BACHELOR THESIS – ME141502

FIRE RISK ASSESSMENT FOR SAFETY PLAN ON KMP PORT LINK 3 THROUGH FIRE DYNAMIC SIMULATOR

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SURABAYA

TUGAS AKHIR – ME141502

ANALISA KEBAKARAN UNTUK RENCANA KESELAMATAN PADA KMP. PORT LINK 3 MENGGUNAKAN FIRE DYNAMIC SIMULATOR

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JURUSAN TEKNIK SISTEM PERKAPALAN
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SURABAYA

APPROVAL FORM

FIRE RISK ASSESSMENT FOR SAFETY PLAN ON KMP. PORT LINK 3 THROUGH FIRE DYNAMIC SIMULATOR

FINAL PROJECT

Submitted to Fulflll One of The Requirement
to Obtain a Bachelor Engineering Degree on Reliability, Availability, Maintainability and Safety (RAMS) Laboratory
S-1 Program Department of Marine Engineering
Faculty of Marine Technology
Institute Technology Sepuluh Nopember

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JULY, 2016

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Approval Form

FIRE RISK ASSESSMENT FOR SAFETY PLAN ON KMP. PORT LINK 3 THROUGH FIRE DYNAMIC SIMULATOR

BACHELOR THESIS

Submitted To Comply One Of The Requirements To Obtain A Bachelor Engineeting Degree
On
Laboratory Of Reliability, Availability, Maintainability, And Safety (RAMS)
S-1 Program Department Of Marine Engineering
Faculty Of Marine Technology
Institut Teknologi Sepuluh Nopember

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FIRE RISK ASSESSMENT FOR SAFETY PLAN ON KMP. PORT LINK 3 THROUGH FIRE DYNAMIC SIMULATOR

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ABSTRACT

Indonesia is a maritime country which has many ships that sailing to sent types of cargo such as raw materials, food and drink, natural resources, gasoline, vehicles until human also can be carried by ship. With this traffic at Indonesia sea, so it needed a risk assessment method to avoid the ship accident. From last five years there is too much ship accident. KNKT notice that mostly the ship accident caused by the fire on their own ship.

Mostly, the fire happened in engine room, car deck, short cirucuit, galley, passenger room and explotion happened on hull and the impact for the ship is loss of assets that should be keep for a long term and cause of death for passenger. This things can be minimized with fire risk assessment for safety plan. With this assessment, it can be expected there is analysis for prevent the fire on the ship.

Fire risk assessment not only can do to the ships that already fired or got accident, but also can be done for the ships that have never been fired or accident to check that the safety plan to function properly or not during the fire comes or accident. This understanding should be done to prevent another accident or fire on the ship soon.

The result of this research recommendation can be used to prevent fire on the ship for the next time with suitable Standart Operational Procedur. It is important to prevent the ship accident that will happen for the next.

Keywords: ships, fire, accident, safety plan, equipment of safety plan, safety plan analysis.

ANALISA KEBAKARAN UNTUK RENCANA KESELAMATAN PADA KAPAL KMP. PORT LINK 3 MENGGUNAKAN FIRE DYNAMIC SIMULATOR

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ABSTRAK

Indonesia adalah negara maritim yang memiliki banyak kapal yang berlayar ke jenis dikirim kargo seperti bahan baku, makanan dan minuman, sumber daya alam, bensin, kendaraan sampai manusia juga dapat dilakukan dengan kapal. Dengan lalu lintas ini di laut Indonesia, maka diperlukan suatu metode penilaian risiko untuk menghindari kecelakaan kapal. Dari lima tahun terakhir ada terlalu banyak kecelakaan kapal. KNKT melihat bahwa sebagian besar kecelakaan kapal yang disebabkan oleh kebakaran pada kapal mereka sendiri.

Sebagian besar, kebakaran terjadi di ruang mesin, dek mobil, arus pendek, dapur, ruang penumpang dan ledakan terjadi pada lambung dan dampak untuk kapal adalah hilangnya aset yang harus terus untuk jangka panjang dan penyebab kematian untuk penumpang. hal ini dapat diminimalkan dengan penilaian risiko kebakaran untuk rencana keselamatan. Dengan penilaian ini, dapat diharapkan ada analisis untuk mencegah kebakaran di kapal.

penilaian risiko kebakaran tidak hanya bisa dilakukan untuk kapal-kapal yang sudah kebakaran atau mendapat kecelakaan, tetapi juga dapat dilakukan untuk kapal-kapal yang belum pernah atau tidak mengalamin kebaran atau kecelakaan *untuk memeriksa bahwa alat keselamata dalam kapal dapat berfungsi dengan baik selama api datang atau kecelakaan. Pemahaman ini harus dilakukan untuk mencegah kecelakaan lain atau kebakaran di kapal kedepannya.*

Hasil rekomendasi penelitian ini dapat digunakan untuk mencegah kebakaran di kapal untuk waktu berikutnya dengan Procedur Operasional Standart yang cocok. Hal ini penting untuk mencegah kecelakaan kapal yang akan terjadi untuk selanjutnya.

Kata kunci: kapal, kebakaran, kecelakaan, rencana keselamatan, alat keselamatan kapal, analisa keselamatan kapal

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CHAPTER I
INTRODUCTION

1.1. BACKGROUND

From many ship accidents that occurred, fire is an event that causes most of ship accidents. Many of ships in Indonesia still have not aware with the danger of fire onboard. Data from KNKT showed that as much as 62% of fire accidents occurred mostly from oil or fuel leak in the engine room and the rest happened because of the material used, short circuit, and human error. Table 1.1 shows that from 2007 – 2013 there are so many ship accidents and most of it were caused by fire. 15 out of 36 accidents were caused by fire. From the incidents mentioned in the table below, the government should be able to make sure that the concept that already exist on the ship must be able to do its job just in time during the accident, so it can reduce the victims.

Table 1.1. Data of Ship Accident from KNKT (2007-2013)

No	Year	Total of Accident	Types of Accident			Victim	
			Sinking	Fire/explosion	Collision	Died/lost	Injuries
1	2007	7	4	3	0	100	104
2	2008	5	2	3	0	10	51
3	2009	4	2	1	1	447	0
4	2010	5	1	1	3	15	85
5	2011	6	1	3	2	86	346
6	2012	4	2	2	2	13	10
7	2013	5	2	2	2	65	9
Total		36	15	15	10	736	645

Until now, various national and international organizations still continue to improve the regulations to regulate the safety of the ships. The improvements are expected to be based on previous accidents that happened because of construction fault, fire detection, safety equipment, evacuation procedure, and crew training. To help the goverment and shipping company, this work will discuss about fire risk assessment of the safety plan on KMPPORT LINK 3, to prevent fire on this ship. KMP PORT LINK 3 was selected because this ship is one of the luxurious roro vessel inside in Indonesia. Because of this, it is unfortunate if the safety plan on this ship is not properly maintained. In case this ship get fire accident, it would cause much losses.

Figure 1.1KMP PORT LINK 3

KMP PORT LINK 3 is a roro vessel that carry passengers and vehicles from Bakauheni to Merak and vice versa. This ship has never had any fire accident. So, in this final project, the safety plan need to be evaluated to ensure that all the safety plan are working properly in case there is a fire. KMP PORT LINK 3 is operated by PT ASDP Indonesia. PT ASDP Indonesia is a company that operate roro ships to transport people, cars, and other in some places.

Fire onboard is one thing that is avoided by every ship owner, because the impact from fire if it cannot be handled as soon possible is the loss of long-term assets. For example, if there is a fire on a passenger ship that would be detrimental to the shipping company, because they will lose the asset, replacing the existing losses and will certainly lose customers or demand due to this accident.

These safety plan analysis will be done with fire modelling to evaluate whether the safety plan that already exist on KMP PORT LINK 3 are already working just in time or not. Cause of the fire should be analyzed so that in the future, precautionary measures can be done for all ships, not only roro ship in Indonesia. So fire will not happen again on ships.

1.2. STATEMENT OF PROBLEMS

Fire is the accident that can detrimental to the ship owner or the shipping company.
Based on the description above, presented several problems:

1. What are the matters that potentially cause a fire?
2. How the evaluation about the safety plan on KMP PORT LINK 3?

1.3. RESEARCH LIMITATION

1. The research focused on the things that potentially cause a fire
2. The research focused to evaluate the safety plan on the ship.
3. The method used to interpret the risk is FDS.

1.4. RESEARCH OBJECTIVES

Based on the problem above, that can be determined the purposes oh these thesis, which is:

1. To find out the matters that potentially cause a fire
2. To evaluate the safety plan to the KMP PORT LINK

1.5. RESEARCH BENEFITS

With the research on this thesis, it can be expected that the benefit can be provided, which is:

1. The result from these final project can help PT. ASDP INDONESIA (PERSERO) to prevent fire on board that produced
2. The result from these final project can find out things that potentially cause a fire
3. The result from these final project can help PT. ASDP INDONESIA (PERSERO) to make a fire fighting system better and more efficient for safety plan assessment.

CHAPTER II
LITERATURE STUDY

2.1 THEORY

2.1.1 Ship Accident

The data of fire accidents that happen on the ship within the last 10 years shown on table 2.1.

Table 2.1 List of Accident caused by fire (sourced :KNKT)

YEARS	VESSEL	LOCATION
2007, 13 January	KM. NUSA BHAKTI	BUG BUG BEACH KARANGASEM, BALI
2007, 22 February	KMP. DHARMA KENCANA I	TANJUNG PRIUK PORT, JAKARTA
2008, 18 May	KMP. DHARMA KENCANA I	MENTAYA HILIR RIVER SOUTH OF EAST WARINGIN CITY, SOUTH KALIMANTAN
2009, 30 May	KM. MANDIRI NUSANTARA	KERAMAIAN TERRITORIAL WATER, BAWEAN, EAST JAVA
2010, 12 April	KM. GEMILANG	KADE 103 SOEKARNO HATTA PORT, MAKASSAR, SOUTH CELEBES
2011, 28 January	KMP. LAUT TEDUH 2	TERRITORIAL WATERS AROUND TEMPURUNG ISLAND, SUND STRAIT – BANTEN
2011,8 February	KM. SALVIA	EAST OF TERRITORIAL WATER AROUND DAMAR ISLAND, THOUSAND ISLANDS, DKI JAKARTA
2011, 4 July	KM. MUSTHIKA KENCANA II	PERAIRAN 45 NM SOUTH OF TERRITORIAL WATER MASALEMBO ISLANDJAVA SEA – EAST JAVA
2012, 3 August	TKG GEMILANG PERKASA	ENGINE ROOM, JETTY TERMINAL PERTAMINA FUEL, SAMARINDA – EAST BORNEO

Table 2.1 List of Accident caused by fire (continue) (sourced :KNKT)

YEARS	VESSEL	LOCATION
2013, 22 August	KM. EXPRESS BAHARI 8C	14 NM TERRITORIAL WATER STRAIT OF NASIK, NORTH WEST OF TANJUNG PANDAN, BANGKA BELITUNG ISLANDS
2013, 12 Septembers	KM. PRAMUDITA	SPECIAL TERRITORIAL WATER OF INDONESIA POWER UNIT BISNIS PEMBANGKIT SURALAYA PORT, PULO MERAK CILEGON, BANTEN

2.1.2 Fire Fighting System

Fire is a constant hazard at sea. The impact of fire on the ship is more total losses ship than other form of casualty. Usually, fire caused by the negligence or carelessness. Therefore, the fire fighting system for ferries and ro-ro vessels must protect both passengers and their vehicles. Some fires may be purely accidental, and others may be caused by circumstances beyond control. No matter how a shipboard free start, it could result in the loss of the ship, and perhaps the loss of lives.

Fires are classified according to the types of material which are acting as fuel. These classifications are also used for extinguishers and it is essential to use the correct classification of extinguisher for a fire, to avoid spreading the fire or creating additional hazards. The classifications use the letters A, B, C, D and E.

Class A Fires burning wood, glass fiber, upholstery and furnishings.
Class B Fires burning liquids such as lubricating oil and fuels.
Class C Fires burning gas fuels such as liquefied petroleum gas.

Class D Fires burning combustible metals such as magnesium and aluminium.
Class E Fires burning any of the above materials together with high voltage electricity.

Many fire extinguishers will have multiple classifications such as A, B and C.

Fire fighting at sea may be considered in three distinct stages, which is:

1. Detection, for locating the fire.
   The use of fire detectors is increasing, particularly with the tendency to reduced manning and unmanned machinery spaces. A fire, if detected quickly, can be fought and brought under control with a minimum of damage. The main function of a fire detector is therefore to detect a fire as quickly as possible; it must also be reliable and require a minimum of attention. An important requirement is that it is not set off by any of the normal occurrences in the protected space, which is it must be appropriately sensitive to its surroundings. Three phenomena associated with fire are used to provide alarms, these are smoke, flames and heat.

2. Alarm, for informing the rest of the ship
   Associated with fire detectors is the electric circuit to ring an alarm bell. This bell will usually sound in the machinery space, if the fire occurs there, and also on the bridge. Fires in other spaces will result in alarm bells sounding on the bridge. Any fire discovered in its early stages will require the finder to give the alarm and or make the decision to deal with it himself if he can. Giving the alarm can take many forms such as shouting fire, banging on bulkheads or any action necessary to attract attention. It is necessary to give an alarm in order to concentrate resources and effort

quickly onto the fire, even if the fire must be left to burn for a short time unchecked.

3. Control, for bringing to bear the means of extinguishing the fire.
   Two basically different types of equipment are available on board ship for the control of fires. These are small portable extinguishers and large fixed installations. The small portable extinguishers are for small fires which, by prompt on-the-spot action, can be rapidly extinguished. The fixed installation is used when the fire cannot be fought or restrained by
   Portable equipment or there is perhaps a greater danger if associated areas were to be set on fire. The use of fixed installations may require evacuation of the area containing the fire which, if it is the machinery space, means the loss of effective control of the ship. Various types of both portable and fixed fire fighting equipment are available.

Fire safety is well represented through the following design regulations:

1. Structural fire protection (hull, superstructure, bulkheads and deck)
2. Restriction on the use of combustible materials
3. Insulations of exhaust system
4. Venting or cargo spaces, fuel tanks and pump rooms
5. Means of escape
6. Minimum stairway sizes
7. Fire detection and alarm system
8. Firemain system
9. Fixed fire extinguishing system
10. Portable and semiportable extinguisher requirement
11. Approved machinery, equipment and installation.

Each bulkhead, deck, hatch, ladder and piece of machinery is built and located to serve a specific purpose or purposes including, wherever possible, fire safety. Good design of the ship just only a beginning, that design must be combined with construction and good workmanship to make a safe vessel. Stated another way, safety begins on the drawing board and is completed only when the vessel is decommissioned.

2.1.3 Fire Fighting Equipment

There are several types of fire fighting equipment that should be added on every each vessel.

1. Portable Extinguisher
   There are four principal types of portable extinguisher usually found on board ship. These are the soda-acid, foam, dry powder and carbon dioxide extinguishers.

2. Soda Acid Extinguisher
   The container of this extinguisher holds a sodium bicarbonate solution. The screw-on cap contains a plunger mechanism covered by a safety guard. The resulting chemical reaction produces carbon dioxide gas, which pressurizes the space above the liquid forcing it out through the internal pipe to the nozzle. This extinguisher is used for Class A fires and will be found in accommodation areas.

3. Foam extinguisher (chemical)
   The main container is filled with sodium bicarbonate solution and a long inner polyethylene container is filled with aluminium sulfate. The inner container is sealed with a cap held in place by a plunger. When the plunger is unlocked by turning it, the cap is released. The extinguisher is then inverted for the two liquids to mix. Carbon dioxide is produced by the reaction which pressurizes the container and forces out the foam.

4. Foam Extinguisher (mechanical)
   The outer container in this case is filled with water. A plunger mechanism with a safety guard is located above the central container. When the plunger is depressed the carbon dioxide is released and the foam solution and water mix. They are then forced out through a special nozzle which creates the mechanical foam. This extinguisher has an internal pipe and is operated upright. The carbon dioxide extinguisher is not permitted in the accommodation since, in a confined space, it could be lethal.

5. Dry powder Extinguisher
   The outer container contains sodium bicarbonate powder. On depressing the plunger the carbon dioxide gas forces the powder up a discharge tube and out of the discharge nozzle. The dry powder extinguisher can be used on all classes of fire, but it has no cooling effect. It is usually located near electrical equipment in the machinery space and elsewhere on the ship.

2.1.4 Safety Plan

A safety plan is a plan that is made to help ship owners avoid danger or potential danger to occured. The purpose of the annual safety is when there is an accident the parties can do an appropriate countermeasures.

With a safety equipment on the ship can prevent the occurrence of excess damage on the ship. For example, when there is a fire on the ship, with a safety plan when the fire broke out, the fire could quickly corrected with a sprinkle of an available hydrant or tubes. However, by the presence of a safety plan could not be ascertained that when fires break out on a steamer will soon be extinguished. It could just be the event of a fire, sprinkle the water squirt should work not working. It should be noted by ship owners. This incident

could have happened because of an existing sensor is not working properly, or the placement of the security tools that do not fit in place, and could have been planning and safety installation not in accordance with existing procedures.
The primary purpose of the annual safety plan is:

- To conduct studies and/or analysis on the impact of not fulfillment of standards and conditions of operation.
- To get an alternative problem solving in terms of guaranteeing the level of operating
- To estimate the effectiveness of each alternative solution of safety issues.
- To make recommendations for changes or restrictions associated with the surgical procedure is not the fulfillment of standards and conditions of operation.
- Identify safety targets that must be met to ensure the safety of the operation.

In the Safety Plan, the standard documents are matters of safety operation include: identification of the hazard, risk assessment and mitigation measures and conditions that must be met to maintain the level of safety steps, steps that must be done are:

a. Objectives, targets and programs. The intent was for what he did on this ship and the
b. Safety plan and commitment what will be achieved.
c. The Assessment Of Risk. Risk Assessment aims to find a balance of resource allocation to all risk and control as well as mitigation. In the management of risk is determined in advance the risk probability and severity /consequences of risk.
d. Environmental impact and Aspect Identification (IADL) was also created, if requested by the Owner/user of the service is the HSE Plan.
e. Mitigation. Mitigation is an action to eliminate the potential danger or reduces the probability or risk level. There are 3 strategies in implementing mitigation, namely:

the first evasion, operation or activity is in the area canceled because the risks are greater than the benefits. The second reduction. The frequency of the operations or activities are reduced, or taken action to reduce the level of the consequences of the risk is acceptable. While the last separation, is the action taken to isolate the effects of the risks or implement layered protection to reduce the level of risk. In mitigation, there are three defenses that may be applied:

1. Technology,
2. Training
3. Regulations/procedures

f. Monitoring. When these changes are made by placing the defenses, it must be ensured that such changes are not carrying the hazard along, and defenses are working as they should. Monitoring and reviewing is done to see if the defenses can really run so that the probability can be reduced.

g. Conclusion

On the safety plan, there is some step that should be designed. A good safety plan will help to ensure the following:

1. Assist fire with the layout and hazards associated with the ship
2. Increase the speed of evacuation of the crew during a fire
3. Indicate if there are any special requirements to assist crew in evacuating

On ship, Things in safety plan that must be understood and considered are:

1. Fire control plan
2. Fire control booklets
3. Live saving appliance plan
4. Emergency situations

5. Fire control and safety plan
6. Safety sign location plan
7. Cabin escape plan

2.1.5 Risk Assesment

Risk Assessment is the very first thing to analyze an event on an object by identifying the occurrence of events that may be occurring, then identificate what factors led to the crash, because a lot of factors that may influence.

After identifying the event on the object, identification of the frequency of incidents or accidents that may occur should also be done. From the identification it can indicate a position or place of risk that will probably occur on the object whether it is acceptable or not. This risk reduction rather than effort must also be appropriate or balanced with cost analysis.

Risk assessment techniques develop processes for identifying risk that can assist in decision making about the system. The logic of modeling the interaction of a system's components can be divided into two general categories: induction and deduction.

Risk assessment in this Final Project has the aim to determine the level of risk that can be generated on ferry ship. By using Fire Dynamic Simulator (FDS), it can be obtained the simulation of fire by smoke overview.

In other terms, if the estimated risk is simply not acceptable, then there are several ways to reduce risks, such as:

- Reduce frequency
- Reduce the consequences or a combination between two

The risk should be minimized as small as possible in order not to crash next time. The point here is that covering risk reduction with consideration of the costs as low as possible. The figure 2.1 is shown the a low as reasonably practicable (ALARP) diagram on risk assessment.

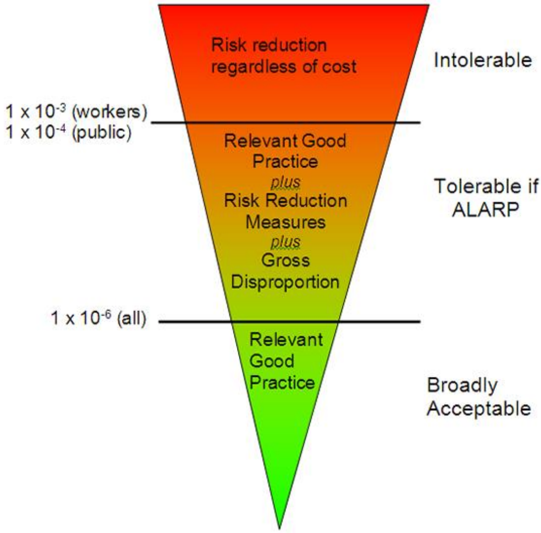

Figure 2.1ALARP (A low as reasonably practicable) diagram

2.1.6 Hazard Identification with Preliminary Hazard Analysis (PHA)

The preliminary hazard analysis (PHA) technique is a broad, initial study used in the early stages of system design. It focuses on identifying apparent hazards, assessing the severity of potential accidents that could occur involving the hazards and identifying safeguards for reducing the risks associated with the hazards. This technique focuses on identifying weaknesses early in the life of a system, thus saving time and money that might be required for major redesign if the hazards were discovered at a later date.

Brief summary of characteristics

- Relies on brainstorming and expert judgment to assess the significance of hazards and assign a ranking to each situation. This helps in prioritizing recommendations for reducing risks.
- Typically performed by one or two people who are knowledgeable about the type of activity in question. They participate in review meetings of documentation and field inspections, if applicable.
- Applicable to any activity or system
- Used as a high-level analysis early in the life of a process
- Generates qualitative descriptions of the hazards related to a process. Provides a qualitative ranking of the hazardous situations; this ranking can be used to prioritize recommendations for reducing or eliminating hazards in subsequent phases of the life cycle.
- The quality of the evaluation depends on the quality and availability of documentation, the training of the review team leader with respect to the various analysis techniques employed, and the experience of the review teams

Most common uses

- Generally applicable for almost any type of risk assessment application, but focuses predominantly on identifying and classifying hazards rather than evaluating them in detail
- Most often conducted early in the development of an activity or system, when there is little detailed information or there are few operating procedures. Often a precursor to further risk assessment.

Because the preliminary hazard analysis technique is typically conducted early in the process, before other analysis techniques are practical, this methodology has two primary limitations:

- Generally requires additional follow-up analyses. Because the PHA is conducted early in the process and uses preliminary design information, additional analyses are generally required to more fully understand and evaluate hazards and potential accidents identified by the PHA team.
- The quality of the results is highly dependent on the knowledge of the team. At the time of a PHA, there are few or no fully developed system specifications and little or no detailed design information. Therefore, the risk assessment relies heavily on the knowledge of subject matter experts. If these experts do not participate in the risk assessment, or if the system is a new technology having little or no early operational history, the results of the PHA will reflect the uncertainty of the team in many of its assessments and assumptions.

The procedure for conducting a preliminary hazard analysis consists of the following steps.

1 Define the activity or system of interest. Specify and clearly define the boundaries of the activity or system for which preliminary hazard information is needed.

2 Define the accident categories of interest and the accident severity categories. Specify the problems of interest that the risk assessment will address (e.g., Health and safety concerns, environmental issues). Specify the accident severity categories that will be used to prioritize resources for risk reduction efforts.

3 Conduct review. Identify the major hazards and associated accidents that could result in undesirable consequences. Also,

identify design criteria or alternatives that could eliminate or reduce the hazards.

4 Use the results in decision making. Evaluate the risk assessment recommendations and the benefits they are intended to achieve (e.g., Improved safety and environmental performance, cost savings).

A hazard has the potential to cause harm. This can take form of death, ill health and injury to people, damage to property, plant, product or the environment, production losses, business harm and increased liabilities. Ill health includes acute and chronic ill health caused by physical, chemical or biological agents as well as adverse effects on mental health.

Hazard analysis involves the identification of undesired or adverse event that lead to the materialization of a hazard, the analysis of the mechanisms by which these undesired events could occur and usually the estimation of the extent, magnitude and likelihood of any harmful effect. In theory, it is applied only to the identification of hazard and the consequences of the credible accident consequences of each hazard.

The general stage in hazard reduction involves:

- The identification of hazard and hazardous
- The identification of the accident scenario
- Hazard review and determination and consequences
- Assessment of risk
- Reduction of the potential consequences of accident
- Reduction of the frequency of occurrence of major accidents
- Control of external threats and unplanned change
- Attention to organization, management, training, procedures, information.
- Implementation, assessment and continued vigilance.

The severity of an event may be classified into rather broad classes. An example of such a classification is:

Table 2.2. Broad Classes

Rank	Severity class	Description
4	Catastrophic	Failure results in major injury or death of personnel
3	Critical	Failure results in minor injury to personnel, personnel exposure to harmful chemicals or radiation, or fire or a release of chemical to the environment.
2	Major	Failure results in a low level of exposure to personnel, or activates facility alarm system.
1	Minor	Failure results in minor system damage but does not cause injury to personnel, allows any kind of exposure to operational or service personnel or allow any release of chemicals into the environment.

2.1.7 Safety Plan

A safety plan is a plan that is made to help ship owners avoid danger or potential danger to occured. The purpose of the annual safety is when there is an accident the parties can do an appropriate countermeasures.

With a safety equipment on the ship can prevent the occurrence of excess damage on the ship. For example, when there is a fire on the ship, with a safety plan when the fire broke out, the fire could quickly corrected with a sprinkle of an available hydrant or tubes. However, by the presence of a safety plan could not be ascertained that when fires break out on a steamer will soon be extinguished. It could just be the event of a fire, sprinkle the water squirt should work not working. It should be noted by ship owners. This incident could have happened because of an existing sensor is not working properly, or the placement of the security tools that do not fit in place, and could have been planning and safety installation not in accordance with existing procedures.
The primary purpose of the annual safety plan is:

- To conduct studies and/or analysis on the impact of not fulfillment of standards and conditions of operation.
- To get an alternative problem solving in terms of guaranteeing the level of operating
- To estimate the effectiveness of each alternative solution of safety issues.
- To make recommendations for changes or restrictions associated with the surgical procedure is not the fulfillment of standards and conditions of operation.
- Identify safety targets that must be met to ensure the safety of the operation.

In the Safety Plan, the standard documents are matters of safety operation include: identification of the hazard, risk assessment and mitigation measures and conditions that must be met to maintain the level of safety steps, steps that must be done are:
On the safety plan, there is some step that should be designed. A good safety plan will help to ensure the following:

1. Assist fire with the layout and hazards associated with the ship
2. Increase the speed of evacuation of the crew during a fire
3. Indicate if there are any special requirements to assist crew in evacuating

On ship, what things safety plan must be understood that should be considered, such as:

1. Fire control plan
2. Fire control booklets
3. Live saving appliance plan
4. Emergency situations
5. Fire control and safety plan
6. Safety sign location plan
7. Cabin escape plan

2.1.8 Pyrosim

PyroSim is a graphical user interface for the Fire Dynamics Simulator (FDS). FDS models can predict smoke, temperature, carbon monoxide, and other substances during fires. The results of these simulations have been used to ensure the safety of buildings before construction, evaluate safety options of existing buildings, reconstruct fires for post-accident investigation, and assist in firefighter training.

FDS is a powerful fire simulator, which was developed at the National Institute of Standards and Technology (NIST) (McGrattan, et al., 2007). FDS simulates fire scenarios using computational fluid dynamics (CFD) optimized for low-speed, thermally-driven flow. This approach is very flexible and can be applied to fires ranging from stove-tops to oil storage tanks. It can also model situations that do not include a fire, such as ventilation in buildings. FDS and the Smokeview visualization program are both closely integrated into PyroSim. The figure 2.2 show about the work page of pyrosim.

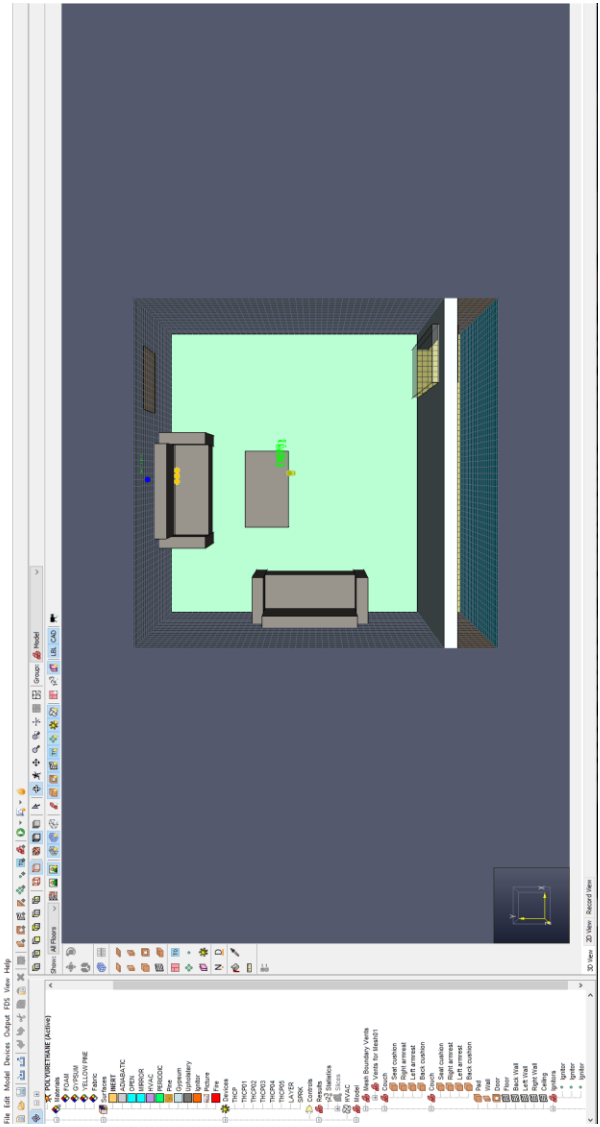

Figure 2.2 Pyrosim Work Page

2.1.8.1 Fire Dynamic Simulator

Fire Dynamic simulator (FDS) is an application that computational fluid dynamics (CFD) model or driven flow. FDS is a computer program that solves the equations that describe the evolution of the fire. FORTRAN programs used to read the input parameters from a text file, calculate the numerical solution to the equation used and the write data output to a file. The fire will shown by smokeview. Smokeview is an additional program for reading FDS output and produced animations on the screen. The Fire Dynamic Simulator is the open source software that can be used to create fire effects. The flame effect can be used in various applications such as games and fire simulations. In this process to make the fire simulations or fire effect, it used a particle system which is a small granules that runs continuously in very many may amount to tens, hundreds or millions of particles.

This is the workflow of particle on fire dynamic simulator (FDS):

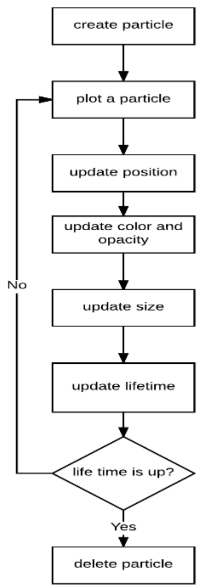

Figure 2.3 flowchart of particle

FDS is the method that applies with this thesis because FDS using particles as a tracer element to visualize the flow. In addition, FDS using particles as hatching to model fire prevention. The application that will be used through FDS is pyrosym. The figure 2.4 shows the simulation during the fire on fire dynamic simulator (FDS).

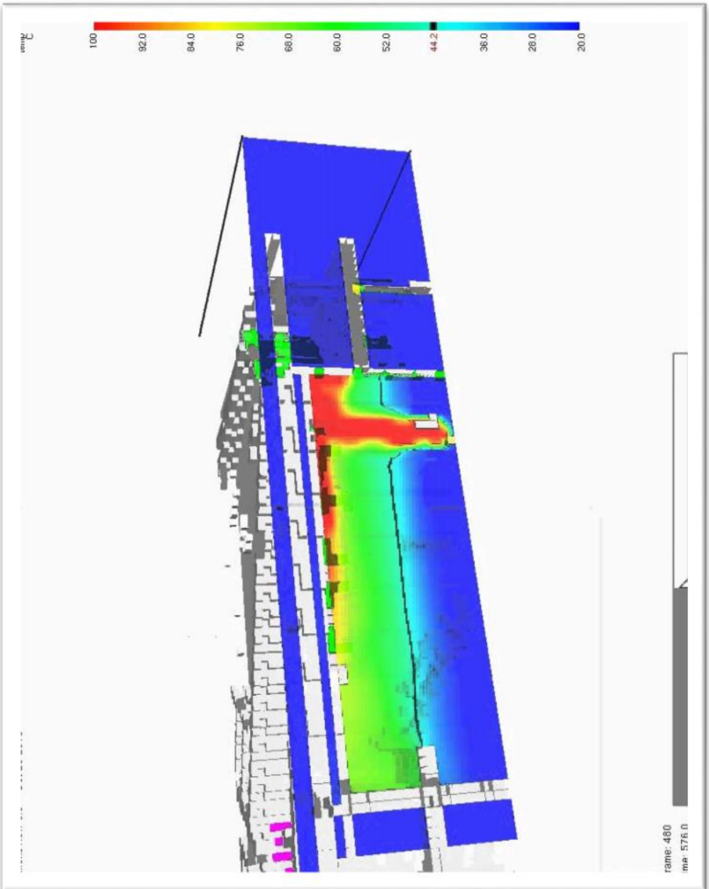

Figure 2.4: Fire Dynamic Simulator

2.1.7 Rules from BKI for fire fighting system

There are several rules about fire fighting system on passenger ships. All ships that used BKI classification shall be equipped an automatic sprinkler, fire detection and fire alarm system in all service spaces, control station and accommodation spaces, including corridors and stairways. Then, a fixed fire detection and alarm system so installed and arranged as to provide smoke detection in every space, control stations and accommodation spaces, including corridors and stairways. Control stations where water may cause damage to essential equipment may be fitted with a fixed fire extinguishing system of another type. And for a smoke detector, smoke detector need not be fitted with private bathrooms and galleys. Spaces having little or no fire risk such as voids, public toilet and similar spaces need not be fitted with an automatic sprinkler, or fixed fire detection and alarm system. And for Ro-ro ship that not in special category spaces and are capable of being sealed from a location outside of the cargo spaces shall be fitted with a fixed gas fire extinguishing system of an approved type and also shall be fitted with a fixed pressure water spraying system for manual operation of an approval type.

And for the station, for passenger ship that carrying more than 36 passengers, there is following safety devices are to be grouped together permanently manned control station :

- The alarm panels of the pressure water spraying system required
- The control and status indicators for the remotely operated fire doors
- The emergency cut-offs of the ventilation fans (except machinery space fans) plus their starters and running lights

For the passenger or ro-ro ship, there are several types of fire extinguishing equipment:

- General water fire extinguishing equipment (fire and deckwash system)

- High pressure CO2 fire extinguishing equipment
- Low pressure CO fire extinguishing equipment

BKI classification also has the rules for number fire pumps. For passenger ships of 4000 GT and over are to be equipped with at least three, and passenger ships of less than 4000 GT with at least two fire pump. In passenger ships of 1000 GT and over, fire pumps, their sea connections and power sources are to be distributed throughout the ship in such a way that an outbreak of fire in one compartment cannot put them out of action simultaneously. On a passenger ship of less than 1000 GT, the main fire pumps are located in one compartment, an additional emergency fire pump is to be provided outside this compartment.

For arrangement the placement of pump, BKI classification also has a rule. For passenger ships of 1000 GT and over, the water fire extinguishing equipment in interior locations is to be installed is such a way that at least one jet of water with the prescribed nozzle discharge pressure is immediately available. The uninterrupted supply of water is to be ensured by the automatic starting of one of the specified fire pumps. The table 2.3 explains the rules of fire fighting equipment that classified by Badan Klasifikasi Indonesia (BKI).

Table 2.3. Fixed Fire Extinguishing System

Spaces and area to be protected	Type of vessel	
	cargo	passenger
Machinery spaces with internal combustion machinery used for the main propulsion and machinery spaces containing oil-fired plants (boilers, incinerators etc.) or oil fuel units		For all ship
	CO_2, high expansion foam or pressure water spraying system[1,2)]	

Table 2.3 Fixed Fire Extinguishing system (Continue)

Spaces and area to be protected	Type of vessel	
	cargo	passenger
Machinery spaces containing internal combustion engine not for used propelling the ship	$\geq$ 375 kW	$\geq$ 375 kW
	CO_2, high expansion foam or pressure water spraying system 2)	
Machinery spaces containing steam engines	$\geq$ 375 kW	$\geq$ 375 kW
	CO_2, high expansion foam or pressure water spraying system 2)	
Fire hazard areas of category A machinery spaces above 500 m^3 in volume acc. to L.3	Fixed water-based local application firefighting systems (FWBLAFFS) 3)	
Fuel oil purifiers in acc. with B.2.	Fixed local fire extinguishing arrangement Low expansion foam-, pressure water spraying- or dry powder system	
Exhaust gas fired thermal oil heaters acc. to L.2.2	Pressure water spraying system	
Scavenge trunks of two stroke engines acc. to Sect. 2, G.6.3	CO_2 system or other equivalent extinguishing system	
Paint lockers and flammable liquid lockers acc. to M.1.	CO_2, dry powder extinguishing or pressure water spraying system 2)	
Deep-fat cooking equipment acc. to M.3.	Automatic or manual fire extinguishing system	
Accommodation, service spaces and control station , include corridor and stairways	Only in the case of structural fire protection method IIC automatic sprinkler system, see C.3.2	Automatic sprinkler system, see C.2.4; if less than 37 passengers, see C.2.1/C.2.2
Cabin balconies		Pressure water-spraying system 6)
Galley range exhaust ducks acc. to M.2	CO_2 system or other equivalent extinguishing system	
Incinerator spaces and waste storage spaces	Automatic sprinkler system or manually released fire extinguishing system, for details refer to N.	

Table 2.3 Fixed Fire Extinguishing system (Continue)

Spaces and area to be protected		Type of vessel: cargo	Type of vessel: passenger
Helicopter landing deck acc. to O.		Low-expansion foam system	
Cargo spaces	Special category spaces on passenger ships		Fixed water-based fire fighting system
	For motor vehicles with fuel in their tanks	CO2-, high-expansion foam- or fixed water-based firefighting system	
	For dangerous good	for all ships CO2 fire-extinguishing system [4,5,8)]	
	4. On ro-ro ships a) closed b) open c) not capable of being sealed	• CO2-, high-expansion foam- or fixed water-based firefighting system • Fixed water-based firefighting system • Fixed water-based firefighting system	
	5. Cargo spaces not include in 1-4	≥ 2000 GT [6)] CO2, or inert gas system	≥ 1000 GT CO2- or inert gas- or highexpansion foam system

Table 2.3 Fixed Fire Extinguishing system (Continue)

Spaces and area to be protected	Type of vessel	
	cargo	passenger
Cargo area and cargo tanks	Tankers to D.2: Low-expansion foam system and inert gas system Chemical tankers acc. to Part 1. Seagoing Ships Volume X, Section 11: Low-expansion foam, dry powder, pressure water spraying and inert gas system Ships for the carriage of liquefied gases acc. to Part 1. Seagoing Ships Volume IX, Section 11 : Pressure water spraying, dry powder system [8] and inert gas systems.	
Cargo pump spaces	Tanker and chemical tankers: CO_2, high expansion foam or water mist system [2]	
Cargo pump and compressor rooms:	Ships for the carriage of liquefied gases: CO_2 system [2]	

1) Also applies to < 500 GT in the case of ships with class notation OT and in the case of chemical tankers.

2) Approved systems using gases other than CO_2 may be applied. Re.1.

3) Applies to passenger ships of 500 GT and above and cargo ships of 2000 GT and above.

4) Special category spaces are closed vehicle decks on passenger ships to which the passengers have access.

5) Pressure water spraying system in ro-ro spaces (open or not capable of being sealed), in open top container cargo spaces (re. D.3) and in special category spaces.

6) May be dispensed with on request where only coal, ore, grain, unseasoned timber, non-combustible cargo or cargo representing a low fire risk are carried. Reference is made to MSC.1/Circ.1395/Rev.1.

7) May be dispensed with, if the furniture and furnishing are only of restricted fire risk, see L.4.

8) Details see J.3.

9) For ships of less than 500 GT the requirement may be dispensed with subject to acceptance by the Administration.

Table2.4. Number and Minimum capacity of fire pumps

<table>
<tr><td colspan="4">Passenger Ship</td><td colspan="2">Cargo Ship</td></tr>
<tr><td colspan="2">≥ 4000 GT</td><td colspan="2">< 4000 GT</td><td>≥ 500 GT</td><td>< 500 GT</td></tr>
<tr><td colspan="6">Number of power-driven fire pumps</td></tr>
<tr><td colspan="2">3</td><td colspan="2">2</td><td>2</td><td>1</td></tr>
<tr><td colspan="6">Minimum capacity V (m3/h) of one fire pump [1)]</td></tr>
<tr><td>[2)] $5,1\cdot10^{-3}\cdot d^2_H$</td><td>$3,8\cdot10^{-3}\cdot d^2_H$</td><td>[2)] $7,65\cdot10^{-3}\cdot d^2_H$</td><td>$5,75\cdot10^{-3}\cdot d^2_H$</td><td colspan="2">$3,8.10^{-3}.d^2_H$</td></tr>
<tr><td colspan="6">1) d_H (mm) = theoretical diameter of the bilge main (see Section 11,N. formula 4.)
2) Applicable to passenger ships with a criterion numeral of 30 or over in accordance with SOLAS 1974 as amended, Chapter II-1, Part B, Regulation 6.</td></tr>
</table>

The table 3.4 is show the regulation about the number and minimum capacity of fire pumps based on Badan Klasifikasi Indonesia (BKI).

And for the shore connection. To prevent the fire in port, BKI classification have a rules for the shore connection. Ships of 500 GT and over to be provided with at least one connector through which water can be pumped from the shore into the ship’s fire main.

CHAPTER III
METHODOLOGY

Methodology represents of the basic framework from stages to finish the final project. The methodology of this final project cover all of the activity that supports the completion of this final project. The activity of this final project used to solve the problem that is given in this final project. The description about methodology is described below. The figure 3.1 is shown the methodology chart on these final projects.

3.1 LITERATURE STUDY

The Study of literature for this final project are collected from the article, journal, book and thesis which have relation about final project. This main idea for study literature is about risk assessment for the safety plan, fire fighting system, fire fighting equipment, classification that applied on board. All the information that already collected will used as basic theory on these final projects.

3.2 COLLECTING DATA

Collecting data is the crucial things that should be added to complete these final projects so, the data collected from the shipping company, PT. ASDP INDONESIA. The data can be collected from the shipping company (PT. ASDP INDONESIA). Data that needed to complete on these final project is the General Arrangement of the safety plan from KMP and fire fighting equipment. PORT LINK 3 and the fire fighting system. All this data will be used for fire modelling and evaluate the safety plan on KMP PORT LINK 3.

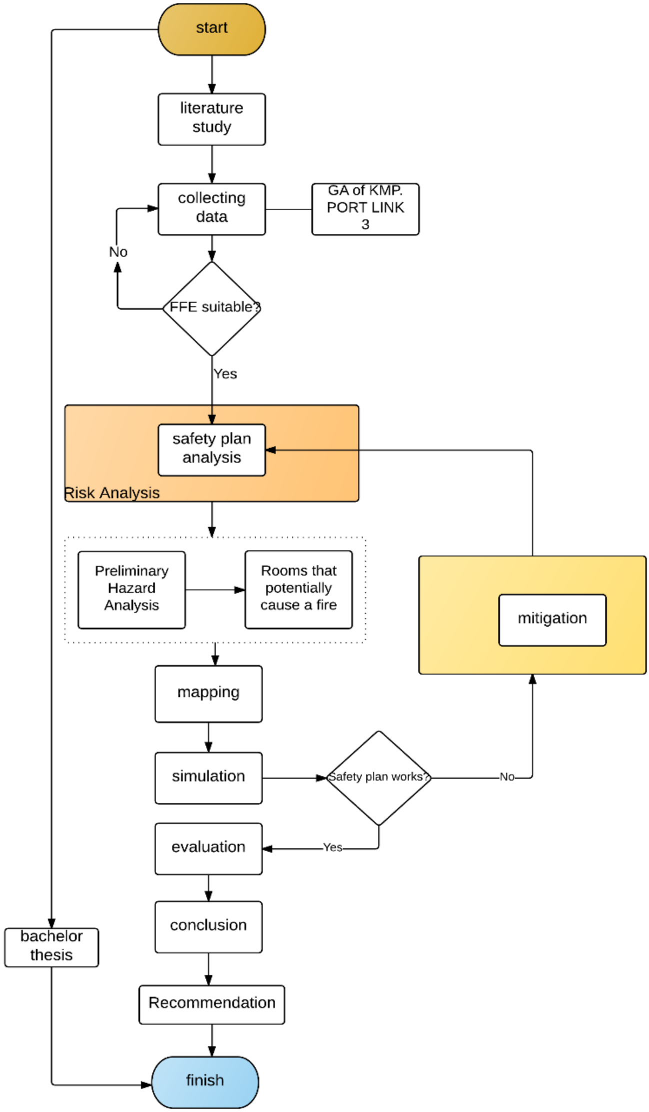

Figure 3.1. Methodology Chart

3.3 FIRE FIGHTING EQUIPMENT

Fire fighting equipment that is given by the shipping company will be sorted and listed. The fire fighting equipment will be sorted and listed based on Badan Klasifikasi Indonesia (BKI). All of the equipment is useful for these final projects due to the fire modelling.

3.4 SAFETY PLAN ANALYSIS

Safety plan analysis will be used to analyze the safety plan that exists on the ship. The safety plan that will be analyzed are based on the fire fighting equipment. The analysis is not using any method but by comparing the fire fighting equipment that exist on the ship with Badan Klasifikasi Indonesia (BKI) classification. The aim of this analysis is to make sure that the safety plan on KMP PORT LINK 3 is already fulfil the classification requirement. The safety plan can be analyzed whether the safety plan is appropriate with a class that used or not. The result of the analysis will be used due to the overcome the fire in fire modelling.

3.5 PRELIMINARY HAZARD ANALYSIS

Preliminary Hazard Analysys (PHA) is the method of risk analysis that can be used in this final project. The objective of using Preliminary Hazard Analysis (PHA) is to know where the potential source that can cause fire on the ship based on the Statistics Indonesia. Method from hazard identification is used only until the consequences stages. The result of Preliminary Hazard Analysis (PHA) will be used for fire modelling to make the sources of the fire.

3.6 REDRAWING

Redrawing is the re-arrangement of picture. On these final projects the redrawing is focused on the General Arrangement from KMP PORT LINK 3 and the placement of the safety plan on KMP PORT LINK 3. The redrawing of the ship is using AutoCad 2013. The redrawing can be done based on the data that's collected from the shipping company. All of the data that has been redrawing will be sent to fire modelling (pyrosim). The data that already sent to pyrosim will be created for floors and walls in every each room and aisle.

3.7 FIRE MODELLING

Fire modelling is done to make sure that safety plan that exist on the ship are working just in time during the fire accident or not. Pyrosim is the selected application that will be used in this final project. Pyrosim application is the part of fire dynamic simulator that has a function to run fire simulation on the ship. On pyrosim, not all of safety equipment can be modelled. In this final project, the safety equipment that will be used are sprinkle, heat detector, thermocouple, and CO2.

To make the 3D model, the first step is to convert the 2D model from AutcoCad. then, make a 3D model on pyrosim with the floors, doors, selecting the material, placement of safety equipment and ignitor. The modelling will take 150 seconds. The aim of this modelling is to see when the safety plan is activated and the fire can be extinguished within 150 seconds. The result of the modelling is the Heat Release Rate (HRR) graph. The Heat Release Rate (HRR) graph will go down if the safety plan are working just in time. If the graph does not show the decreasing value, then a mitigation should be done.

3.8 MITIGATION

Mitigation is the method that used to prevent the accident of the ship. On these final project mitigation only can be done if the safety plan that existing on the ship can’t work or active when the fire come just in time. Mitigation done based on the fire modelling result, if the result explain that the sprinkle are works just in time so on these final project no need to be done the mitigation. If the result show that the safety plan not works well during the fire, so the mitigation need to do. On these final projects the mitigation only changed the placement of safety equipment or reducing/increasing the total number of safety equipment but should be fulfilled the classification. The result of mitigation will be seen through the fire modelling.

3.9 EVALUATION

The evaluation of these projects is to see how the safety plan is working during the modelling. The evaluation will be used based on the result from modelling. Then, the evaluation will be forwarded through recommendation that can useful to the shipping company.

3.10 CONCLUSION & RECOMMENDATION BASED ON EVALUATION

Make conclusions based on the results obtained and suggestions for further research development. On these final projects, the conclusion is taken from the result of modelling. The content of the conclusion explains the results from modelling.

Recommendation are used to make the best solution in further. For these final project the recommendation intended for the shipping company. The recommendation can be expected to avoid the accident or fire in the further. The recommendation will be related to the conclusion of these final projects.

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CHAPTER IV
DATA ANALYSIS AND SIMULATION

4.1 DATA ANALYSIS

KMP.PORT LINK 3 is a roro ship operated by PT. ASDP INDONESIA. KMP. PORT LINK 3 has a route for carrying passengers from merak port to bakaheuni port and also the other way around.

KMP.PORT LINK 3 can be carrying passenger up to 900 passengers. KMP. PORT LINK 3 is ship renewal that produced on 1986 at Japan. The figure 4.1 is show the KMP. PORT LINK 3.

Figure 4.1. KMP PORT LINK 3

Here is the principal dimension data about KMP. PORT LINK 3:

LOA	: 150,87 m
Lpp	: 140 m
B	: 25 m
Depth D-deck	: 13,30 m
Depth E-deck	: 8,10 m
Draft	: 5,471 m
GT	: 15.661 T
DWT	: 3.864 T
Passenger	: 900
Crew	: 50
Register Number	: 18786
IMO Number	: 8604333

The table 4.1 is how the specific data of Main engine on KMP. PORT LINK 3.

Table 4.1. Main Engine of KMP PORT LINK 3

No	Brand	Manufacture	cyl	BHP	RPM	year	model	series	Pos
1	Mitsubishi	MITSUBISHI HEAVY INDUSTRIES CO., LTD.	8	12.000	428	1986	8L 58/64	D164004	PA
2	Mitsubishi	MITSUBISHI HEAVY INDUSTRIES CO., LTD.	8	12.000	428	1986	8L 58/64	D164004	SA

The table 4.2 is how the specific data of Auxiliary engine on KMP. PORT LINK 3.

Table 4.2. Auxiliary Engine of KMP PORT LINK 3

Item	Brand	Manufacture	Location	Model	BHP	Year
AO1	DAIHATSU	DAIHATSU DIESEL MFG. CO., LTD.	JAPAN	6DLB-26	2020	1986
AO2	DAIHATSU	DAIHATSU DIESEL MFG. CO., LTD.	JAPAN	6DLB-26	2020	1986

Data that collected on this thesis is from ASDP Indonesia that gave the information about the General Arrangement the ship, safety equipment list and safety plan from KMP. PORT LINK 3. The safety equipment list that already exist on the ship will compare with the safety equipment list from class (BKI). This step is done to make sure that safety plan or safety equipment that already exist in KMP. PORT LINK 3 is corresponding with BKI class.

Redrawing of the General Arrangement will use autocad and pyrosim, so a simulation can be done to know whether the existing safety plan is really working or not. This step will be repeated many times until the system can overcome the fire.

The figure 4.2 is show the General Arrangement of KMP. PORT LINK 3 that collected fom PT. ASDP INDONESIA

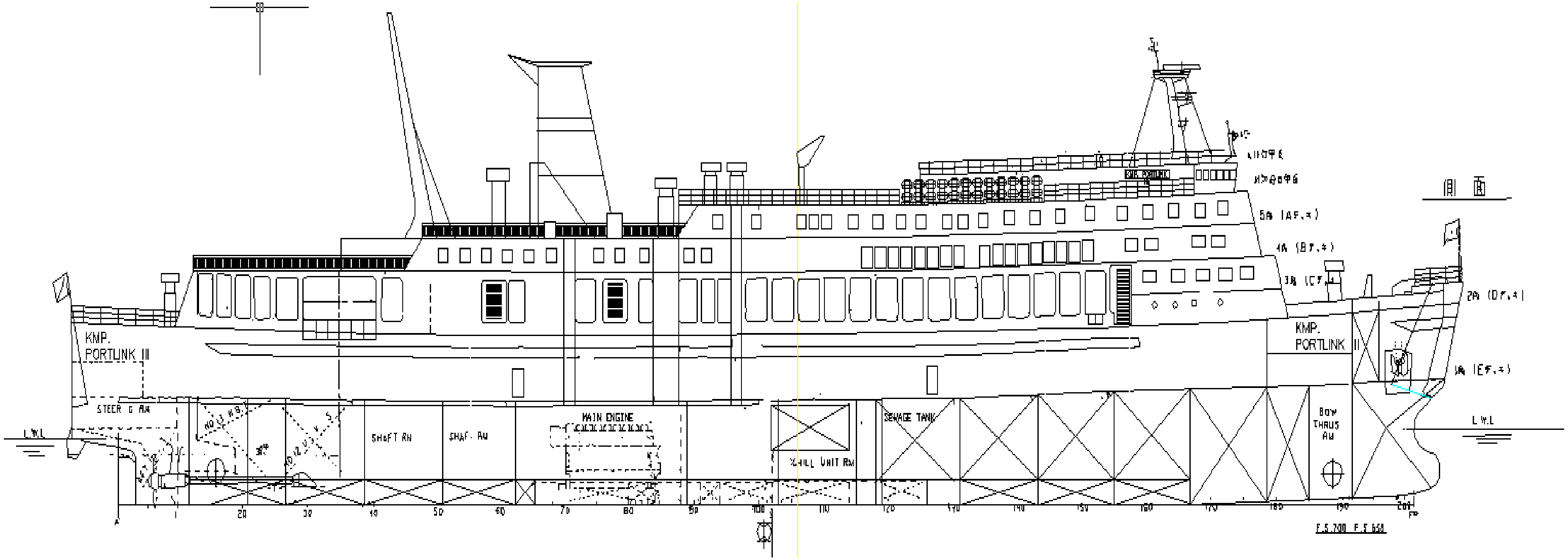

Figure 4.2. General Arrangement

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4.2 FIRE FIGHTING EQUIPMENT

Fire fighting equipment need to be considered because this is the crucial things on board to avoid fire. The fire fighting equipment need to be sorted and listed based on Badan Klasifikasi Indonesia (BKI) classification. The list only focused on fire fighting equipment.

In order make fire fighting equipment list, the first step is to take a look at the General Arrangement from PT. ASDP INDONESIA. The safety equipment will be sorted and listed based on it. Table 4.3 shows the list of fire fighting equipment that exist on KMP. PORT LINK 3.

Table 4.3. List of Fire Fighting

Safety Equipment List	Total of number
International Shore Connection	2
Fire Control Plan	3
Water Leakage Detection System	2
Fire Door Indicator	1
Portable Flammable Gas Detector	1
Sprinkle	495

All equipment that already listed will be used in this final project. But not all of these equipment are available in pyrosim. The equipment that can be used are sprinkle, fire detector, smoke detector and CO2.

4.3. SAFETY PLAN ANALYSIS

Safety plan analysis will be used to analyze the safety plan that exists on the ship. The analysis does not use any particular method but only by comparing the fire fighting equipment that exist on the ship with Biro Klasifikasi Indonesia (BKI) regulations which is based on Vol II and Vol III of the rules. The aim of this analysis is to make sure that the safety plan on KMP PORT LINK 3 is already fulfil the requirement. The safety plan on KMP PORT LINK will shown on Attachment 1 (Safety Plan).

The result from the comparison between the installed safety plan on KMP. PORT LINK 3 and Biro Klasifikasi Indonesia (BKI) are listed on the table 4.4 below .

Table 4.4. Comparison Safety Equipment

No	equipment	Requirement BKI classification	Actual
1	Portable dry powder fire extinguisher	having a total capacity of not less than 12 kg of dry powder	Portable dry powder fire extinguisher (12 kg)
2	Hoses of hydrant	the hoses of hydrants located within the superstructure are to be kept permanently coupled to the hydrant	coupled to the hydrant
3	Fire extinguisher	- located at the access to the individual space - located in public spaces - located at or near the main entrances and exits	- located at the access to the individual space - located in public spaces - located at or near the main entrances and exits

Table 4.5. Comparison Safety Equipment (continue)

No	equipment	Requirement BKI classification	Actual
4	sprinklers	The sprinklers are to be grouped into sections. Each section may not comprise more than 200 Sprinklers.	Total of sprinklers less than 200 sprinklers.

From table 4.4, it can be concluded that all the installed safety plan are already fulfil the requirement of the classification society rules. Therefore, pyrosim will be used to analyze how the safety plan will work on KMP PORT LINK 3.

4.3. PRELIMINARY HAZARD ANALYSIS

Preliminary Hazard Analysys (PHA) are the method of risk analysis that can be used in this final project. The objective of using Preliminary Hazard Analysis (PHA) is to know where the potential fire sources are located based on the Statistics Indonesia. This method will only be used from hazard identification until the consequences stages. Table 4.5 shows the potential rooms where fire can occured.

Table 4.6. Rooms that Potentially cause a fire

POTENTIALLY FIRE	POSSIBLE ORIGIN AND CAUSE	POSSIBLE CONSEQUENCE
Car Deck	four-wheel drive and two-wheel experience the spark that could cause a fire	Fire could come out of vehicles and cause spread of fire in the car deck

Table 4.7. Comparison Safety Equipment (continue)

POTENTIALLY FIRE	POSSIBLE ORIGIN AND CAUSE	POSSIBLE CONSEQUENCE
Engine Room	sparks from the engine, auxiliary engine and electrical that triggered the fire in the engine room due to the accumulation of fuel vapors and lubricant	flashpoint are sourced from the engine room can potentially causing a fire that may spread to others compartment around the deck
Galley	LPG gas leak could cause a fire or explosion	an explosion that could cause a fire can spread through a compartment in the surrounding areas, because the source of fire was in a deck with deck passenger
Passenger Deck	fire from cigarette butts are then burned the surrounding areas	a fire on the deck passengers who can make fire quickly spread through the goods and existing facilities

Table 4.5 described the rooms that potentially cause a fire. Based on the Statistic Indonesia, the most recent fire accident that happened on the ship come from the four selected rooms described on table 4.5. The four rooms with highest possibility to cause fire are car deck, engine room, galley and passenger deck.

In car deck, fire could comes from short circuit on car electrical equipment that would then generate sparks. It can be potential to inflict fire. In Main engine room, fire could comes from the sparks from the engine, auxiliary engine and electrical that triggered the fire in the engine room due to the accumulation of fuel vapors and lubricant that can spread out to another deck. In the third room, galley, the fire could comes from LPG gas leak that cause a fire or explosion. This the critical point, because galley is located near to the restaurant, so the possibility of fire to spread out are high. For the Passenger deck the fire can comes from cigarette butts that could burn surrounding areas and spread out through the goods and existing facilities.The result from this method will be used to create the fire modelling on KMP PORT LINK 3.

4.4 REDRAWING

Redrawing is the step to redraw the General Arrangement of KMP PORT LINK 3. To complete redrawing, in this final project, the application that will be used is AutoCad 2013. The figure 4.3 show the result from redrawing one of the deck on KMP PORT LINK 3

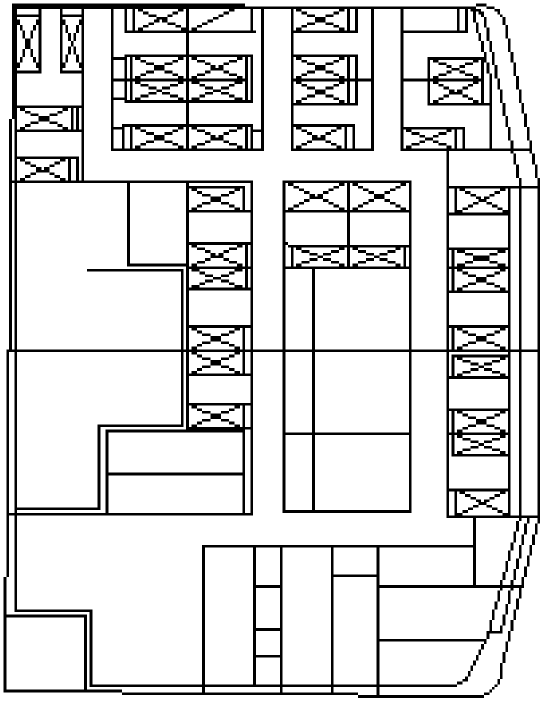

Figure 4.3. The Example of Redrawing on CAD

The redrawing only redraw the outline of the ship without any explanation about the room and others, because the result from the modelling will be used to create the 3d model of the ship on pyrosim.

4.5. FIRE MODELLING

Fire modelling in this thesis use fire dynamic simulator with pyrosim application. Pyrosim application is used to simulate fire that can happened on board. Pyrosim can also be used to make the evacuation route on board. In this thesis, the simulation will not only show how the fire spread, but also to know how the fire can be extinguished.

In this final project, Fire accident has never happened on KMP. PORT LINK. So, with Preliminary Hazard Identification (PHA) the modelling will be done.

After redrawing the outline of the ship on AutoCad 2013, the next step is to send the file to the pyrosim to render it into 3D model, but safety equipment such as doors, floors and walls must be manually drawn.

During the drawing of 3D model the material should be considered, because the material very influential due to fire spread during fire simulation. The material that used on this final project are steel, fabric, foam and innert which show on figure 4.5. In this application, the placement of the doors need to be considered, because the door also very influental for the fire spread during the fire simulation. The figure 4.4 show the 3D model layout on pyrosim. After draw the walls, floors, doors and considered about the materials, the next step is put the safety equipment into the model. But, in pyrosim the safety equipment that only exist is only smoke detector, heat detector,CO2 and sprinkle. After that, the sprinkle drawn into the model in pyrosim. The figure 4.6, figure 4.7, figure 4.8, figure 4.9 and figure 4.10 show the placement of satey equipment.

After draw the walls, floors, doors and considered about the materials, the next step is put the safety equipment into the model. But, in pyrosim the safety equipment that only exist is only smoke detector, heat detector,CO2 and sprinkle. After that, the sprinkle drawn into the model in pyrosim. The figure 4.6, figure 4.7, figure 4.8, figure 4.9 and figure 4.10 show the placement of satey equipment.

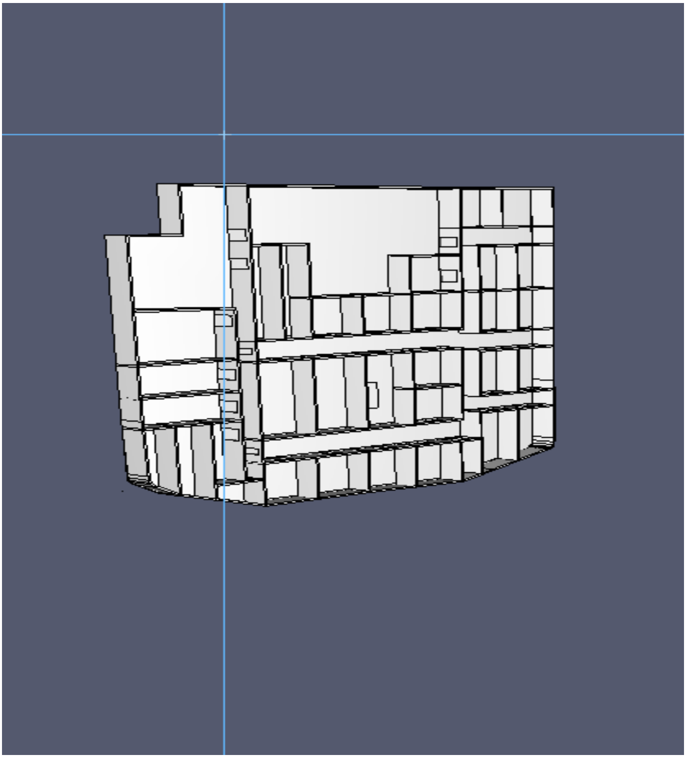

Figure 4.4. 3D model on Pyrosim

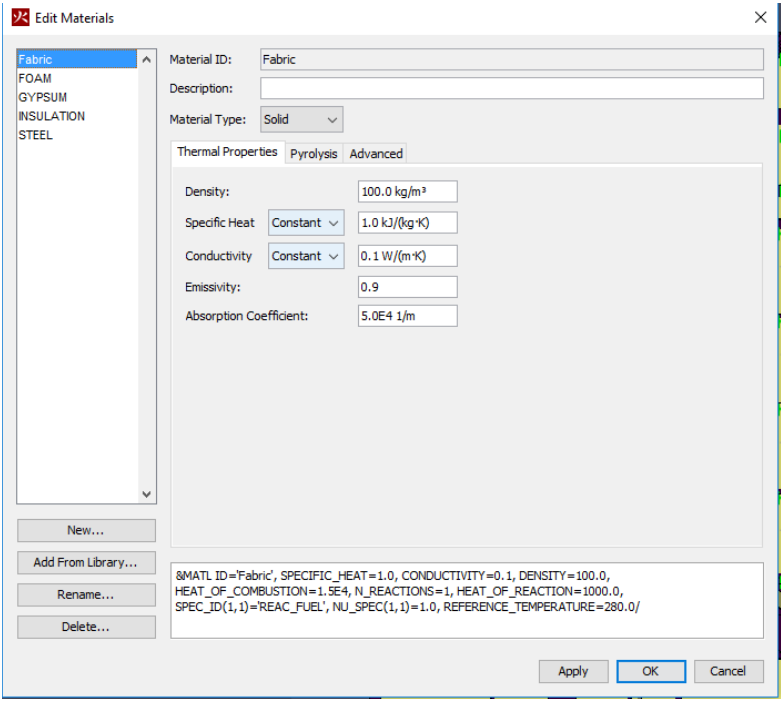

Figure 4.5. Material Setting

After draw the walls, floors, doors and considered about the materials, the next step is put the safety equipment into the model. But, in pyrosim the safety equipment that only exist is only smoke detector, heat detector,CO2 and sprinkle. After that, the sprinkle drawn into the model in pyrosim. The figure 4.6, figure 4.7, figure 4.8, figure 4.9 and figure 4.10 show the placement of satey equipment.

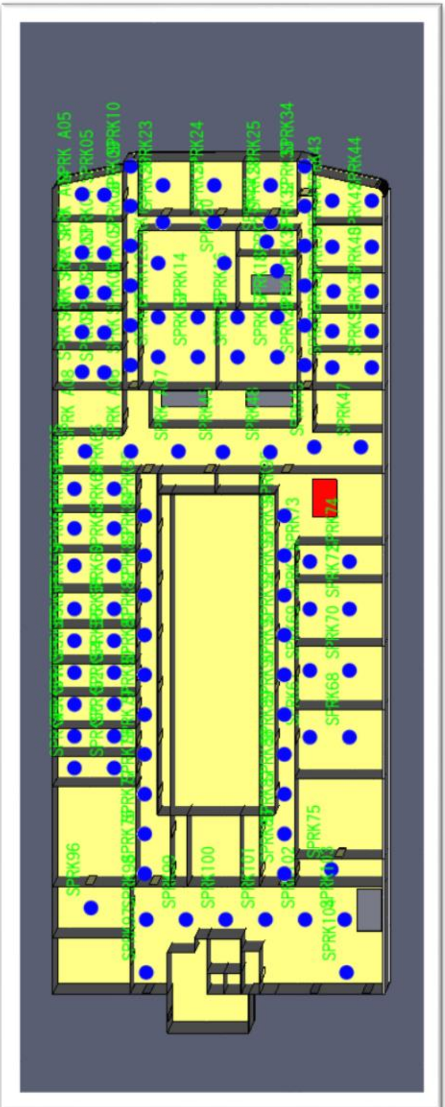

Figure 4.6. Safety Equipment on Deck A

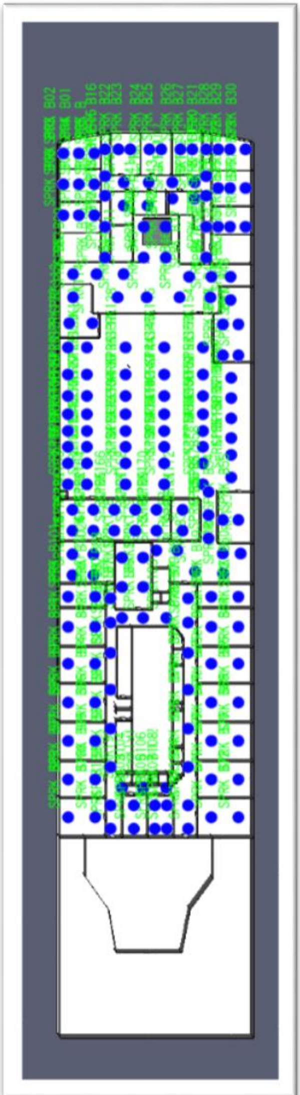

Figure 4.7. Safety Plan on Deck B

Figure 4.8. Safety Plan on Deck C

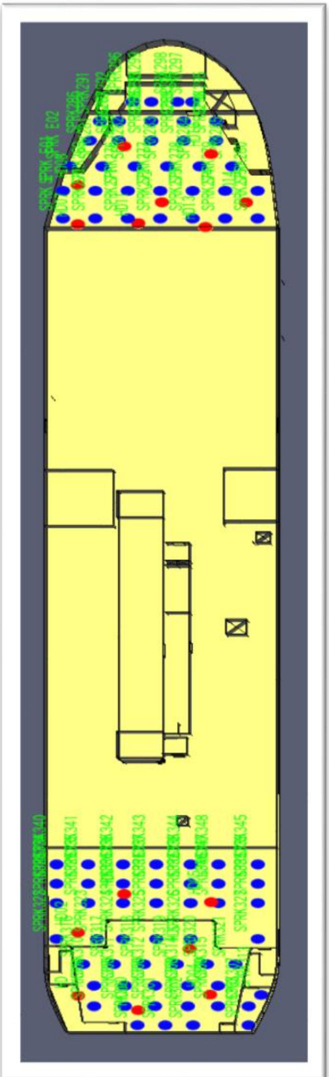

Figure 4.9. Safety Plan on Deck D

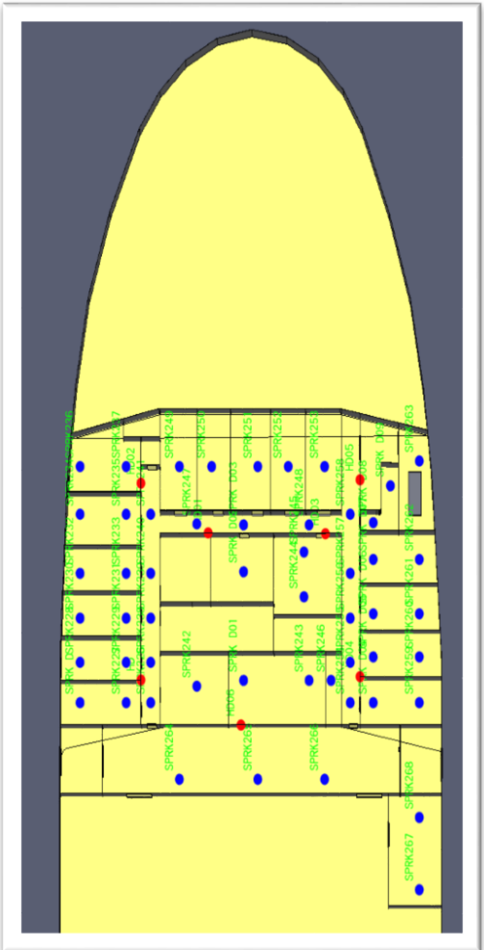

Figure 4.10. Safety Plan on Deck E

The sprinkles can be actived by many option. But in this final project the sprinkle actived by the certain temperature.The temperature that used is by assumption or original from the pyrosim, which is 50°C which show on figure 4.11. So, the sprinkle will actived or triggered when the temperature around the sprinkle reach up to 50°C during the fire.

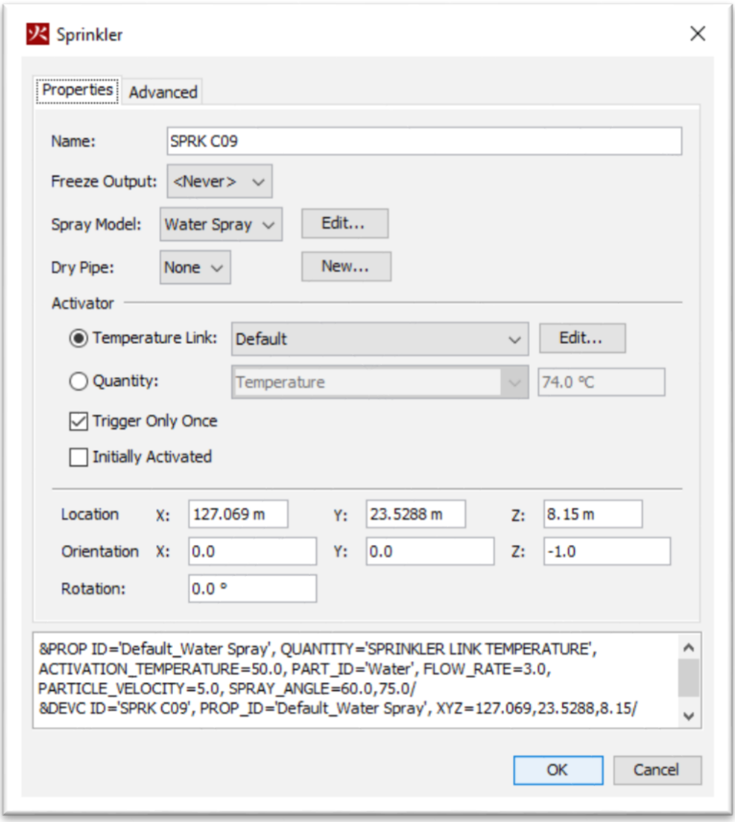

Figure 4.11. Sprinkle Setting

after draw the doors, walls, floors, selecting the material and put the safety equipment. The last step before do the modelling is to make the ignitor as the fire source. The function of ignitor is to ignite the material, so the material will burn and make a fire that can spread allover the room. The inital surface temperature of the ignitor is 1000 °C .The figure 4.16 show the setting of ignitor.

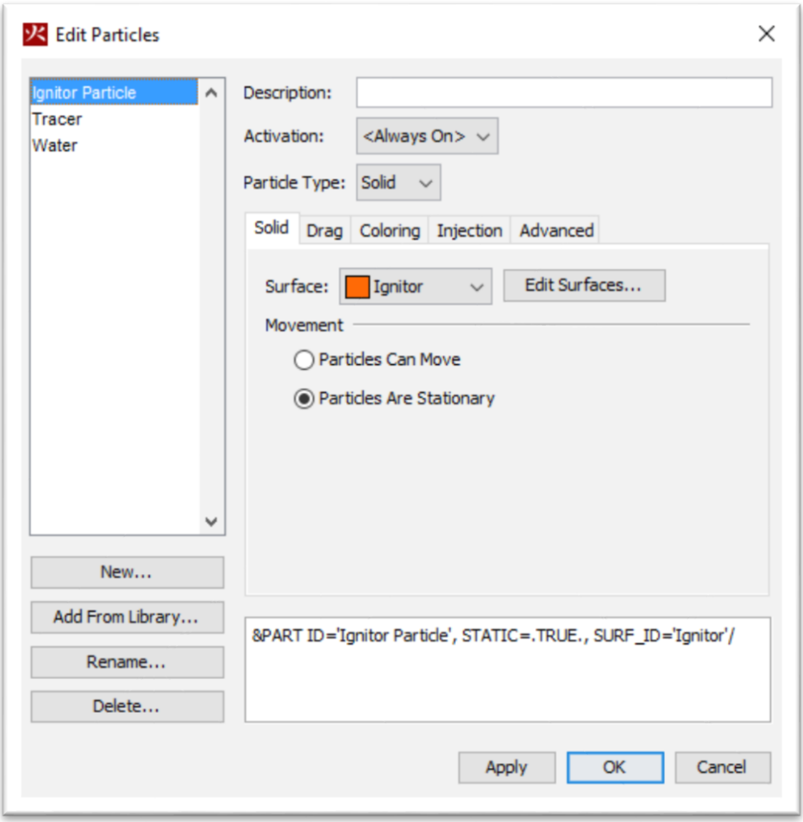

Figure 4.12. Ignitor Setting

After the model is ready the simulation can be start. The simulation will be run around 150 seconds, because it is only to see when the sprinkle actived and how long it takes to extinguish the fire. The simulation will be run on each deck of the ship. Figure 4.13 show the example simulation of FDS from Deck C.

The result of FDS simulation will shown as Heat Release Graphic (HRR). If the Graphic show the decreasing on Heat Release Rate (HRR) value, it means the safety equipment are doing well. All of the variable about the simulation shown attachment 2 (Record view).

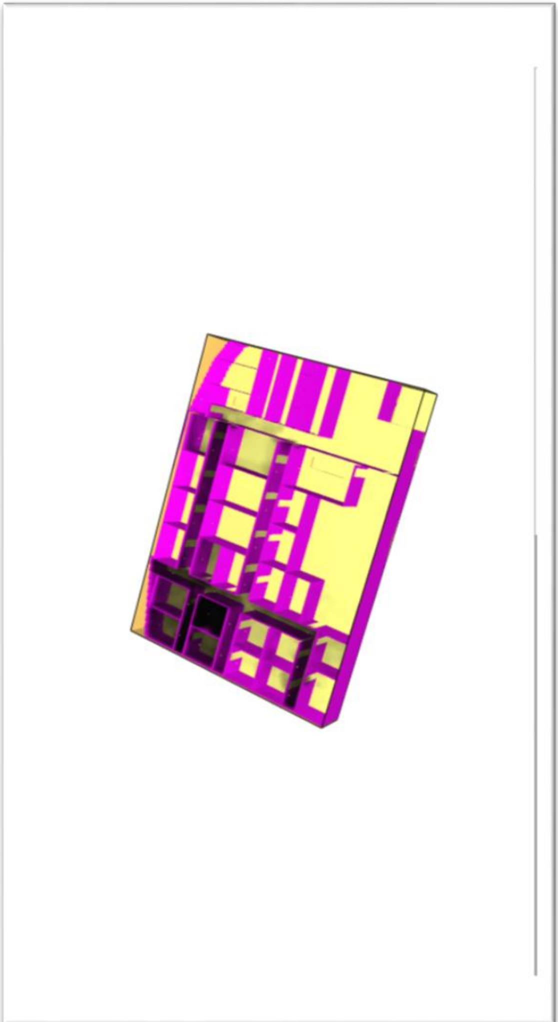

Figure 4.13. FDS simulation

4.5.1 RESULT FROM MODELLING

The modelling will be run around 150 seconds. The result will be shown as Heat Release Rate (HRR). Heat Release Rate (HRR) is the heat energy around the model during the fire, so if the Heat Release Rate (HRR) reach the zero value, it means there are no heat energy that released from the fire. Based on the result from Deck C that sourced from the passenger room, Heat Release Rate (HRR) reach zero around 90 seconds. It means there is no heat energy that released from the fire sourced. The sprinkle actived at 85 second. Which is the time to extinguish the fire it takes around 5 seconds.This figure about temperature and Heat Release Rate (HRR) graphic will be shown on figure 4.14, figure 4.15 and figure 4.16. The Fire Modelling from each deck will shown on Attachment 2 (Simulation).

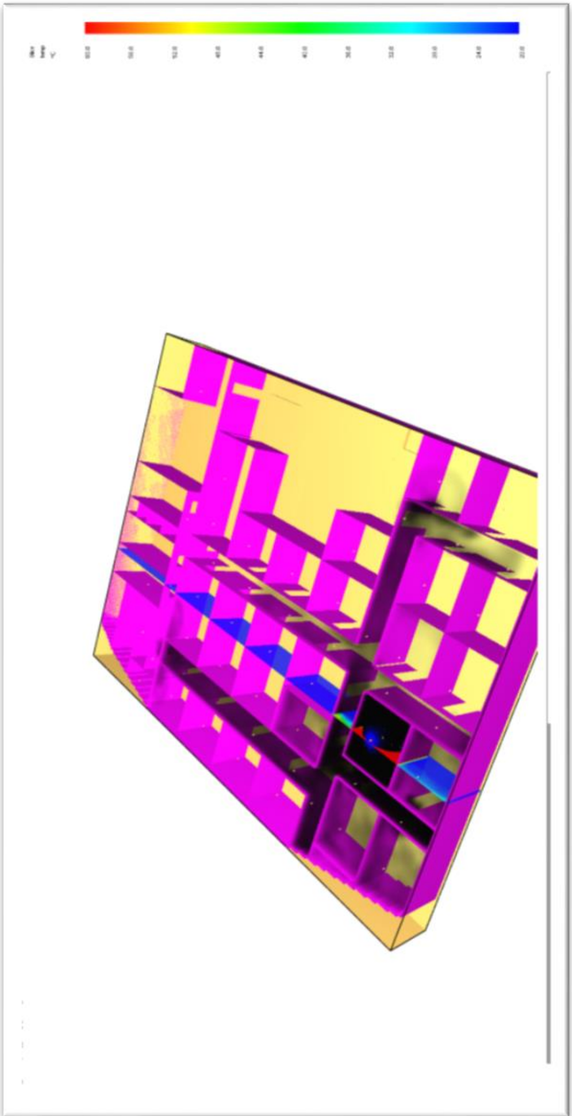

Figure 4.14. The Fire Modelling on Deck C

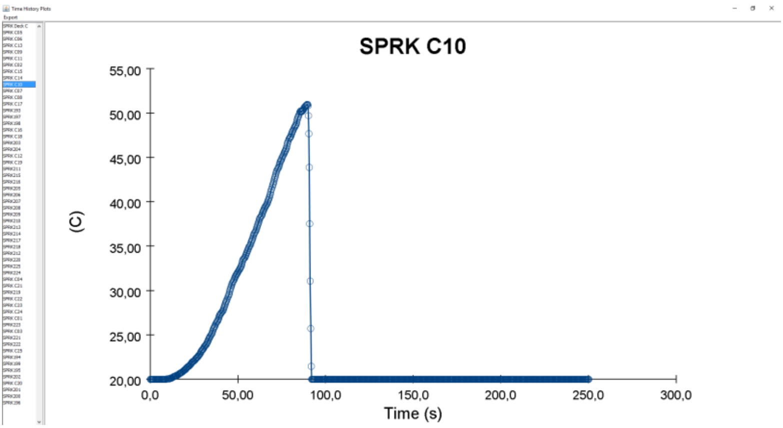

Figure 4.15. Temperature of Sprinkle on Deck C

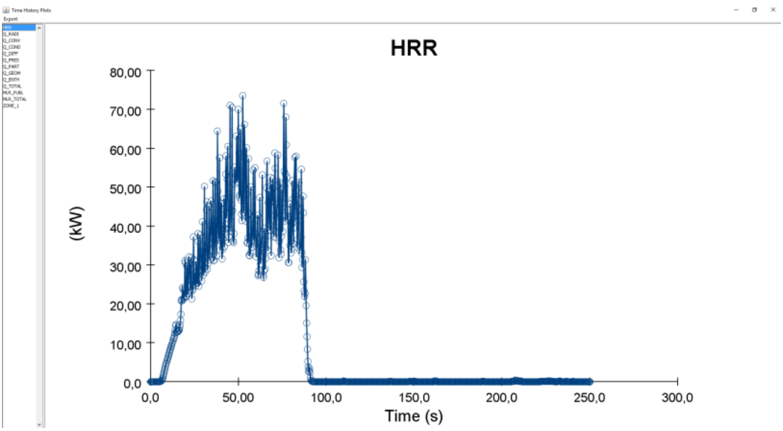

Figure 4.16. Heat Release Rate (HRR) Graphic on Deck C

After running the simulation on the Deck C, the next simulation will be simulated on Deck B (Galley) around 100 seconds. The result will be shown as Heat Release Rate (HRR). Based on the result from Deck B (Galley), Heat Release Rate (HRR) decreasing at 30 seconds. The sprinkle actived at 20 second. Which is the time to extinguish the fire takes 10 seconds. The figure 4.17 and figure 4.18 are show about the temperature and Heat Release Rate (HRR) grapchic.

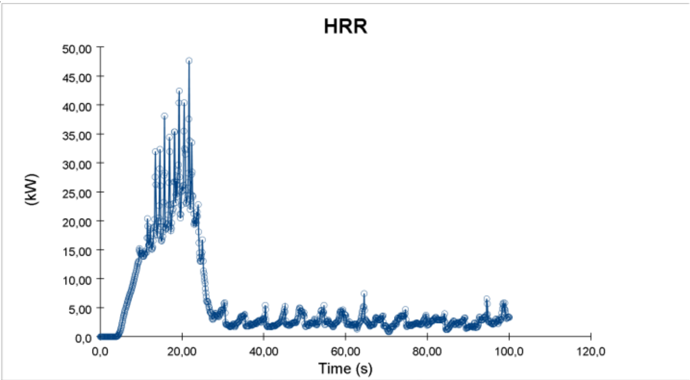

Figure 4.17. Heat Release Rate (HRR) graphic on Galley

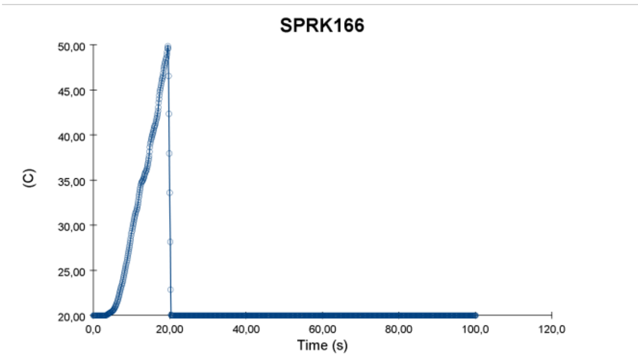

Figure 4.18. Temperature Sprinkle on Galley

The next simulation will be done on Engine room. The simulation will be simulated about 100 seconds. The result will be shown as the Heat Release Rate (HRR) graphic. Based on the result of simulation, Heat Release Rate (HRR) reach zero at 30 seconds. The water in engine room is prohibited. So, in the engine room it needs

CO2 to extinguish the fire. CO2 actived when the temperature reach 50°C. In this simulation the CO2 actived at 25 seconds. Which is, the time to extinguish the fire it tooks 5 seconds. The figure 4.19 and figure 4.20 are show about the temperature and Heat Release Rate (HRR) grapchic.

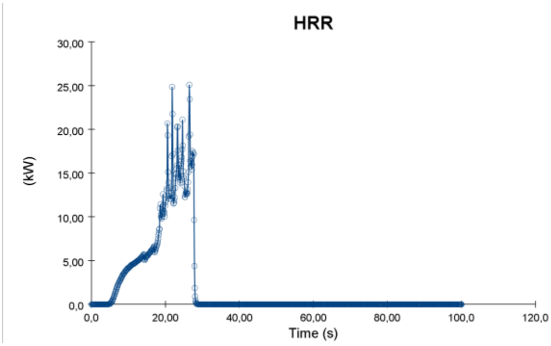

Figure 4.19. Heat Release Rate (HRR) Graphic on Engine room

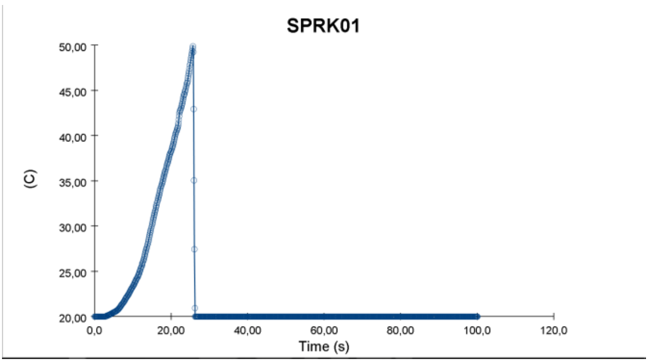

Figure 4.20. Temperature sprinkle (CO2) on Engine room

The next simulation will be done on car deck. The simulation will be simulated about 100 seconds. The result will be shown as the Heat Release Rate (HRR) graphic. Based on the result from Car

Deck, Heat Release Rate (HRR) graphic reach zero at 30 seconds. The sprinkle actived at 27 seconds. Which is the time to extinguish the fire takes 3 – 5 seconds. The figure 4.25 and 4.26 are show about the Heat Release Rate (HRR) graphic and temperature.

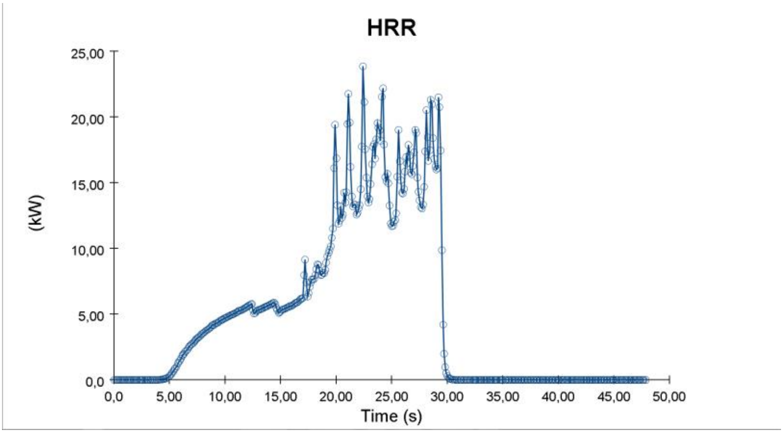

Figure 4.21. Heat Release Rate (HRR) graphic on Car Deck

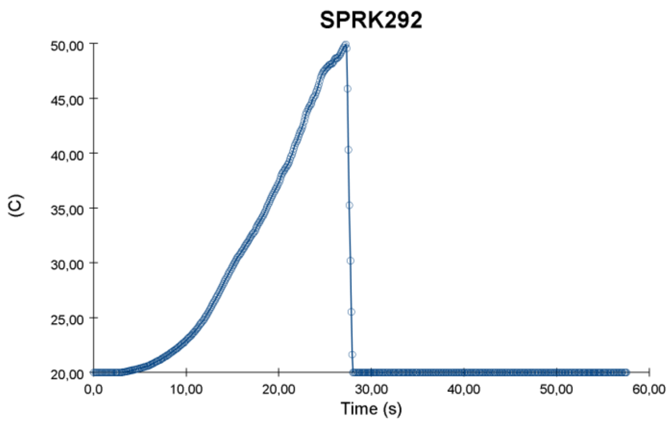

Figure 4.22. Temperature Sprinkle on Car Deck

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Simulation from Passenger Deck

CHAPTER V
CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the result from this final project, the writer concludes several conclusions as mention below:

1. There is four possibles can potentially caused the fire, from the big potentially are from main engine, galley, car deck and passenger room.
2. The safety plan on passenger room show that the safety plan work effectively. The fire can be extinguish at 90 seconds, when the sprinkle actived at 85 seconds. So, the HRR reach zero by 5 seconds.
3. The safety plan on Galley show that the safety plan work less effective, because the Heat Release Rate (HRR) can't reach zero kw. But the value of Heat Release Rate (HRR) reach below 5 kw. The fire can de be extinguish at 30 seconds, when the sprinkle actived at 20 seconds. So, the Heat Release Rate (HRR) decreasing by 10 seconds.
4. The safety plan on Engine room show that the safety plan work effectively. The fire can be extinguish at 30 seconds, when the sprinkle actived at 25 seconds. So, the Heat Release Rate (HRR) reach zero by 5 seconds.
5. The safety plan on Car Deck show that the safety plan work effectively. The fire can be extinguish at 30 seconds, when the sprinkle actived at 27 seconds. So, the Heat Release Rate (HRR) reach zero by 3 seconds.
6. The reccomendation for this final project is to add more water quantity for sprinkle on Deck B, because at Deck B the Heat Release Rate (HRR) can't reach zero kw.

5.2 Suggestion

The suggestion for the next research are :

1. Make an evacuation route during the fire
2. Add more safety equipment on KMP. PORT LINK 3

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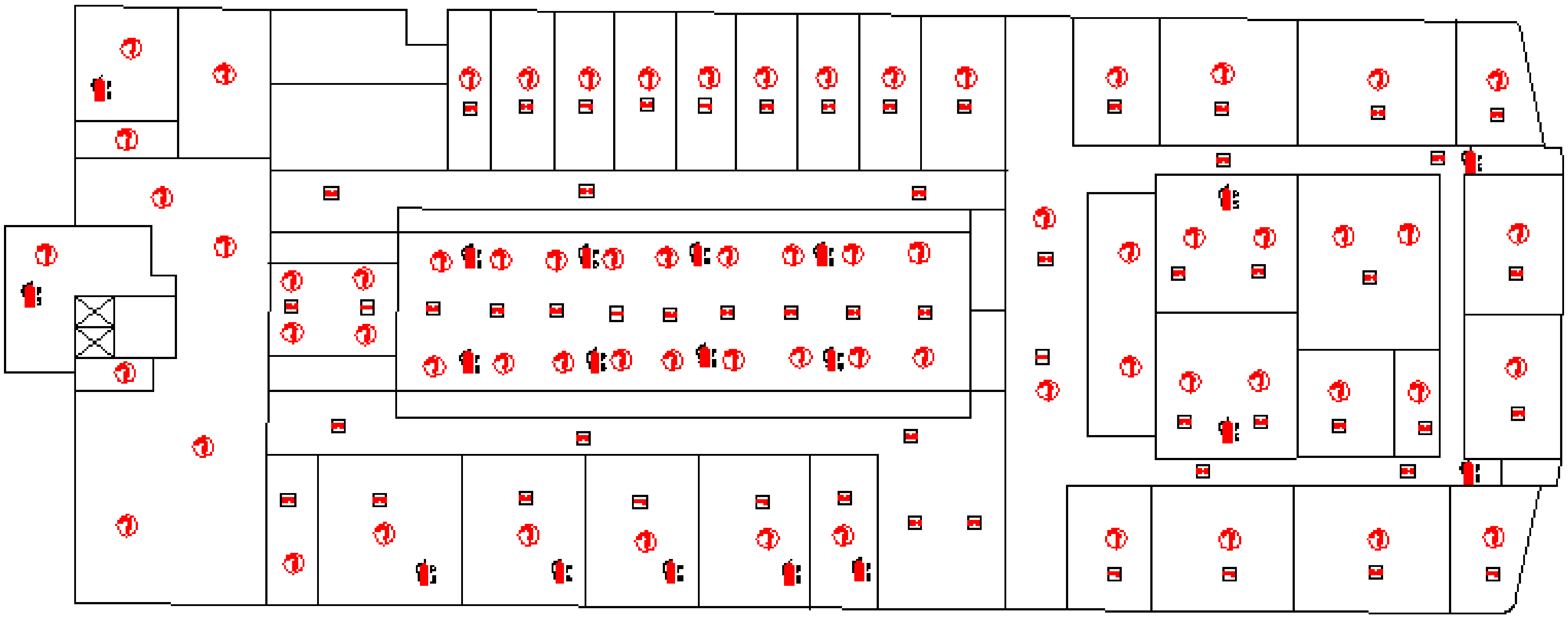
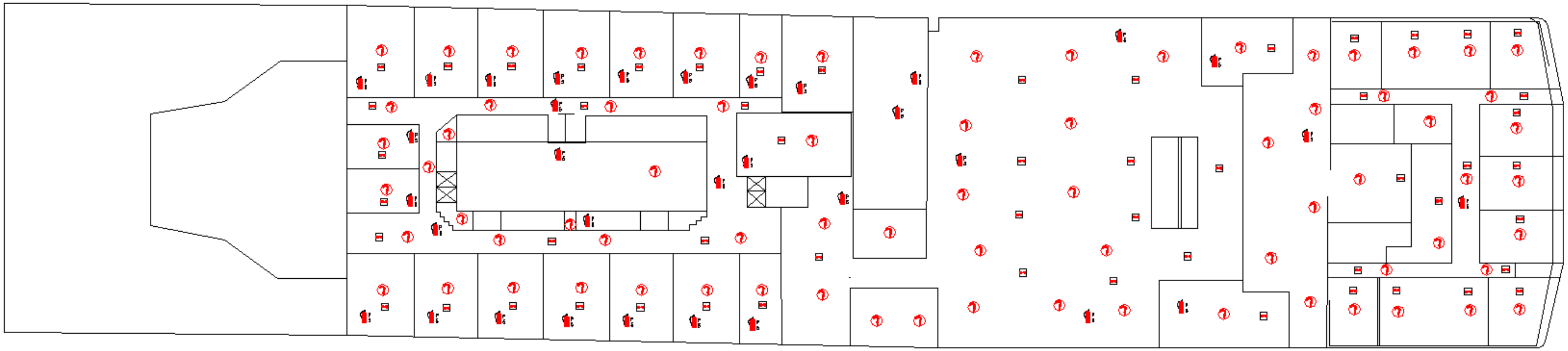
ENCLOSURE

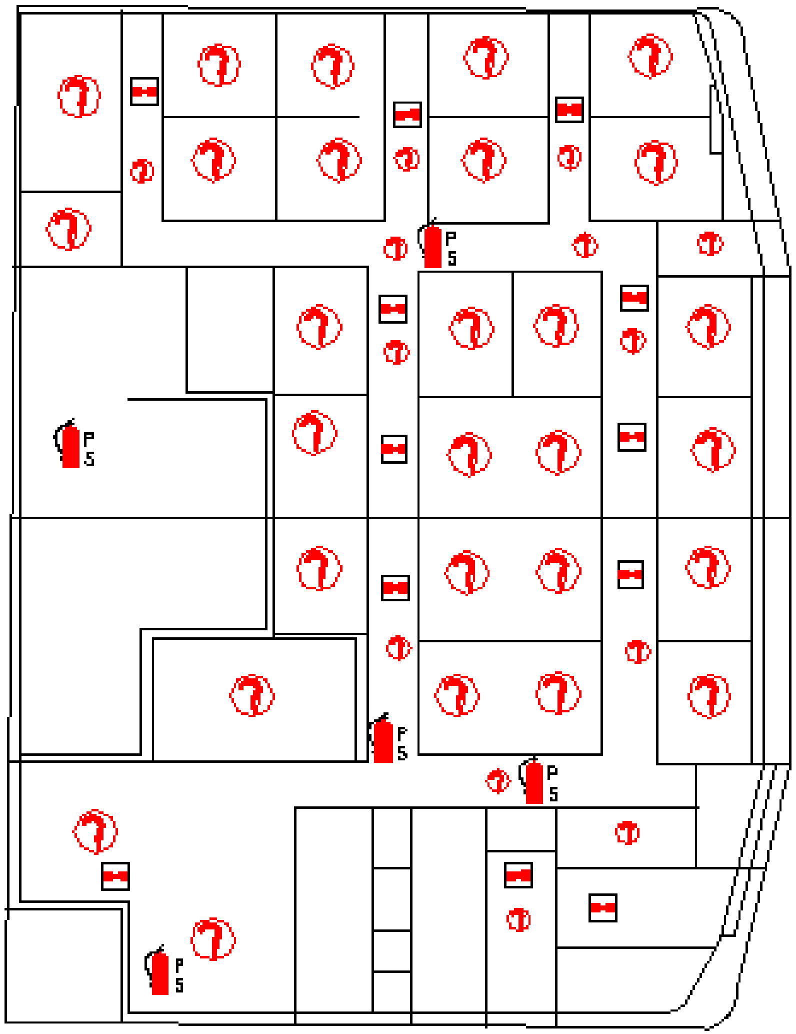


Safety Plan on Deck A

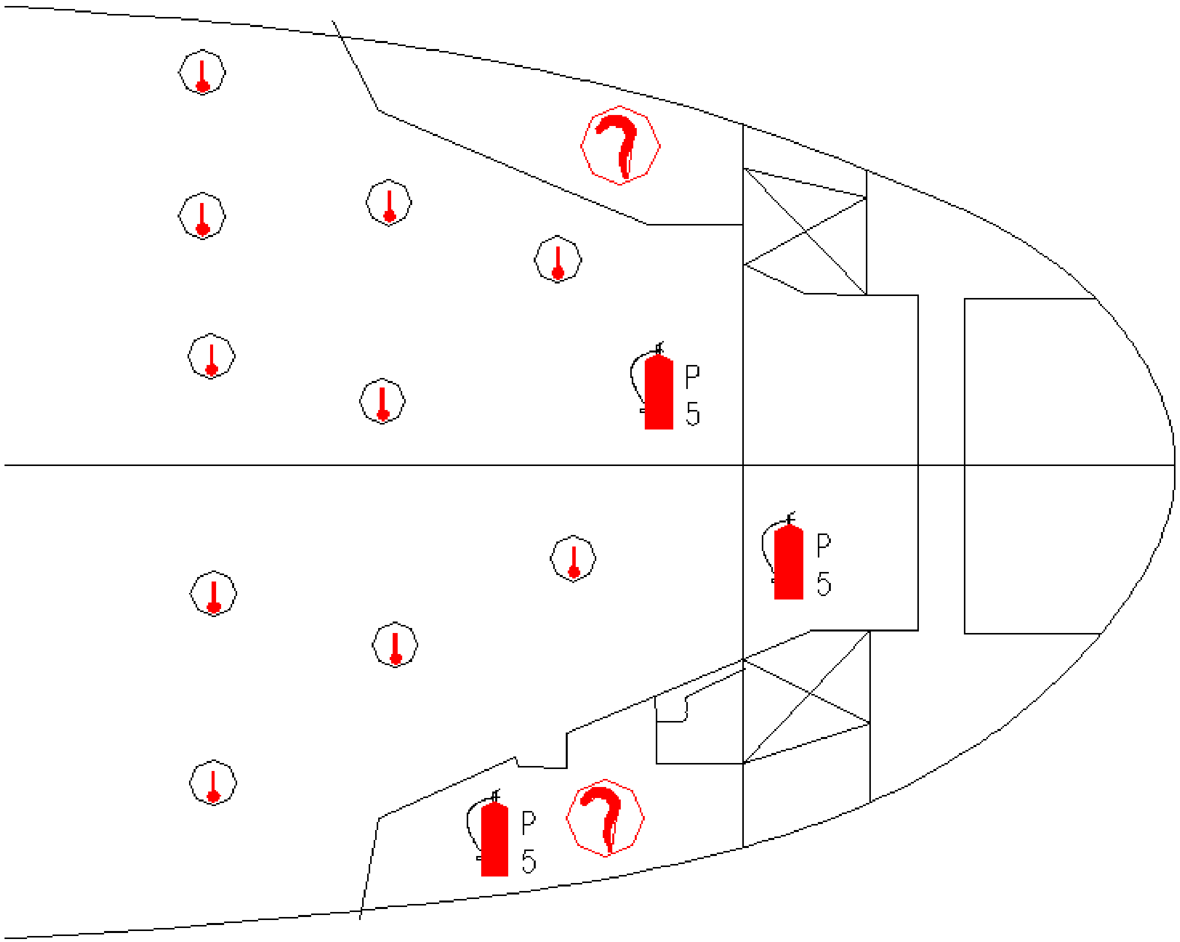
ENCLOSURE 1 (Safety Plan)



Safety Plan on Deck B.



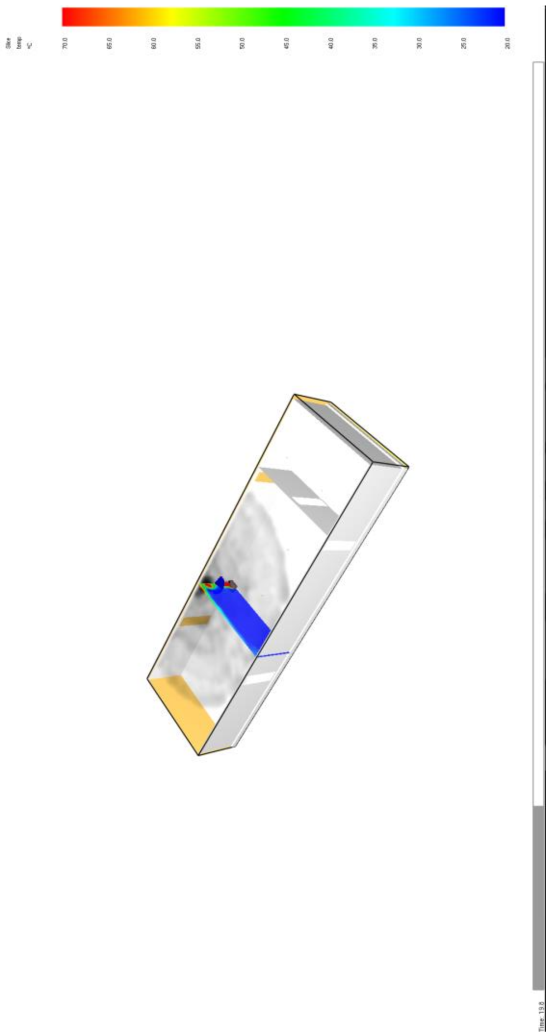
Safety Plan on Deck C



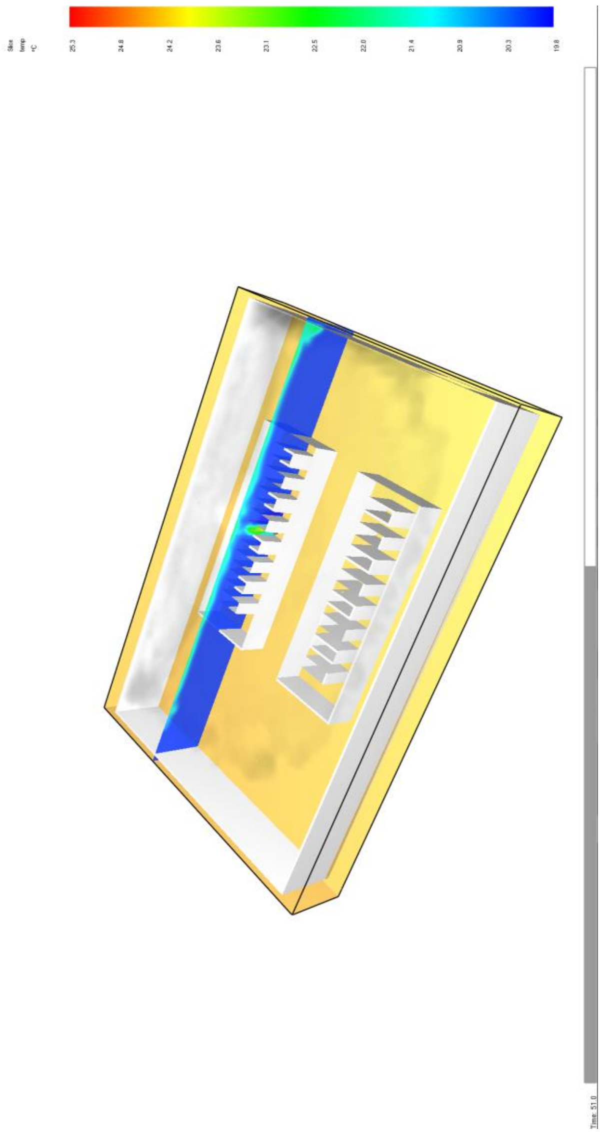
Safety Plan on Deck E

ENCLOSURE 2 (Simulation)

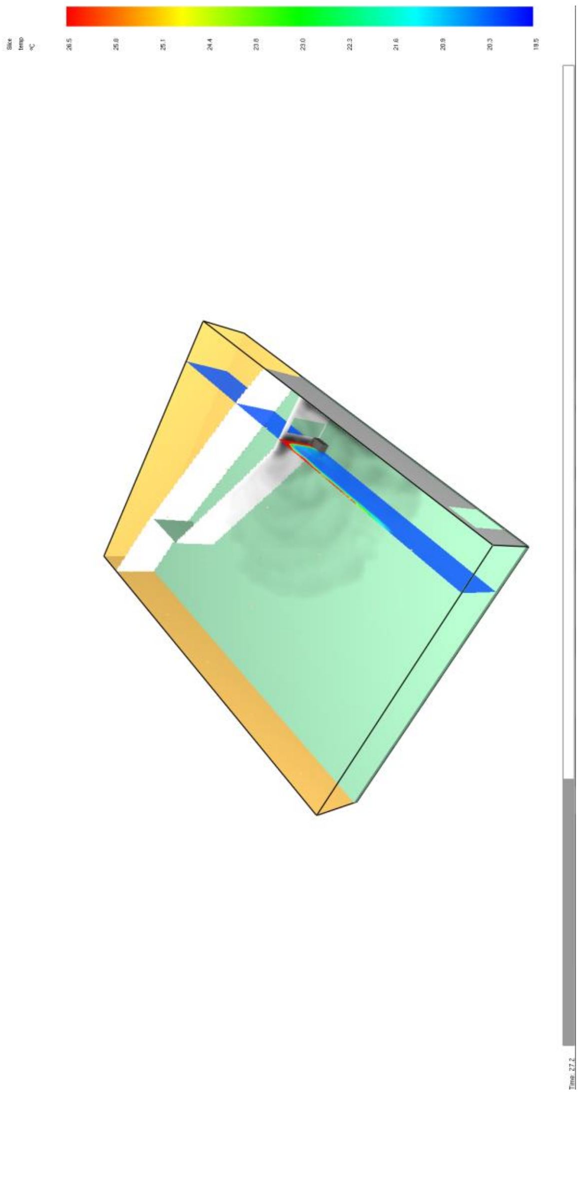
Simulation from Galley



Simulation from Engine Room



Simulation from Car Deck



BIOGRAPHY

The author was born on December 17th, 1994 with the full name was Christman Shiva Irya Gurning. The author was the oldest brother from three children from the couple of Mr. Sahat Damanik Gurning and Mrs. Ida Novelina Silalahi. The author began his studies in kindergarten of TK Kasih Ananda IV to SD BUDHAYA II ST. AGUSTINUS, graduated on 2006. On the 2006 - 2009 the author continued his study to the Junior High School of Saint of Jacobus. Then continued his education to the SMAN 103 Jakarta Timur in the 2009 -2012. After graduated from the Senior High School, the author continued to the college on Departement of Marine Engineering, Faculty of Marine Technology, ITS Surabaya at 2012 with student register 4212101025. The author finished his bachelor program at 2016, he took the Final Project on the Reliability, Availability, Maintainability and Safety (RAMS) Laboratory with the title "*Fire Risk Assessment for Safety Plan on KMP PORT LINK 3 through Fire Dynamic Simulator*".
Keep calm and stay awesome.

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