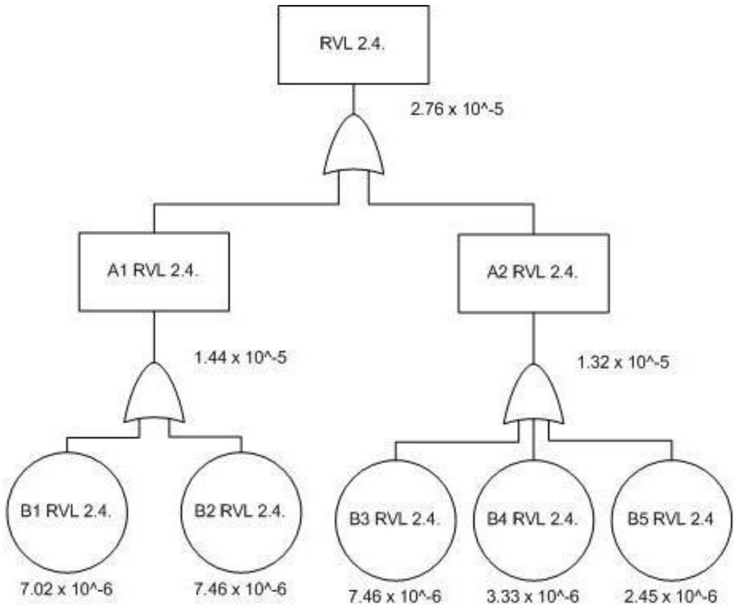
A1: Error visual measuring
A2: Error calibration
B1 : Abnormal instrument reading
B2 : Parameter deviation
B3 : Structural deficiency
B4 : Vibration



Causes of Stuck on panel (RVL 2.4.)

A1: Failure on panel
A2: Fail to control valve
B1 : Vibration
B2 : Structural deficiency
B3 : Structural deficiency

B4 : Parameter deviation
B5 : External leakage



After obtaining all the value of frequency, the next step is determine the level of consequence, to determine the level of consequence will be use table of Severity Description (Page 33).

4.4 Risk Evaluation

Risk evaluation will be the next step after risk analysis, for example from failure mode Failure on Control valve which stuck on panel. Based on table severity and table of probability these failure has a level of severity on 3 and level of probability on 1. Both result will be plotted on risk matrix from International Marine Contractors Association (IMCA) M 166 2002.

Sheet no : 01				Item : Retrieval arrangen	
Operating mode : Launching Operation				Prepared by : PT. Surya S	
Item ref.	**Description / Function**	**Failure Mode**	**Potential Effects of Failure**	**Possible Failure Causes**	**Severity Class**
2	Hydraulic power pack system	Failure on electric motor	Unsuccessful Recovery operation	loss of power	IMCA M 166
		Failure on pressure gauge	Error calibration	Error judgement	IMCA M 166
		Failure on starter	Can't start hydraulic power pack system	Hydraulic power pack system can't work	IMCA M 166
		Failure on control valve	Can't control and adjust hydraulic power pack	Stuck on panel	IMCA M 166

Figure 4.19 *Consequence from Failure on Control Valve*

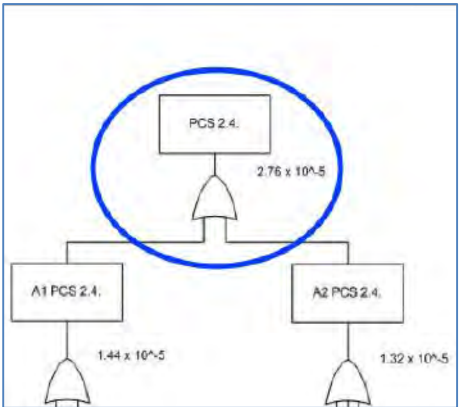


Figure 4.20 *Frequency from Failure on Control Valve*

Table 4.21 *Severity Description from Failure on Control Valve*

Category	Degree	Description
I	Minor	Functional failure of part of a machine or process with no potential for injury, damage or pollution
II	Critical	Failure will probably occur without major damage to system, pollution or serious injury
III	Major	Major damage to system with a potential for serious injury to personnel and minor pollution
IV	Catastrophic	Failure causes complete system loss with a high potential for fatal injury and major pollution.

Table 2.1 *Probability Description from Failure on Control Valve*

Level	Probability	Description
A	10^{-1}	Likely to occur frequently
B	10^{-2}	Probable – may occur several times in the life of an item
C	10^{-3}	Occasional – may occur sometime in the life of an item
D	10^{-4}	Remote – unlikely to occur but possible
E	10^{-5}	Improbable – unlikely to occur at all

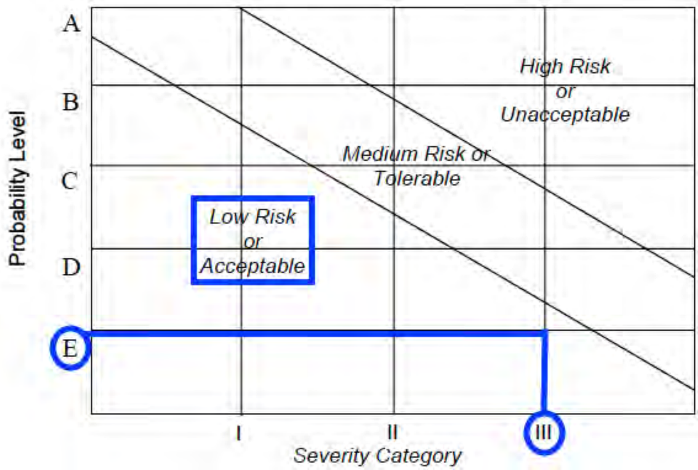


Figure 4.22 *Risk Matrix IMCA*

From Figure 35 shown that the Failure on Control Valve which stuck on panel has a level of risk on Low risk or Acceptable. Different with Figure 36 there's result has a High Risk or Unacceptable. That is mean these failure shall be reduced.

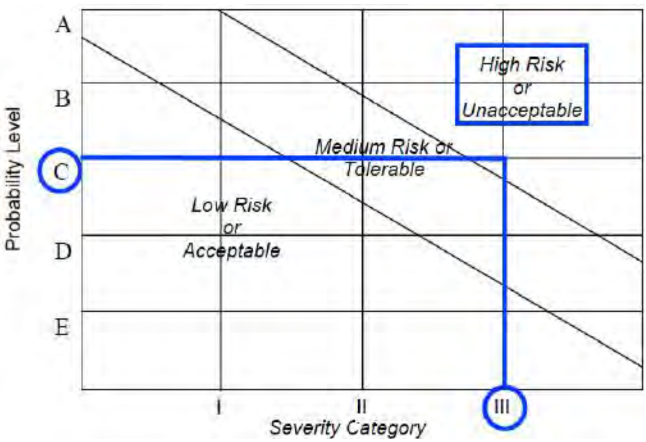


Figure 4.23 *Risk Matrix IMCA*

To reduce the risk level from these failure will use LOPA method for mitigation.

Worksheet on the below shown the risk evaluation for Retrieval Arrangement (RVL).

Sheet no : 01				Item : Retrieval arrangement				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Retrieve lifeboat back to platform/ship	Overload of lifting arrangement	Loss of Lifeboat	Jerk in wire because of dynamic affects (due to waves)	IMCA M 166	5×10^{-4}	Safety factor for the lifeboat lifting arrangement must be decided and verified	3	2	Medium
	Retrieve lifeboat back to platform/ship	Man overboard	Rescue operation	Climbing on top of lifeboat while connecting lifting hook	IMCA M 166	2.5×10^{-3}	Safety for personel that will be performing drop testing must be examined when system and procedures are in place	3	3	High
2	Hydraulic power pack system	Failure on electric motor	Unsuccessful Recovery operation	loss of power	IMCA M 166	5.41×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on pressure gauge	Error calibration	Error judgement	IMCA M 166	1.2×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on starter	Can't start hydraulic power pack system	Hydraulic power pack system can't work	IMCA M 166	5.39×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on control valve	Can't control and adjust hydraulic power pack	Stuck on panel	IMCA M 166	2.76×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium

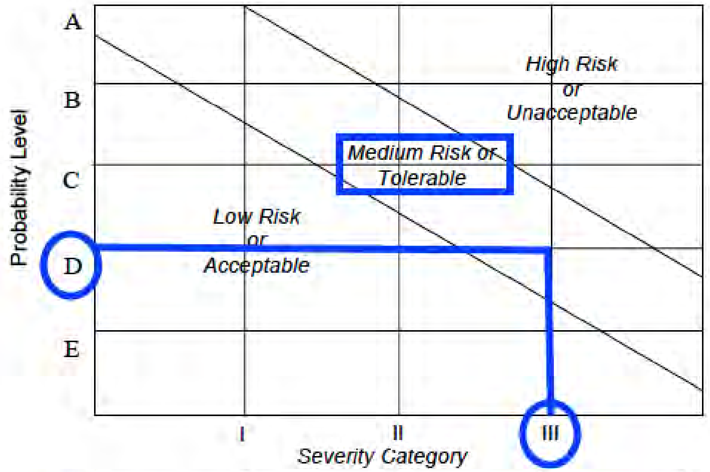
4.5 Mitigation

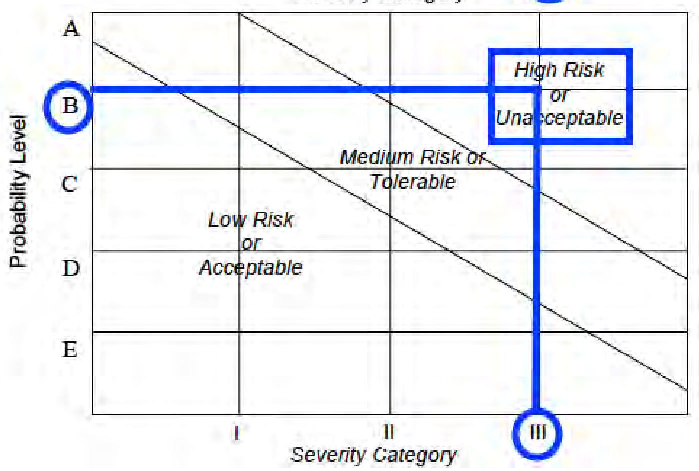
The last step will be kind of mitigation to reduce the level of risk that can happen. This mitigation is needed for high risk criteria. Whenever that high risk need to identify for protection and prevention to be adopted in order to reduce the frequency.

Below is shown an example for mitigation task with LOPA method from worksheet FMEA Node No. 1 which is failure crack in hull caused by Insufficient (QA).

Scenario No. 1	Crack in hull caused by Insufficient Quality Assurance (QA) during production process		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Excess buoyancy should keep the boat afloat even if hull cracks		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			6.6×10^{-2}
Frequency of Unmitigated Consequence			6.6×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.98×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. perlu dilakukan training pada production proses		
	2. A QA program must be in force during the production of the lifeboat		

From LOPA worksheet above the result is frequency for failure crack in hull caused by Insufficient (QA). The number of Insufficient QA will be reduce to 1.98 x 10^{-4}, That result is generated from calculation within frequency and protection layers given. After that the result will be ploted on Risk Matrix again as shown below.





The result shown risk level which is on High risk criteria can be reduce to medium criteria after use mitigation with LOPA method.

ATTACHMENT

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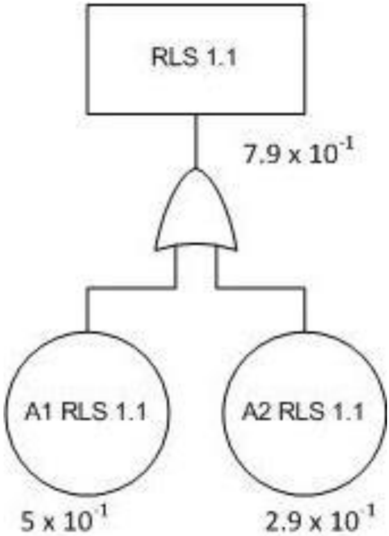
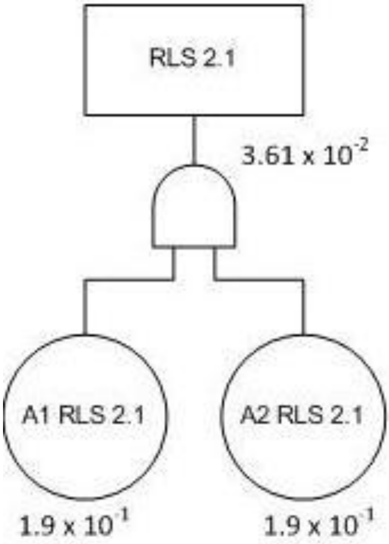
Causes of Change in design

A1: Failure on Re-hooking
A2: Design fault



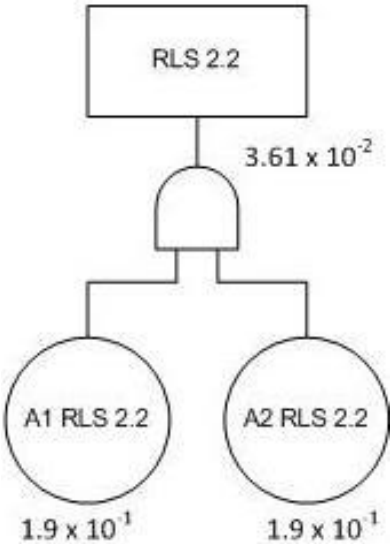
Causes of Any rust or corrosion

A1: The insufficient maintenance of lifeboats
A2: Equipment failure



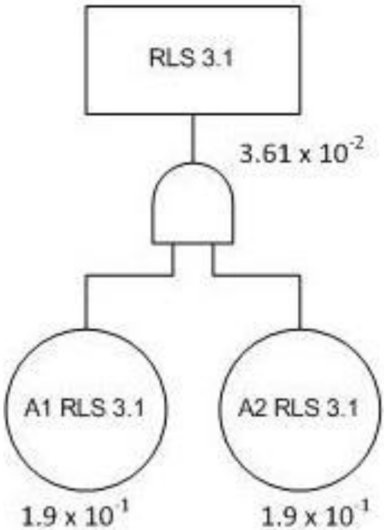
Causes of Any rust or corrosion

A1: Inadequate or ineffective maintenance of release mechanism
A2: Equipment failure



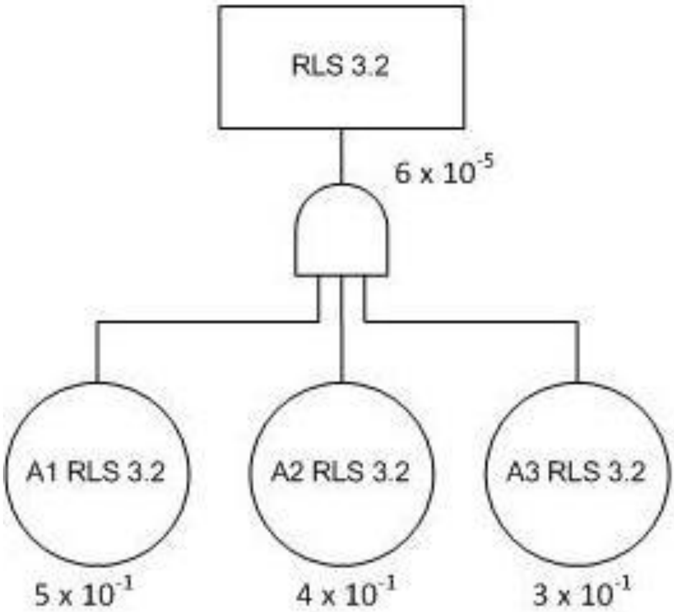
Causes of The insufficient maintenance of lifeboats

A1: Inadequate or ineffective maintenance of release mechanism
A2: Equipment failure



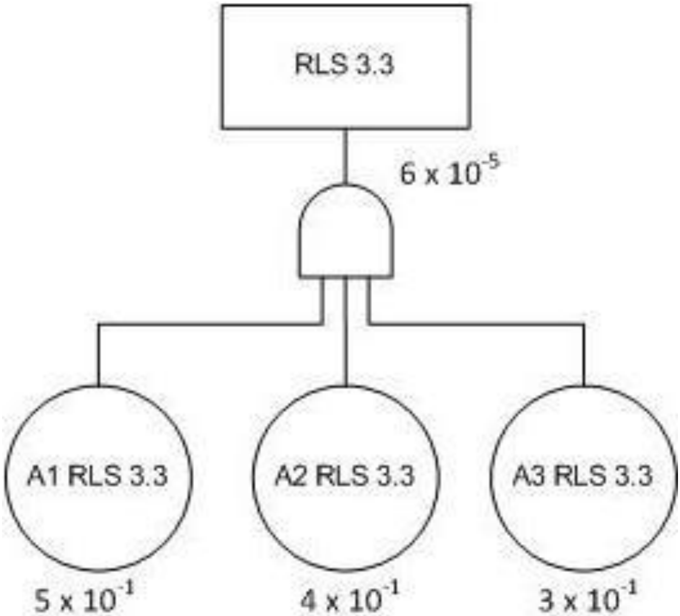
Causes of The lack of familiarity with lifeboats and the associated equipment

A1: Training
A2: Physical condition
A3: Communications / training



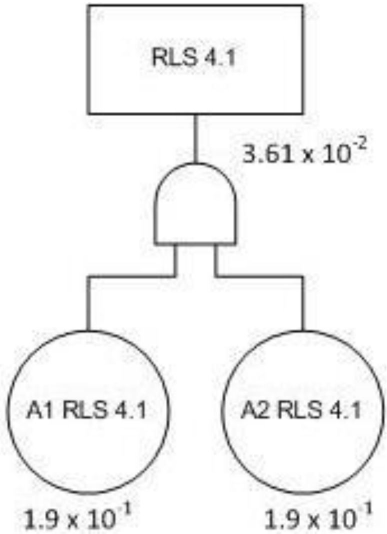
Causes of The lack of familiarity with lifeboats and the associated equipment

A1: Training
A2: Physical condition
A3: Communications / training



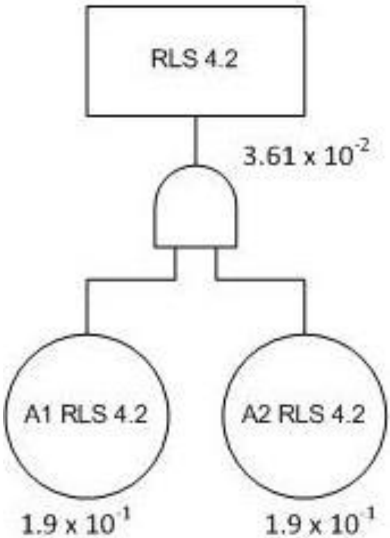
Causes of Equipment failure

A1: Any rust or corrosion
A2: Inadequate or ineffective maintenance of release mechanism



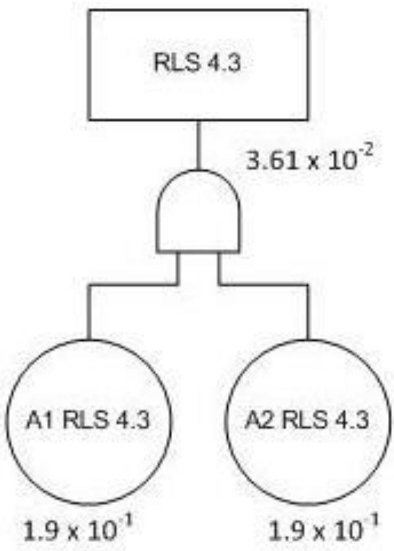
Causes of Equipment failure

A1: Any rust or corrosion
A2: Inadequate or ineffective maintenance of release mechanism



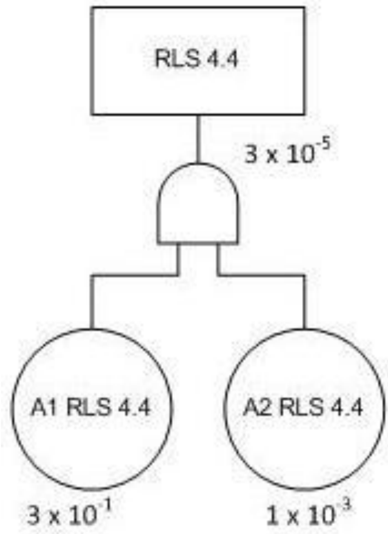
Causes of Equipment failure

A1: Any rust or corrosion
A2: Inadequate or ineffective maintenance of release mechanism



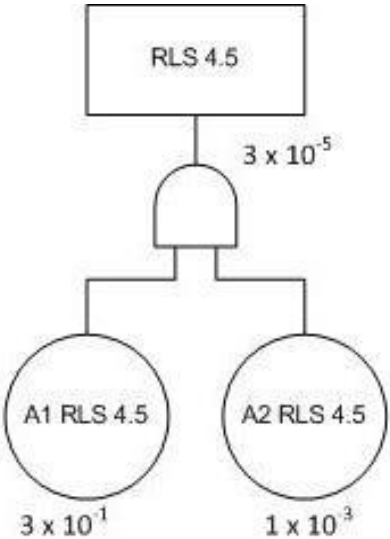
Causes of Hydraulic oil lever below markings

A1: Communications / training
A2: Uncontrolled descent



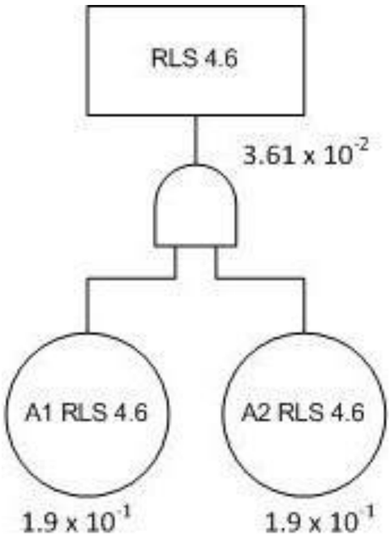
Causes of Hydraulic oil lever below markings

A1: Communications / training
A2: Uncontrolled descent



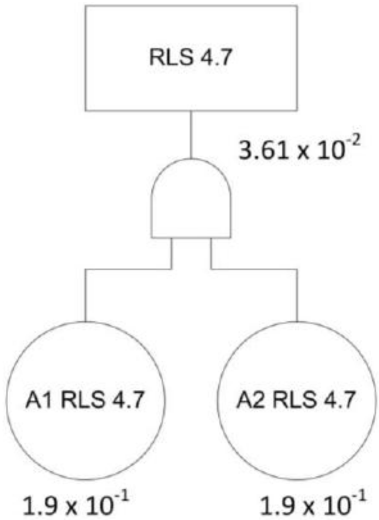
Causes of Equipment failure

A1: Inadequate or ineffective maintenance of release mechanism
A2: Any rust or corrosion



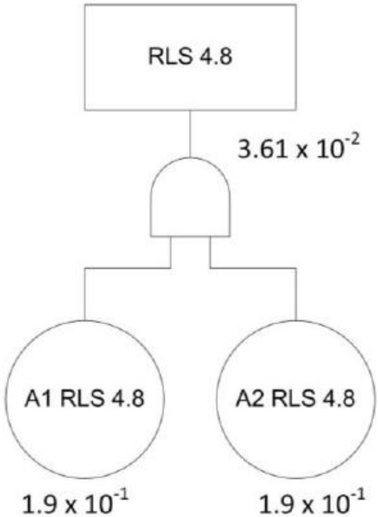
Causes of Equipment failure

A1: Inadequate or ineffective maintenance of release mechanism
A2: Any rust or corrosion



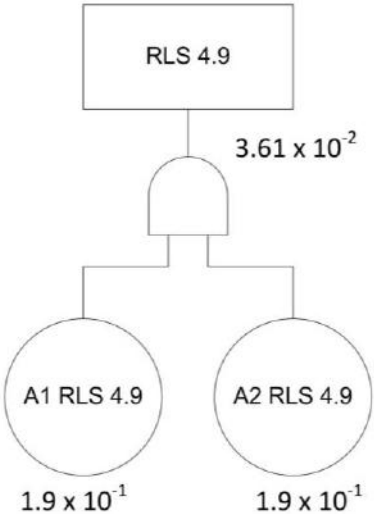
Causes of Equipment failure

A1: Inadequate or ineffective maintenance of release mechanism
A2: Any rust or corrosion



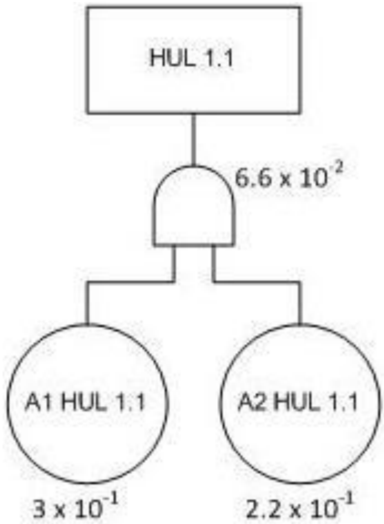
Causes of Equipment failure

A1: Inadequate or ineffective maintenance of release mechanism
A2: Any rust or corrosion



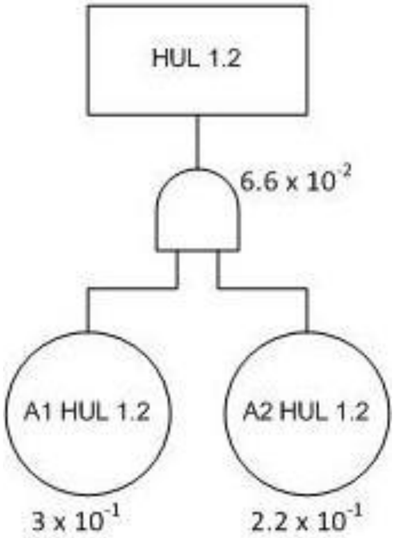
Causes of Insufficient Quality Assurance (QA) during production process

A1: Incorrect design
A2: Human error



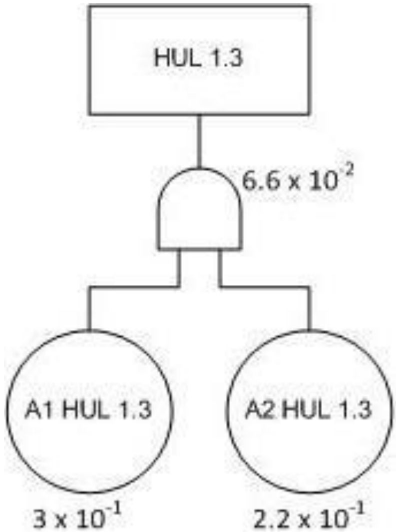
Causes of Impairment and decomposition of gelcoat

A1: Incorrect design
A2: Human error



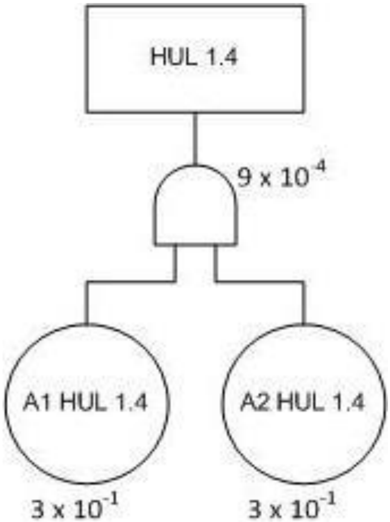
Causes of Poorly designed bow geometry

A1: Incorrect design
A2: Human error



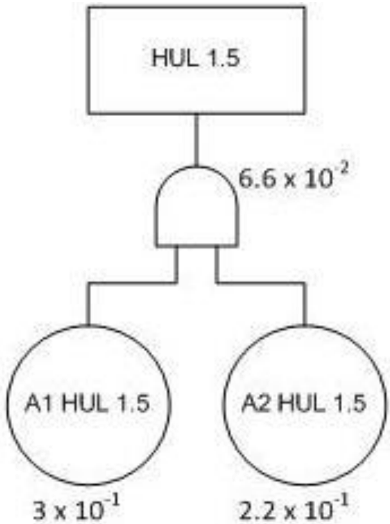
Causes of Interference with other free fall lifeboats during or after the lunch

A1: Underlying causes
A2: Communications / training



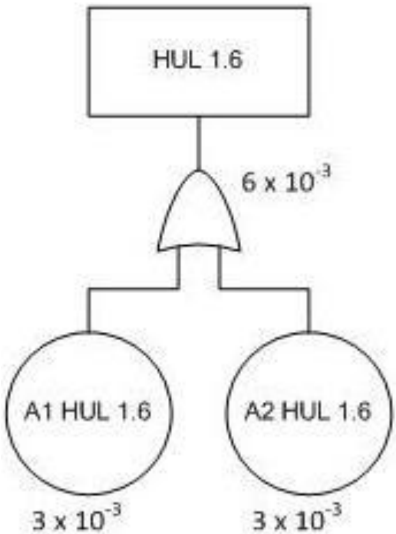
Causes of Leaking of gas below water surface reduces effective water density and hence buoyancy of lifeboat

A1: Incorrect design
A2: Human error



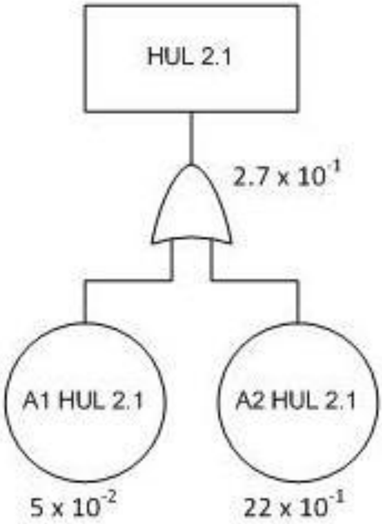
Causes of Burning oil on sea surface

A1: Insufficient water spray (fire resistance) system
A2: Fails to leave area



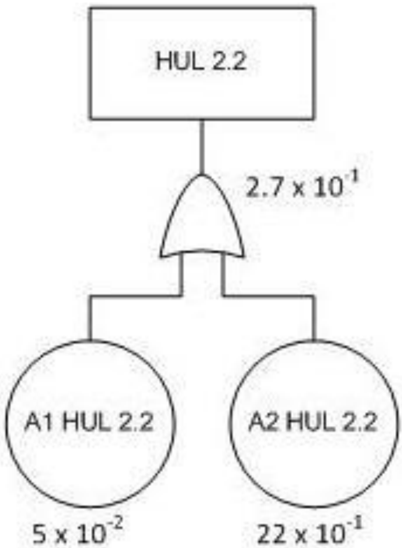
Causes of Skew landing due to erroneous understanding of environmental loads

A1: Bad weather conditions
A2: Human error



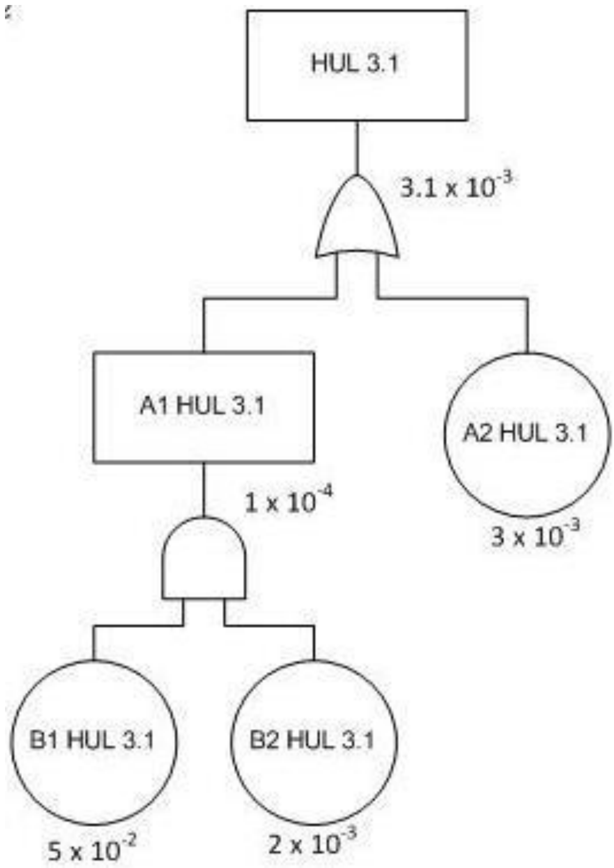
Causes of Ice on the water

A1: Bad weather conditions
A2: Human error



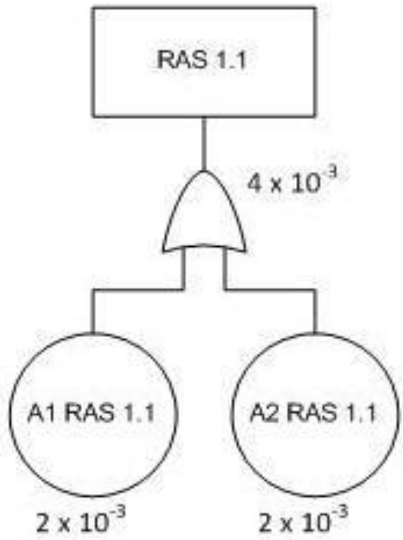
Causes of Excessive rolling leading to air intake in submerged position

A1: Abnormality breather valve functions
A2: Any obstacle exists in the breather valve
A3: Any rust and foreign matter



Causes of Dynamic motion on skid or davit

A1: Any rust or corrosion on skid or davit
A2: Overload capacity during launch



Causes of Dynamic motion on skid or davit

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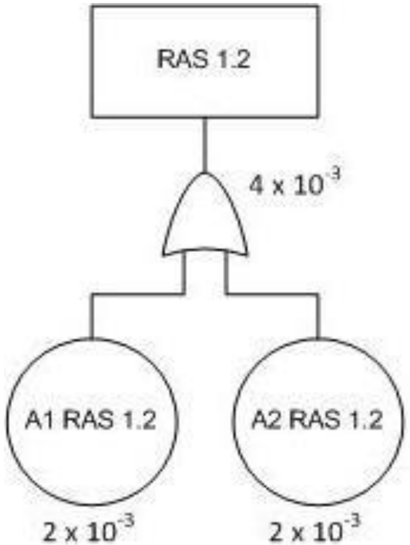
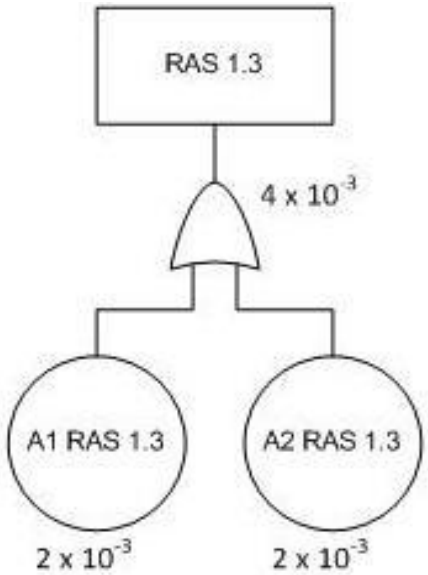
A2: Overload capacity during launch



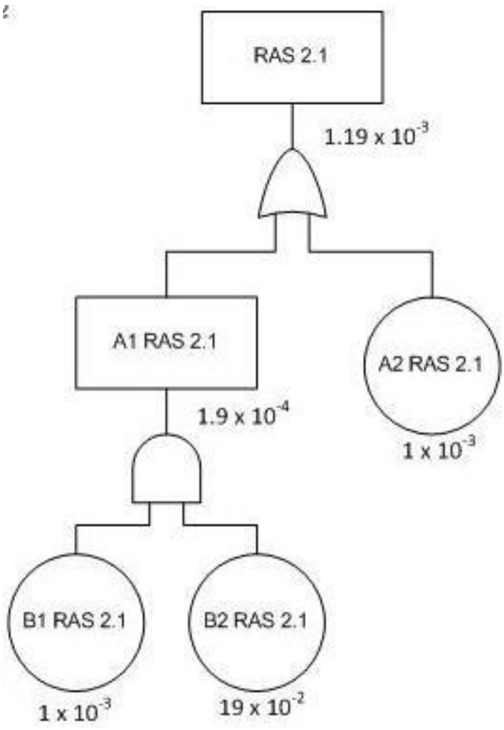
Causes of Dynamic motion on skid or davit

A1: Any rust or corrosion on skid or davit
A2: Overload capacity during launch



Causes of Dirt or contamination on skid. Broken friction pads. Angle during damaged condition.

A1: Any obstacle exists in the boat fall path
A2: Less of lubrication
A3: Inadequate or ineffective maintenance of rails



Causes of Dirt or contamination on skid. Broken friction pads. Angle during damaged condition.

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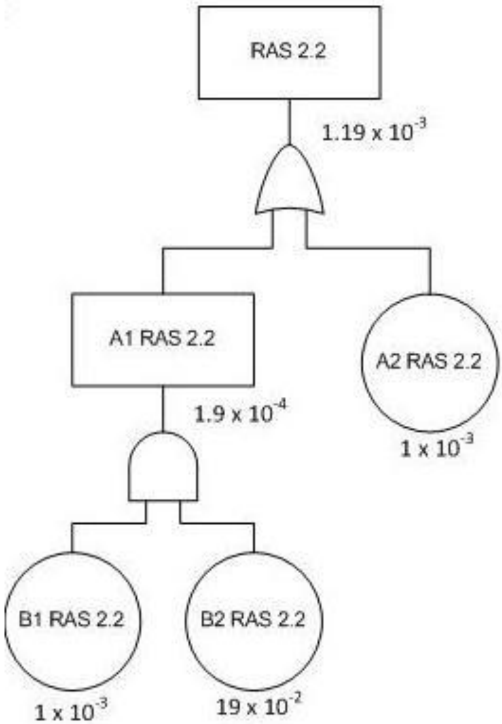
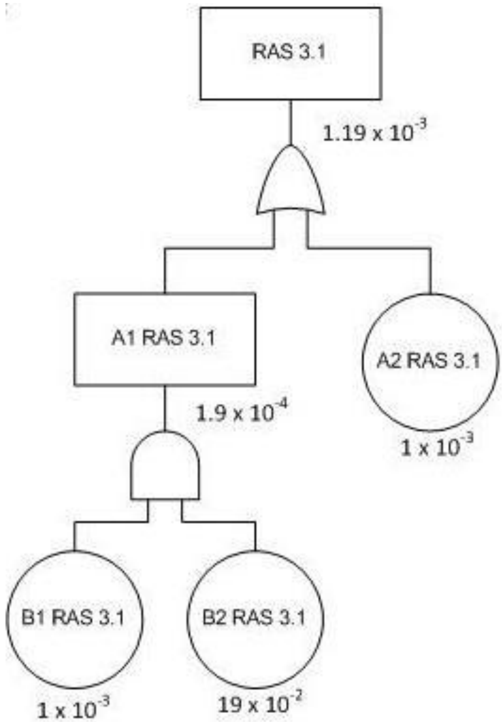
A3: Inadequate or ineffective maintenance of rails



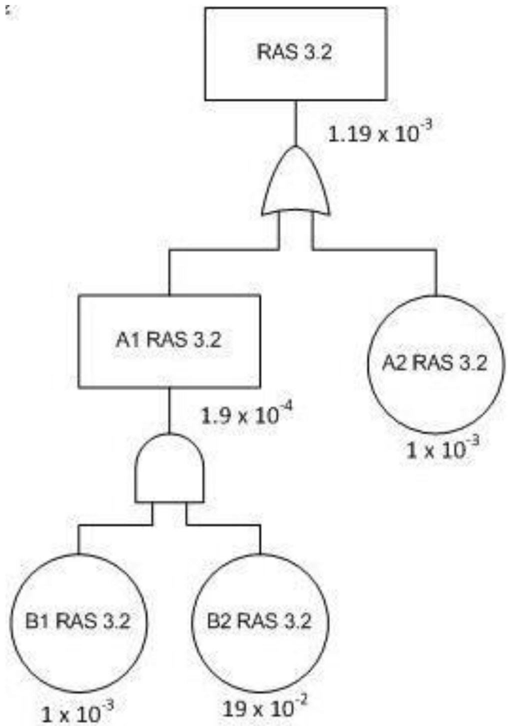
Causes of Failure on slide track.

A1: Any obstacle exists in the boat fall path
A2: Less of lubrication
A3: Inadequate or ineffective maintenance of rails



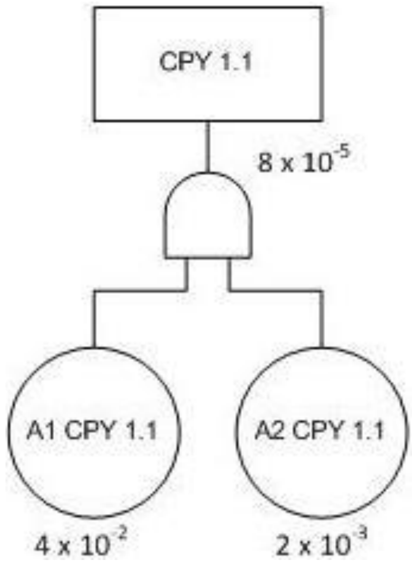
Causes of Failure on slide track.

A1: Any obstacle exists in the boat fall path
A2: Less of lubrication
A3: Inadequate or ineffective maintenance of rails



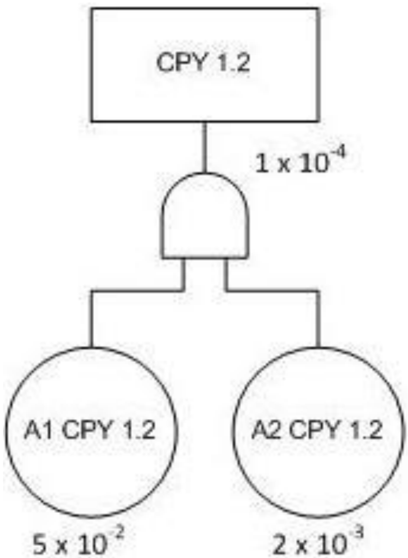
Causes of Maximum pressure

A1: Bad weather conditions
A2: Operator decision to embarkation.



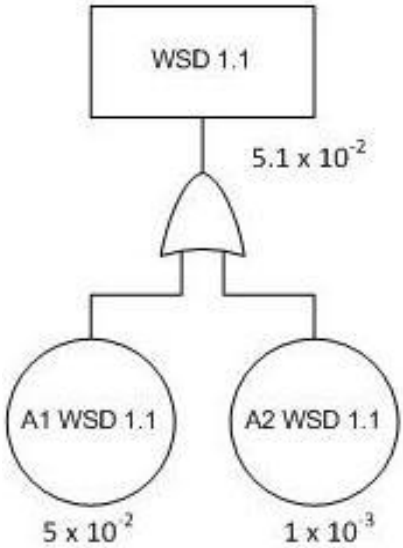
Causes of Rough sea

A1: Bad weather conditions
A2: Operator decision to embarkation.



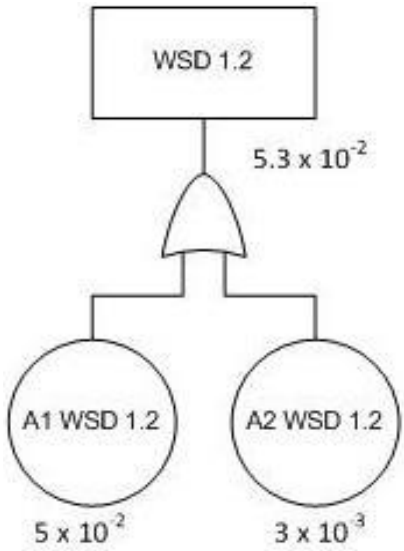
Causes of Windshield covered by oil or salt

A1: Bad weather conditions
A2: Uncontrolled descent



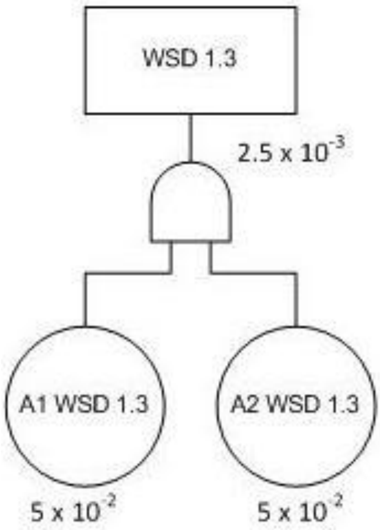
Causes of Dew

A1: Bad weather conditions
A2: Different temperature between outside and inside conditions



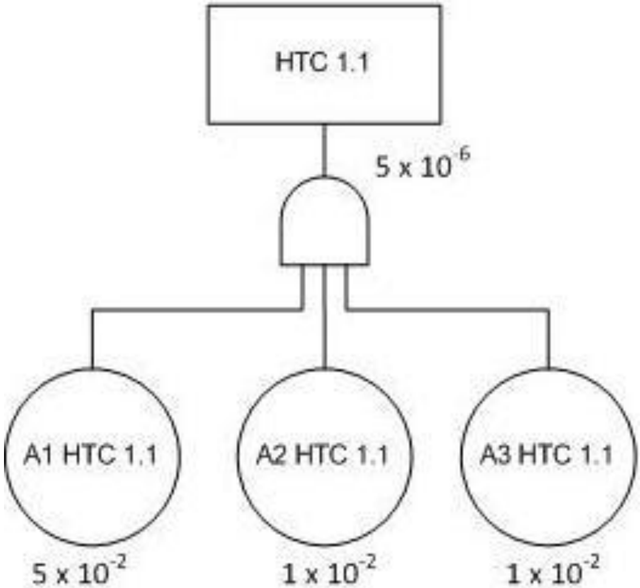
Causes of Hydrodynamic pressure

A1: Bad weather conditions
A2: Wave damages craft



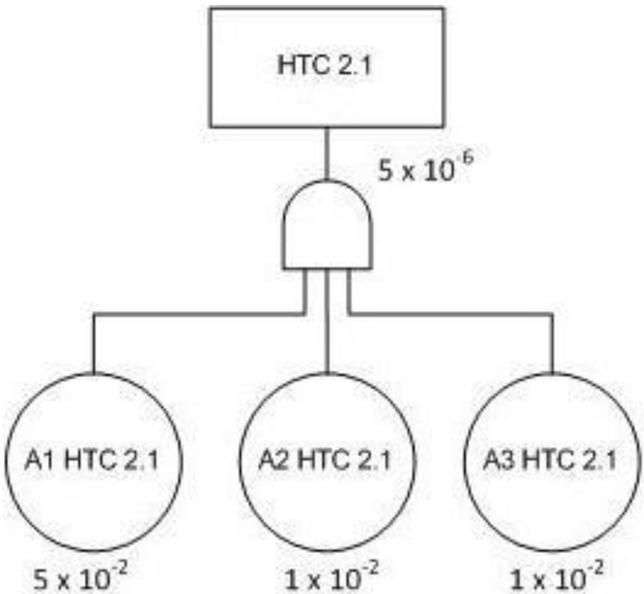
Causes of Open hatch

A1: Any leakage on water shield
A2: Any damaged on doors and hatches
A3: Lack of lifting device



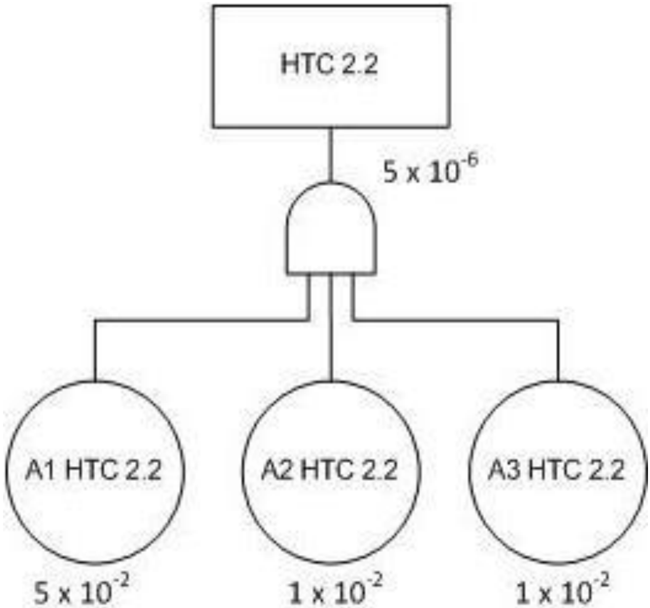
Causes of Open hatch

A1: Any leakage on water shield
A2: Any damaged on doors and hatches
A3: Lack of lifting device



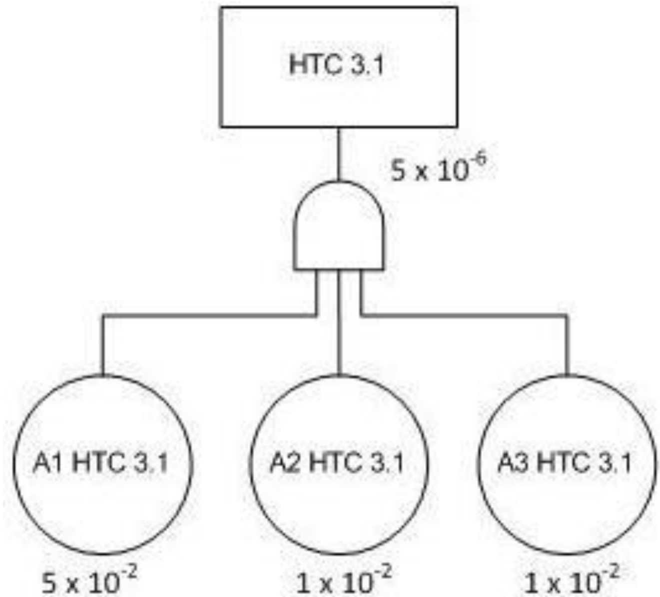
Causes of Any hazardous rust

A1: Any leakage on water shield
A2: Any damaged on doors and hatches
A3: Lack of lifting device

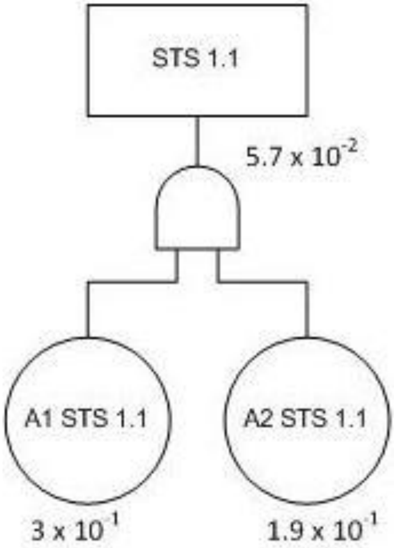


Causes of Open hatch

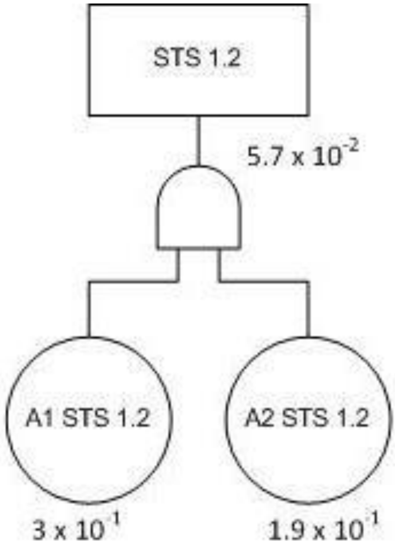
A1: Any leakage on water shield
A2: Any damaged on doors and hatches
A3: Lack of lifting device



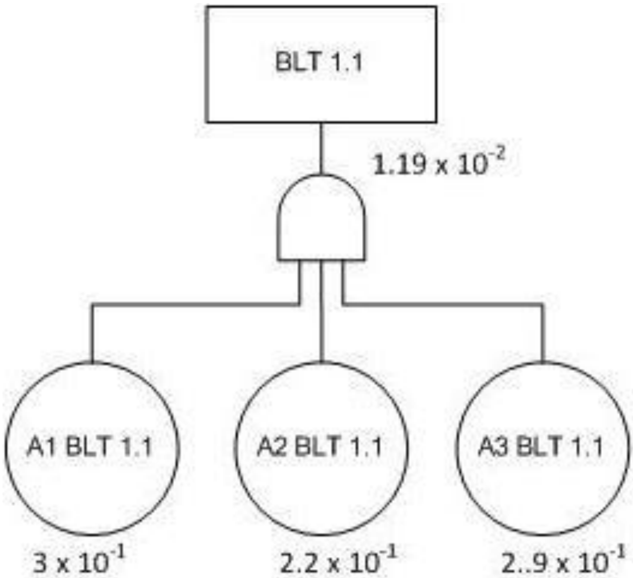
Causes of Missing requirements
A1: Incorrect design
A2: Malfunctions



Causes of Pilot seat design
A1: Incorrect design
A2: Malfunctions



Causes of Improper/missing requirements
A1: Incorrect design
A2: Not follow the instructions
A3: On bad condition of seat belt



Causes of Improper/missing requirements

A1: Incorrect design
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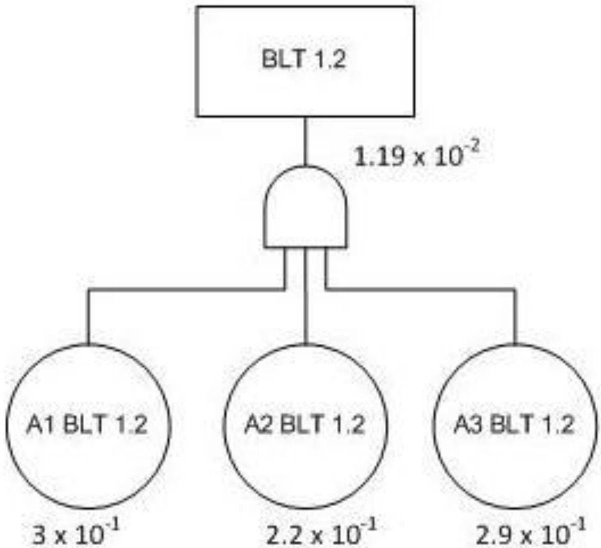
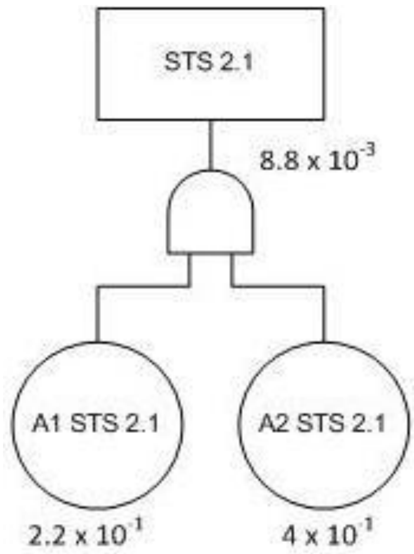
A3: On bad condition of seat belt



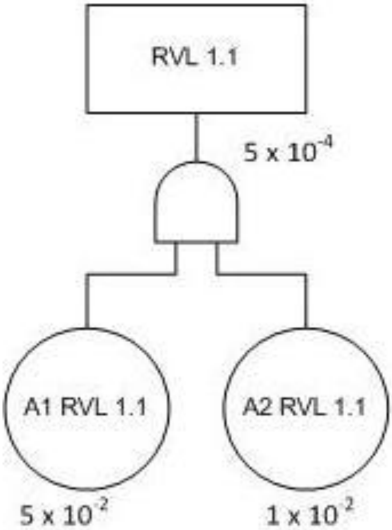
Causes of Unsafe practices during lifeboat inspections and drills

A1: Not follow the instructions
A2: Uncontrolled panic, panic attack by passenger



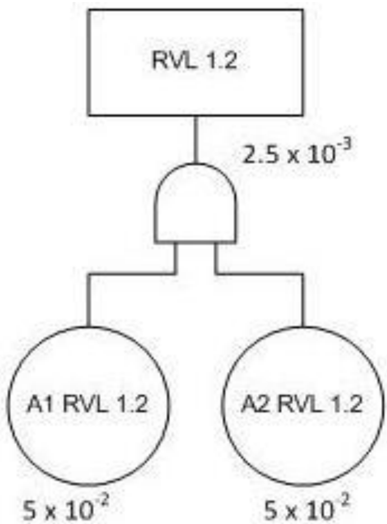
Causes of Jerk in wire because of dynamic affects

A1: Bad weather conditions
A2: Overload of lifting arrangement



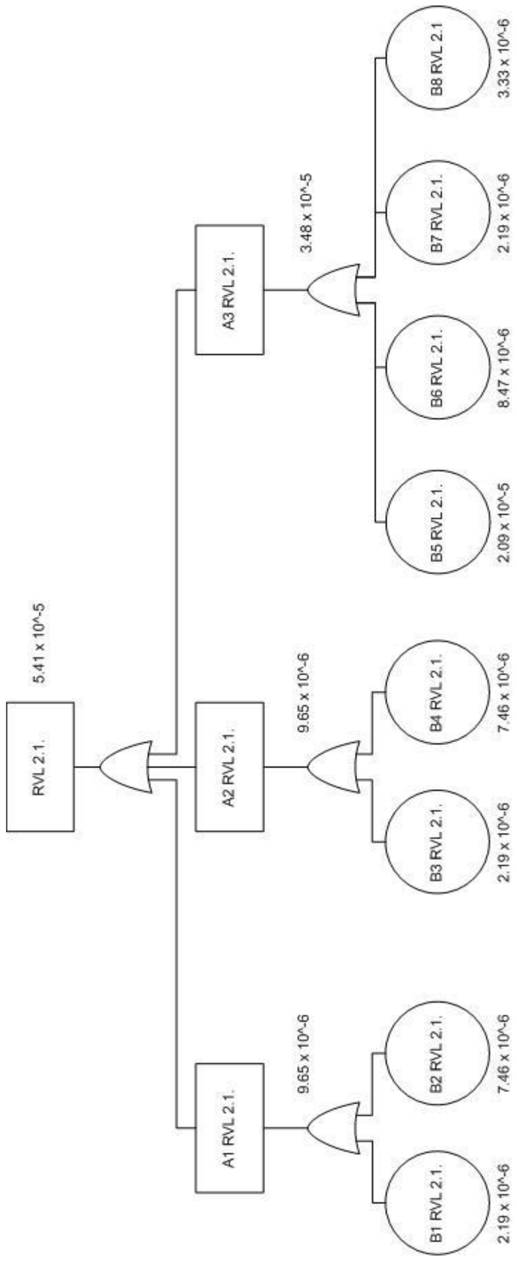
Causes of Climbing on top of lifeboat while connecting lifting hook

A1: Bad weather conditions
A2: Training



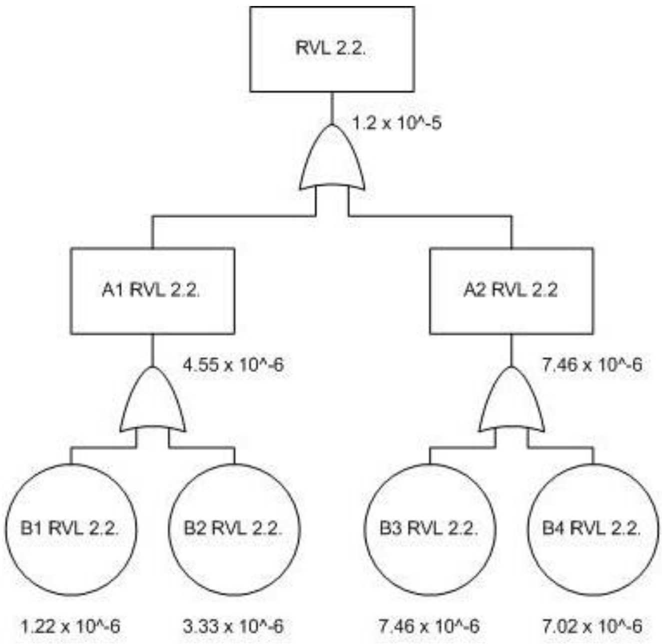
Causes of Loss of power

A1: Higher voltage inlet
A2: Lower voltage inlet
A3 : Loss of power
B1 : Overheating
B2 : Structural deficiency
B3 : Overheating
B4 : Structural deficiency
B5 : Fail to start on demand
B6 : Breakdown
B7 : Overheating
B8 : Parameter deviation


RVL 2.1.
5.41 x 10^-5
A1 RVL 2.1.
9.65 x 10^-6
A2 RVL 2.1.
9.65 x 10^-6
A3 RVL 2.1.
3.48 x 10^-5
B1 RVL 2.1.
2.19 x 10^-6
B2 RVL 2.1.
7.46 x 10^-6
B3 RVL 2.1.
2.19 x 10^-6
B4 RVL 2.1.
7.46 x 10^-6
B5 RVL 2.1.
2.09 x 10^-5
B6 RVL 2.1.
8.47 x 10^-6
B7 RVL 2.1.
2.19 x 10^-6
B8 RVL 2.1
3.33 x 10^-6

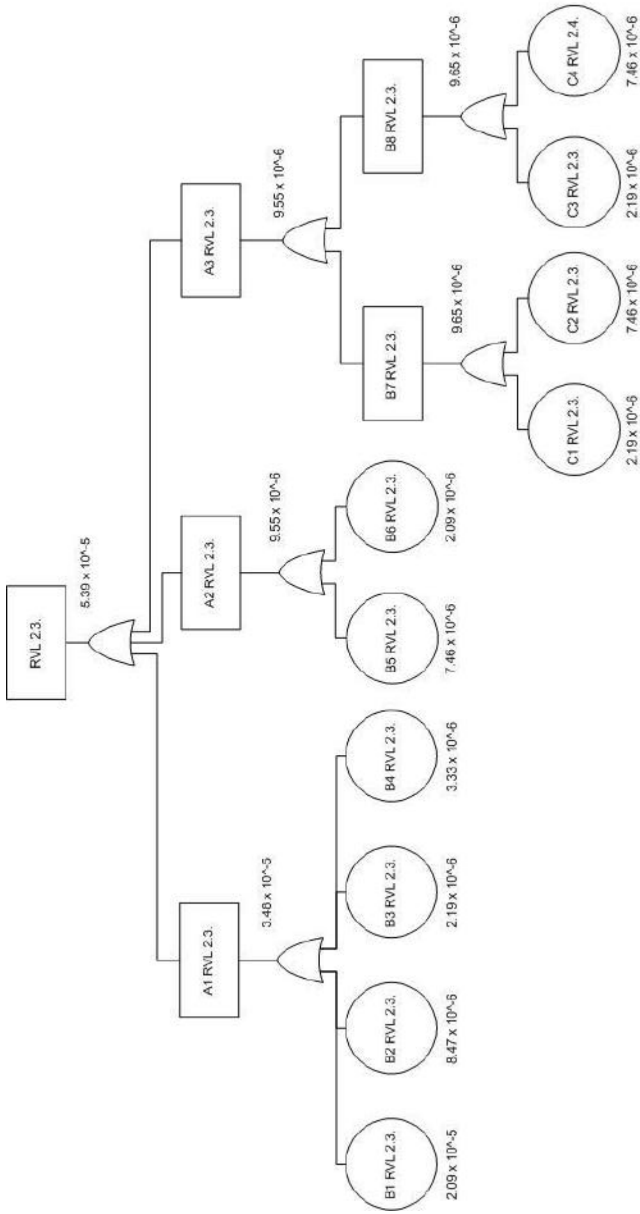
Causes of Error judgement

A1: Error visual measuring
A2: Error calibration
B1 : Abnormal instrument reading
B2 : Parameter deviation
B3 : Structural deficiency
B4 : Vibration



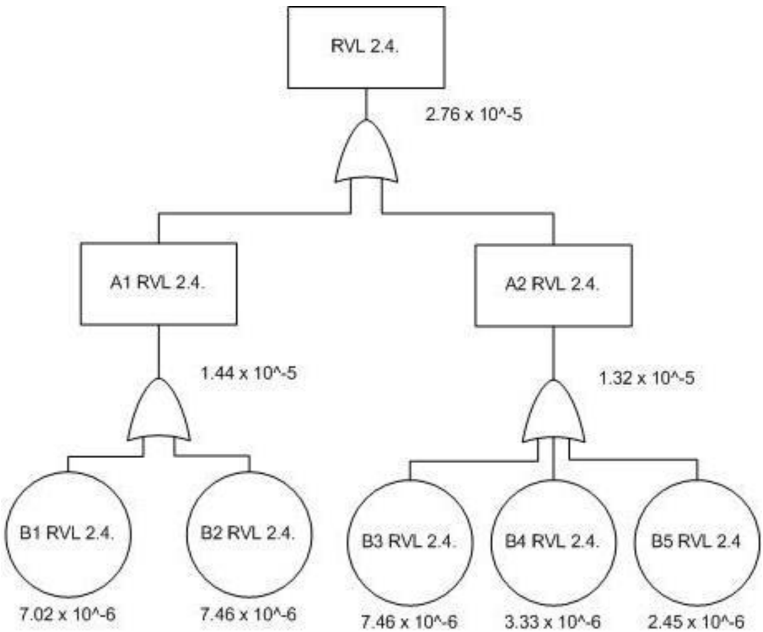
Causes of Hydraulic power pack system can't work

A1: Loss of power
A2: Internal leakage on hydraulic motor
A3 : Short circuit
B1 : Fail to start on demand
B2 : Breakdown
B3 : Overheating
B4 : Parameter deviation
B5 : Structural deficiency
B6 : Fail to start on demand
B7 : High voltage inlet
B8 : low voltage inlet
C1 : Overheating
C2 : Structural deficiency
C3 : Overheating
C4 : Structural deficiency


RVL 2.3.
5.39 x 10^-5
A1 RVL 2.3.
3.48 x 10^-5
A2 RVL 2.3.
9.55 x 10^-6
A3 RVL 2.3.
9.55 x 10^-6
B1 RVL 2.3.
2.09 x 10^-5
B2 RVL 2.3.
8.47 x 10^-6
B3 RVL 2.3.
2.19 x 10^-6
B4 RVL 2.3.
3.33 x 10^-6
B5 RVL 2.3.
7.46 x 10^-6
B6 RVL 2.3.
2.09 x 10^-6
B7 RVL 2.3.
9.65 x 10^-6
B8 RVL 2.3.
9.65 x 10^-6
C1 RVL 2.3.
2.19 x 10^-6
C2 RVL 2.3.
7.46 x 10^-6
C3 RVL 2.3.
2.19 x 10^-6
C4 RVL 2.4.
7.46 x 10^-6

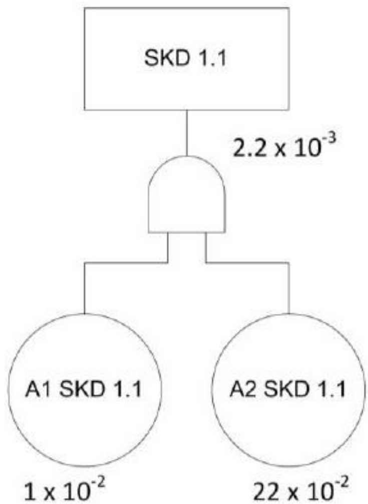
Causes of Stuck on panel

A1: Failure on panel
A2: Fail to control valve
B1 : Vibration
B2 : Structural deficiency
B3 : Structural deficiency
B4 : Parameter deviation
B5 : External leakage



Causes of Launching while the skid is tilting sideways

A1: Overload of the skid
A2: Doesn't follow the instruction



Sheet no : 01				Item : Hull						FMEA
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	The lifeboat shall resist all loads occurring during launch	Crack in hull while launching operation	Major damage and serious injury. Excess buoyancy should keep the boat afloat even if hull cracks	Insufficient Quality Assurance (QA) during production process	IMCA M 166	6.6×10^{-2}	A QA program must be in force during the production of the lifeboat	3	4	High
		Crack in hull while launching operation	Ingress of water to laminate leading to delamination	Impairment and decomposition of gelcoat	IMCA M 166	6.6×10^{-2}	Specification of gelcoat must be confirmed and followed up during production	3	4	High
		Crack in bow while launching operation	Excess buoyancy should keep the boat afloat even if hull cracks	Poorly designed bow geometry	IMCA M 166	6.6×10^{-2}	Production follow-up for the bow geometry is important	3	4	High
		Collision damages when multiple lifeboats are positioned close to each other	Loss of lifeboat or/and fatalities happen	Interference with other free fall lifeboats during or after the lauch	IMCA M 166	9×10^{-4}	A coordination control system for the launches of the individual boats may have to be applied	1	2	Medium

Sheet no : 01.1				Item : Hull				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result Sev	Action Result Occ	Risk Priority
1	The lifeboat shall resist all loads occurring during launch	Insufficient buoyancy	The lifeboat becomes partly submerged or even sinks	Leaking of gas below water surface reduces effective water density and hence buoyancy of lifeboat	IMCA M 166	6.6×10^{-2}	It is assumed that the launch zone will be cleared for gas prior to the launch. Still it will be valuable to know which level of gas content will cause reduced bouyancy to become a problem.	3	4	High
		Insufficient water spray (fire resistance) system	Fire exposure of hull. High temperature inside lifeboat.	Burning oil on sea surface	IMCA M 166	6 x 10-3	It must be verified that the SOLAS requirements for fire prevention are sufficient.	2	3	Low
2	Lifeboat accelerations shall be within acceptable limits tolerated by passengers	Excessive accelerations	Passenger fatalities	Skew landing due to erroneous understanding of environmental loads	IMCA M 166	2.7×10^{-1}	The likelihood for ice on the water during the launch should be investigated for the specified location.	4	5	High
		Collapse of hull and excessive accelerations	Passenger fatalities	Ice on the water	IMCA M 166	2.7×10^{-1}	The likelihood for ice on the water during the launch should be investigated for the specified location.	4	4	High

Sheet no : 01.2				Item : Hull						FMEA
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
3	The lifeboat shall be seaworthy after drop	Air intake in submerged position below water surface	Insufficient breathing air for passengers. Water in cabin. Collapse of hull.	Excessive rolling leading to air intake in submerged position	IMCA M 166	3.1×10^{-5}	Sufficient breathable air supply must be ensured for all operating conditions. Water in the cabin should be minimized which may dictate the position of the air intake. However, if a check valve or vent is used to prevent water from being sucked into the cabin, the hull must be checked for collapse.	2	3	Medium

Sheet no : 02				Item : Rails				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Interaction between guide rails on lifeboat and guide rails on davit	Jam while launching operation	Inability to launch. Lifeboat falls through launch skid. No potential serious injury	Dynamic motions on skid or davit caused by Jam	IMCA M 166	4×10^{-3}	Situations that can lead to jamming or fall through of the lifeboat should be investigated. The stiffness of the davit as well as the tolerance between the lifeboat and the davit shall be checked.	2	3	Medium
		Fall through while launching operation	Inability to launch. Lifeboat falls through launch skid. No potential serious injury	Dynamic motions on skid or davit caused by Fall	IMCA M 166	4×10^{-3}	Situations that can lead to jamming or fall through of the lifeboat should be investigated. The stiffness of the davit as well as the tolerance between the lifeboat and the davit shall be checked.	2	3	Medium
		Derailment while launching operation	Inability to launch. Lifeboat falls through launch skid. No potential serious injury	Dynamic motions on skid or davit caused by Derailment	IMCA M 166	4×10^{-3}	Situations that can lead to jamming or fall through of the lifeboat should be investigated. The stiffness of the davit as well as the tolerance between the lifeboat and the davit shall be checked.	2	3	Medium

Sheet no : 02.1				Item : Rails				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
2	Ensure sufficient launch speed for lifeboat. Minimize/limit friction	High friction while launching operation	Too low speed as the boat leaves the launch skid may cause the lifeboat to rotate excessively and hit the water surface upside down. Potential for serious injury	Dirt or contamination on skid. Broken friction pads (on guide rail). Angle during damaged condition.	IMCA M 166	1.19×10^{-3}	An assessment of the expected friction for the materials in use should be performed. Laboratory friction test are straightforward to carry out and will give reliable data. The condition of the friction pads should be included in the inspection routines.	4	3	High
		Excessive rotation while launching operation	Too low speed as the boat leaves the launch skid may cause the lifeboat to rotate excessively and hit the water surface upside down Potential for serious injury	Dirt or contamination on skid. Broken friction pads (on guide rail). Angle during damaged condition.	IMCA M 166	1.19×10^{-3}	An assessment of the expected friction for the materials in use should be performed. Laboratory friction test are straightforward to carry out and will give reliable data. The condition of the friction pads should be included in the inspection routines.	4	3	High

Sheet no : 02.2				Item : Rails				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
3	Boat rails	Boat rails on davit cannot rollers properly while launching operation	It may cause an accident during launching. No potential serious injury	Failure on slide track/Equipment failure	IMCA M 166	1.19×10^{-3}	Double visual check	2	3	Medium
			Unsuccessful launch. No potential serious injury	Failure on slide track/Equipment failure	IMCA M 166	1.19×10^{-3}	Double visual check	2	3	Medium

Sheet no : 03				Item : Canopy and roof				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Resist loads from drop and be seaworthy after fall	Collapse or deflection of canopy while launching operation	Deflecting canopy hitting the heads of the occupants, potential of injury by occupants	Assumption that maximum pressure is limited to some threshold for the diving depth.	IMCA M 166	8×10^{-7}	Sensitivity of wave steepness with respect to maximum pressure should be performed.	2	1	Low
	Resist loads from drop and wave impact loads after drop and be seaworthy after fall	Crack or damage on Canopy or roof while launching operation	Damage to lifeboat machinery makes failure on machinery equipment	Rough sea or bad weather conditions happen	IMCA M 166	1×10^{-4}	An assessment of impact forces (e.g. slamming, falling sideways from a crest) when sailing in rough sea until passengers are rescued from the lifeboat	3	2	Low

Sheet no : 04				Item : Wind Shield				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	360 degree visibility	Poor visibility	Erroneous navigation	Windshield covered by oil or salt	IMCA M 166	5×10^{-5}	A mechanism to remove contamination (wash nozle, wiper, etc.) on the window would improve the conditions.	1	1	Low
			Erroneous navigation	Dew	IMCA M 166	1.5×10^{-4}	A mechanism to remove dew on the inside of the windshield should be provided.	1	2	Low
			Leakage	Hydrodynamic pressure	IMCA M 166	2.5×10^{-3}	Design of windshield as well as its attachment mechanism will be important to prevent any leakage into the cabin.	2	3	Medium

Sheet no : 05				Item : Hatch				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	**Description / Function**	**Failure Mode**	**Potential Effects of Failure**	**Possible Failure Causes**	**Severity Class**	**Failure rate F/Mhr**	**Recommendations and Actions Taken**	**Action Result**		**Risk Priority**
								Sev	**Occ**	
1	Hatch for boarding of passengers designed to keep water out	Leakage or unintentional opening the hatch	Cabin filling up with water during launch, potential injury by occupants	Any corrosion on watershield. Hatch are open	IMCA M 166	5×10^{-4}	Design verification should include the hatch closure mechanism.	2	1	Low
2	Doors and hatches	The drain of the boat is open	Water in rush during launch, potential injury by occupants, sink the boat	Any corrosion on watershield. Hatch are open	IMCA M 166	5×10^{-6}	Double visual check	3	1	Low
				Any hazardous rust inside the seal	IMCA M 166	5×10^{-5}	Double visual check	3	1	Low
3	window	Any crack in the glass of window	Water in rush during water entry phase, potential injury by occupants, sink the boat	The part of window is open because of crack	IMCA M 166	5×10^{-5}	Double visual check	3	1	Low

Sheet no : 06				Item : Seats				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Seats shall be designed to protect occupants during drop	Incorrect design	Fatal injuries	Missing requirements	IMCA M 166	5.7×10^{-2}	Boarding time shall be less than 3 minutes	3	4	High
		Pilot reaction time after drop	Inability to gain control over the lifeboat in time	Pilot seat design	IMCA M 166	5.7×10^{-2}	Seat design for pilot is regarded as important with respect to headway requirement.	3	4	High

Sheet no : 07				Item : Safety belts				FMEA		
Operating mode : Launching Operation				**Prepared by : PT. Surya Segara, DNV - OS - E406**						
Item ref.	**Description / Function**	**Failure Mode**	**Potential Effects of Failure**	**Possible Failure Causes**	**Severity Class**	**Failure rate F/Mhr**	**Recommendations and Actions Taken**	**Action Result**		**Risk Priority**
								Sev	**Occ**	
1	Keep passengers in place	Incorrect design	Mortal injury	Improper/missing requirements	IMCA M 166	1.19×10^{-2}	CAR<1 may lead to hazardous situations because of the lifeboat boat rotation during impact.	3	4	High
	Individual fastening is required	Incorrect design	Mortal injury	Improper/missing requirements	IMCA M 166	1.19×10^{-2}	CAR<1 may lead to hazardous situations because of the lifeboat boat rotation during impact.	3	4	High
2	Seat belt	On bad condition of seat belt	Fatal injury by the passengers of the boat	Unsafe practices during lifeboat inspections and drills	IMCA M 166	8.8×10^{-3}	Double visual check	3	3	High

Sheet no : 08				Item : Release mechanism				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Release of hook initiates drop	Malfunction of release mechanism	Failure to release lifeboat when intended	Change in design	IMCA M 166	1.45×10^{-3}	The changes to the design of the releasing hook must be avaluated to prevent unforeseen effects	3	5	High
2	Lashing Unit	Failure on lashing line	Lifeboat can't be launch	Any rust or corrosion on lashing line	IMCA M 166	3.61×10^{-2}	Release it using a nylon rope	3	4	High
		Failure on sleep hook turnbuckle	Lashing line can't be remove	Any rust or corrosion on sleep hook turnbuckle	IMCA M 166	3.61×10^{-2}	Double visual check	3	4	High

Sheet no : 08.1				Item : Release mechanism			FMEA	FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
3	Jumping stoppers	Jumping stoppers aren't set	Failure on lifeboat launching. Process of launching will be delay	The insufficient maintenance of lifeboats	IMCA M 166	3.61×10^{-2}	Double visual check	3	4	High
				A lack of familiarity with lifeboats and the associated equipment	IMCA M 166	6×10^{-5}	Double visual check	3	1	Low
			It may cause an accident during launching	A lack of familiarity with lifeboats and the associated equipment	IMCA M 166	6×10^{-5}	Double visual check	3	1	Low
4	Freefall release gear operation	Can't take out safety pin	Release gear operation can't working	Equipment failure	IMCA M 166	3.61×10^{-2}	Review the redundancy of the release mechanism	1	4	Medium
			can't launch the lifeboat	Equipment failure	IMCA M 166	3.61×10^{-2}	Double visual check	1	4	Medium
			It may cause an accident during launching	Equipment failure	IMCA M 166	3.61×10^{-2}	Double visual check	2	4	High

Sheet no : 08.2				Item : Release mechanism			FMEA	FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
4	Freefall release gear operation	Failure on hydraulic release lever	Release hook can't open	hydraulic oil lever below markings	IMCA M 166	3×10^{-5}	take out handle for emergency release bolt	3	1	Low
			can't launch the lifeboat	hydraulic oil lever below markings	IMCA M 166	3×10^{-5}	Double visual check	3	1	Low
			It may cause an accident during launching	Equipment failure	IMCA M 166	3.61×10^{-2}	Double visual check	1	4	Medium
		Failure on release hook	Release hook can't open	Equipment failure	IMCA M 166	3.61×10^{-2}	Review the redundancy of the release mechanism	1	4	Medium
			can't launch the lifeboat	Equipment failure	IMCA M 166	3.61×10^{-2}	Review the redundancy of the release mechanism	1	4	Medium
			It may cause an accident during launching	Equipment failure	IMCA M 166	3.61×10^{-2}	Review the redundancy of the release mechanism	2	4	High

Sheet no : 09				Item : Skid				FMEA		
Operating mode : Launching Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Interaction between guide rails on lifeboat and guide rails on davit	Overload of the skid causing damages to skid and boat	Plastic yield and breakage (critical at end of the skid right before boat is leaving the skid)	Launching while the skid is tilting sideways	IMCA M 166	2.2×10^{-3}	This is a load case for the skid design which normally is overlooked. It will likely not prevent the launch. But the consequence of this load case must be considered both in design and during full scale testing.	2	3	Medium

Sheet no : 10				Item : Retrieval arrangement				FMEA		
Operating mode : Recovery Operation				Prepared by : PT. Surya Segara, DNV - OS - E406						
Item ref.	Description / Function	Failure Mode	Potential Effects of Failure	Possible Failure Causes	Severity Class	Failure rate F/Mhr	Recommendations and Actions Taken	Action Result		Risk Priority
								Sev	Occ	
1	Retrieve lifeboat back to platform/ship	Overload of lifting arrangement while recovery operation	Loss of Lifeboat because the boat got damaged	Jerk in wire because of dynamic affects (due to waves)	IMCA M 166	5×10^{-4}	Safety factor for the lifeboat lifting arrangement must be decided and verified	3	2	Medium
	Retrieve lifeboat back to platform/ship	Potential injury on man overboard	Rescue operation	Climbing on top of lifeboat while connecting lifting hook	IMCA M 166	2.5×10^{-3}	Safety for personel that will be performing drop testing must be examined when system and procedures are in place	3	3	High
2	Hydraulic power pack system	Failure on electric motor	Unsuccessful Recovery operation	loss power of electric motor	IMCA M 166	5.41×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on pressure gauge	Error calibration on pressure gauge	Error judgement by operator	IMCA M 166	1.2×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on starter	Can't start hydraulic power pack system	Hydraulic power pack system can't work	IMCA M 166	5.39×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium
		Failure on control valve	Can't control and adjust hydraulic power pack	Stuck on panel of control valve	IMCA M 166	2.76×10^{-5}	Safety factor for the lifeboat hydraulic power pack system must be decided and verified	3	1	Medium

Scenario No. 1	Crack in hull caused by Insufficient Quality Assurance (QA) during production process		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Excess buoyancy should keep the boat afloat even if hull cracks		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			6.6×10^{-2}
Frequency of Unmitigated Consequence			6.6×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.98×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. perlu dilakukan training pada production proses		
	2. A QA program must be in force during the production of the lifeboat		

Scenario No. 2	Crack in hull caused by Impairment and decomposition of gelcoat		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Ingress of water to laminate leading to delamination		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			6.6×10^{-2}
Frequency of Unmitigated Consequence			6.6×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.98×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. perlu dilakukan training pada production proses		
	2. Specification of gelcoat must be confirmed and followed up during production		

Scenario No. 3	Crack in bow caused by Poorly designed bow geometry		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Excess buoyancy should keep the boat afloat even if hull cracks		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			6.6×10^{-2}
Frequency of Unmitigated Consequence			6.6×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.98×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. perlu dilakukan training pada production proses		
	2. Production follow-up for the bow geometry is important		

Scenario No. 4	Insufficient buoyancy caused by Leaking of gas below water surface reduces effective water density and hence buoyancy of lifeboat		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	The lifeboat becomes partly submerged or even sinks		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			6.6×10^{-2}
Frequency of Unmitigated Consequence			6.6×10^{-2}
Independent Protection Layers	Fire detector	6.31×10^{-3}	
	Survey	6×10^{-2}	
Total PFD		3.8×10^{-4}	
Frequency of Mitigated Consequence			2.49×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. perlu dilakukan training pada production proses		
	2. It is assumed that the launch zone will be cleared for gas prior to the launch. Still it will be valuable to know which level of gas content will cause reduced bouyancy to become a problem.		

Scenario No. 6	Collapse of hull and excessive accelerations caused by Ice on the water		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Passenger fatalities		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			2.7×10^{-1}
Frequency of Unmitigated Consequence			2.7×10^{-1}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			8.1×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. The likelihood for ice on the water during the launch should be investigated for the specified location.		

Scenario No. 5	Excessive accelerations caused by Skew landing due to erroneous understanding of environmental loads		Node No. 1
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Passenger fatalities		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			2.7×10^{-1}
Frequency of Unmitigated Consequence			2.7×10^{-1}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			8.1×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. The likelihood for ice on the water during the launch should be investigated for the specified location.		

Scenario No. 2	Excessive rotation caused by Dirt or contamination on skid. Broken friction pads (on guide rail). Angle during damaged condition.		Node No. 2
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Too low speed as the boat leaves the launch skid may cause the lifeboat to rotate excessively and hit the water surface upside down		
Risk Tolerance Criteria	Action required		$<10^{-3}$
	Tolerable		$>10^{-3}$
Initiating event			1.19×10^{-3}
Frequency of Unmitigated Consequence			1.19×10^{-3}
Independent Protection Layers	Maintenance	5×10^{-2}	
Total PFD		5×10^{-2}	
Frequency of Mitigated Consequence			5.95×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. An assessment of the expected friction for the materials in use should be performed. Laboratory friction test are straightforward to carry out and will give reliable data. The condition of the friction pads should be included in the inspection routines.		

Scenario No. 1	High friction caused by Dirt or contamination on skid. Broken friction pads (on guide rail). Angle during damaged condition.		Node No. 2
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Too low speed as the boat leaves the launch skid may cause the lifeboat to rotate excessively and hit the water surface upside down		
Risk Tolerance Criteria	Action required		$<10^{-3}$
	Tolerable		$>10^{-3}$
Initiating event			1.19×10^{-3}
Frequency of Unmitigated Consequence			1.19×10^{-3}
Independent Protection Layers	Maintenance	5×10^{-2}	
Total PFD		5×10^{-2}	
Frequency of Mitigated Consequence			5.95×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. An assessment of the expected friction for the materials in use should be performed. Laboratory friction test are straightforward to carry out and will give reliable data. The condition of the friction pads should be included in the inspection routines.		

Scenario No. 2	Pilot reaction time after drop caused by pilot seat design		Node No. 3
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Inability to gain control over the lifeboat in time		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			5.7×10^{-2}
Frequency of Unmitigated Consequence			5.7×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.71×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for production process		
	2. Seat design for pilot is regarded as important with respect to headway		

Scenario No. 1	Incorrect design caused by Missing requirements		Node No. 3
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Fatal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			5.7×10^{-2}
Frequency of Unmitigated Consequence			5.7×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.71×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for production process		
	2. Boarding time shall be less than 3 minutes		

Scenario No. 2	Incorrect design caused by Missing requirements		Node No. 4
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			1.19×10^{-2}
Frequency of Unmitigated Consequence			1.19×10^{-2}
Independent Protection Layers	Training	5×10^{-7}	
	Survey	6×10^{-7}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			3.57×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. CAR<1 may lead to hazardous situations because of the lifeboat boat		

Scenario No. 1	Incorrect design caused by Missing requirements		Node No. 4
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			1.19×10^{-2}
Frequency of Unmitigated Consequence			1.19×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			3.57×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. CAR<1 may lead to hazardous situations because of the lifeboat boat		

Scenario No. 3	On bad condition of seat belt caused by Unsafe practices during lifeboat inspections and drills		Node No. 4
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			8.8×10^{-3}
Frequency of Unmitigated Consequence			8.8×10^{-3}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			2.64×10^{-5}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 1	Man overboard caused by Climbing on top of lifeboat while connecting lifting hook		Node No. 5
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			2.5×10^{-3}
Frequency of Unmitigated Consequence			2.5×10^{-3}
Independent Protection Layers	Training	5×10^{-2}	
Total PFD		5×10^{-2}	
Frequency of Mitigated Consequence			1.25×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 1	Malfunction of release mechanism caused by Change in design		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			1.45×10^{-1}
Frequency of Unmitigated Consequence			1.45×10^{-1}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			4.35×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for production process		
	2. The changes to the design of the releasing hook must be avaluated to prevent unforeseen effects		

Scenario No. 2	Failure on lashing line caused by Any rust or corrosion		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			3.61×10^{-2}
Frequency of Unmitigated Consequence			3.61×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.083×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 3	Failure on sleep hook turnbuckle caused by Any rust or corrosion		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			3.61×10^{-2}
Frequency of Unmitigated Consequence			3.61×10^{-2}
Independent Protection Layers	Training	5×10^{-7}	
	Survey	6×10^{-7}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.083×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 4	Jumping stoppers aren't set caused by The insufficient maintenance of lifeboats		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			3.61×10^{-2}
Frequency of Unmitigated Consequence			3.61×10^{-2}
Independent Protection Layers	Training	5×10^{-7}	
	Survey	6×10^{-7}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.083×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 5	Can't take out safety pin caused by Equipment failure		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			3.61×10^{-2}
Frequency of Unmitigated Consequence			3.61×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.083×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Double visual check		

Scenario No. 6	Failure on release hook caused by Equipment failure		Node No. 6
Date: 28 June 2016	Description	Probability	Frequency (per year)
Consequence description/ Category	Mortal injuries		
Risk Tolerance Criteria	Action required		$<10^{-1}$
	Tolerable		$>10^{-1}$
Initiating event			3.61×10^{-2}
Frequency of Unmitigated Consequence			3.61×10^{-2}
Independent Protection Layers	Training	5×10^{-2}	
	Survey	6×10^{-2}	
Total PFD		3×10^{-3}	
Frequency of Mitigated Consequence			1.083×10^{-4}
Risk Tolerance Criteria Met? (Yes/ No)		Yes	
Action required to meet Risk Tolerance Criteria	1. Training needed for operator		
	2. Review the redundancy of the release mechanism		

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CHAPTER V
CONCLUSION

Depend on the result of risk assessment for free fall lifeboat launching concluded that :

1. There is so many risk can happen on the process of launching and retrieval. But that can be reduced with mitigation for decrease the frequency or give a prevention.

2. Human error proved to be a significant contributory factor in many of the reported lifeboat incidents, as it is in most accidents. Lack of supervision was not found to be a significant factor in the cause of reported human error related incidents therefore the potential for mistakes might reasonably be expected to increase during the stress of a real emergency situation.

3. The design and construction of lifeboats and in particular auxiliary equipment, such as brakes and release gear, play a significant part in contributing towards the cause of many lifeboat incidents with the most catastrophic event being the opening of a boat hook with the boat some distance from the water, Incidents of this nature can be avoided if the boat crew is able to confirm the hook is secure for lowering or lifting. Their repeated failure has, however, played a large role in reducing ship staff confidence in lifeboats.

4. SOLAS requirements for lifeboats are focused on launching. Although regular training is required, insufficient emphasis is placed on measures designed to ensure that routine operations, such as recovery and lifting of lifeboats can be conducted safely.

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