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.

I. INTRODUCTION

P From many ship accidents that occurred, the fire is an event that causes the most ship accident. It is inevitable that ships in Indonesia are still many have not complied and analyzed the danger of fire on ship. Data showed as much as 62% source fires occur mostly oil or fuel leak in the engine room and the rest happens because of the material used, short circuit as well as human error. PT ASDP Indonesia is a company that distributes roro ship to cross the people, vessels, and others in some places as an example of inter-island port to the port of bakauheuni. Fire on ship is one thing that is avoided by every owner of the ship, because of the impact resulting from the fire if it can not be handled is the loss of assets that should be used for a long period of time. For example, if there is a fire on the passenger ship that will go from the port of peacock towards bakaheuni then of course it would be detrimental to the PT ASDP, because they will lose the asset, replacing the existing losses and will certainly lose customers or demand due to this accident. Cause of the fire should be analyzed so that the future can be done for precautionary measures on all ships not only roro ship in Indonesia so it will not happen again fires on ships.

II. LITERATURE STUDY

A. Management Information System

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 aims to determine the level of risk that can be generated in ferry ship, by using Fire Dynamic Simulator (FDS) can be obtained the simulation of the 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.

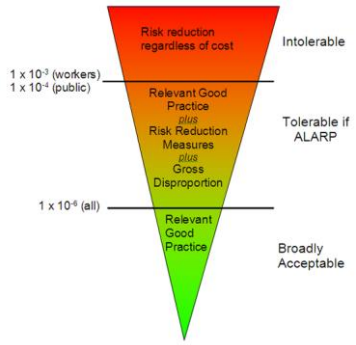

Figure 1. ALARP (A low as reasonably practicable) diagram

B. Hazard Identification with Preliminary Hazard Analysis (PHA)

Hazard analysis involves the indentification 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 severity of an event may be classified into rather broad classes. An example of such a classification is:

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, allow any kind of exposure to operational or service personnel or allow any release of chemicals into the environment.

C. Safety Plan

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.
d. Mitigation. In mitigation, there are three defences that may be applied:
    1. technology,
    2. training
    3. regulations/procedures
e. Monitoring.
    f. Conclusion

D. Fire Fighting System

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

1. Detection, for locating the fire.
   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.

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. Giving the alarm can take many forms such as shouting fire, banging on bulkheads or any action necessary to attract attention.

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

E. Fire Fighting Equipment

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

1. Portable Extinguisher
2. Soda Acid Extinguisher
3. Foam extinguisher (chemical)
4. Foam Extinguisher (mechanical)
5. Dry powder Extinguisher

F. Rules from BKI

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 is 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

For arrangement the placement of pump, BKI classification also have a rules. For passenger ship 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 ensured by the automatic starting of one of the specified fire pumps.

G. Fire Dynamic Simulator

FDS is the method that applicable with this thesis because FDS using particles as a tracer element to visualize the flow. In addition, FDS using particles as hatchling to model fire prevention. The application that will be used through FDS is pyrosym.

I. METHODOLOGY

A. Preparation

The preparation for this final project use the list of safety equipment. The equipment will be sorted based Badan Klasifikasi Indonesia (BKI) that classified KMP. PORT LINK 3. After the list of safety equipment, the next data that needed due to this final project is the placenment of the safety pan based on the General Arrangement KMP. PORT LINK 3.

B. Data Analysis

The data analysis of this final project are doing the assessment due to the safety plan and doing the fire modelling to check that the safety plan that already existing are active just in time. Before the modelling, the first step is should be re arrangement the safety plan.

The safety plan will be analyzed due to doing mitigation. Mitigation that used on these final not by the method. The mitigation that used in these final project are replacement of a sprinkle, hydrant, fire extinguisher and others.

KMP PORT LINK 3 have never been fired, so to make the simulation should be done by the scenario. The scenario will be done based on the Preliminary Hazard Analysis (PHA). And for the result, there is four scenario will be used to doing the fire modelling which is the fire will come from main engine room, card deck, galley and passenger deck.

Goal Based Standard (GBS) is the method from SOLAS that used to improvement and prevent ship from the accident. On this final project due to Goal Based Standard the safety equipment need to be reduce the number of safety equipment to check if the safety plan equipment can be fulfil based on the calssification rules.

C. Fire Modelling

The final step on this final project is fire modelling with Pyrosim Application. The fire modelling will took about 500 seconds start from the fire come. The task oh these thesis is to knowing that the safety equipment are working or not during the fire. Fire modelling will be simulated into 8 times. The 4th one simulated from the safety plan that already existing with the Badan Klasifikasi Indonesia (BKI) and the rest will be simulated with Goal Based Maintenance(GBS). So, if the heat release rate from the modified safety plan have a likely result from the original safety plan it can be said that the modified safety plan still fulfil the classification. After that, the final result is comparing the Heat Release Rate (HRR) from safety plan during fire that already existing and the modified safety equipment.

II. DATA PROCESSING AND SIMULATION

A. Equipment list of fire fighting

The list of equipment from the collected data will be listed based on Badan Klasifikasi Indonesia (BKI) rules. This list only focused on fire fighting system. The equipment that will be used on this thesis is safety equipment which are related with fire fighting system, so the other part of safety beside the fire fighting system will not used on this thesis. The aim to do comparing the safety equipment in this thesis between Badan Klasifikasi Indonesia (BKI) classification and KMP.PORT LINK 3 is to make sure that the requirements on board are same with the rules. But, in fact the requirements are not fullfil on board.

Table 1. Fire Fighting Equipment List

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

B. 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.

Table 2. 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
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.

C. Preliminary Hazard Analysis (PHA)

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.

Table 3. Source of Fire

Potentially Room cause a fire	POSSIBLE ORIGIN AND CAUSE	POSSIBLE CONSEQUENCE
Car Deck	four-wheel drive and two-wheel experience the spark that could cause a fire	happening flashpoint from the vehicle which can cause and spread the fire in the car deck
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 potentially causing a fire that may spread to others through the compartment aorund 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
Passanger 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

D. 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 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.

E. Fire Modeling

Fire modelling in this thesis using fire dynamic simulator with pyrosim application. Pyrosim application is used to simulate the fire that can happened on board. Pyrosim also can used for doing the evacuate route on board. In this thesis the simulation that will be simulated not only show how the fire spread, but also to knowing how the fire can be extinguished. This figure below will show the spread out of the fire.

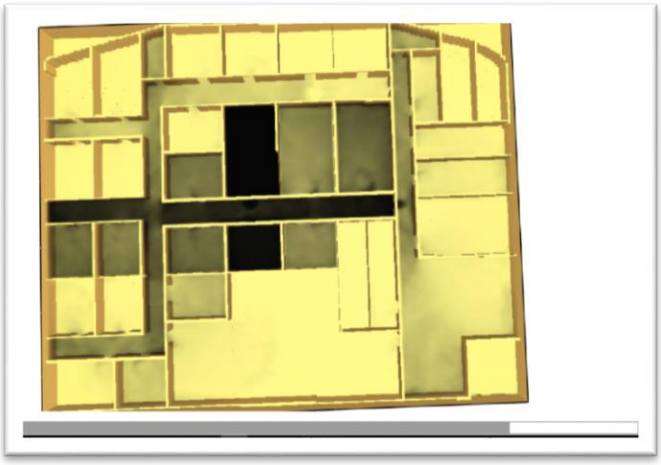

Figure 2. Fire modelling on Deck C

The simulation without sprinkle is just to make sure the spreading of fire, where is the flow of the fire. Then, after knowing the the spreading of fire, the next simulation will be simulate with the sprinkles. This figure will show at which second the sprinkle will active after the fire come out. The sprinkle active with spout the blue color at 20 seconds of 100 seconds. The meaning is the temperature around the flash point is already reach the 74°C. This figure below will show the spread out of the fire and the sprinkle.

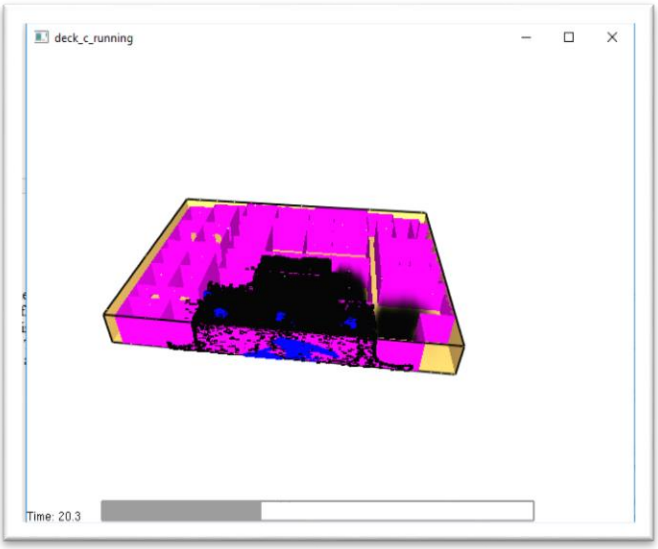

Figure 3. Fire modelling with sprinkle

F. 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.

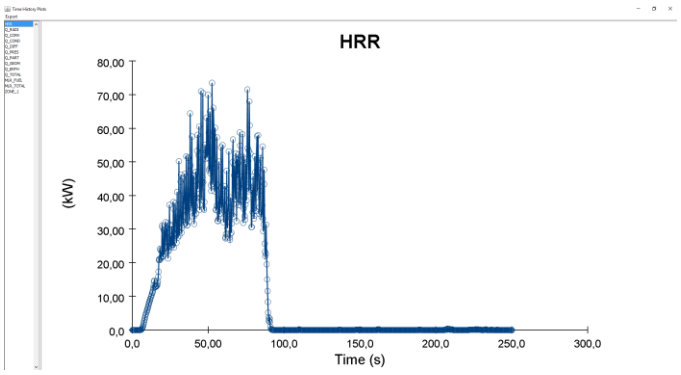

Figure 4. Heat Release Graphic source on deck C

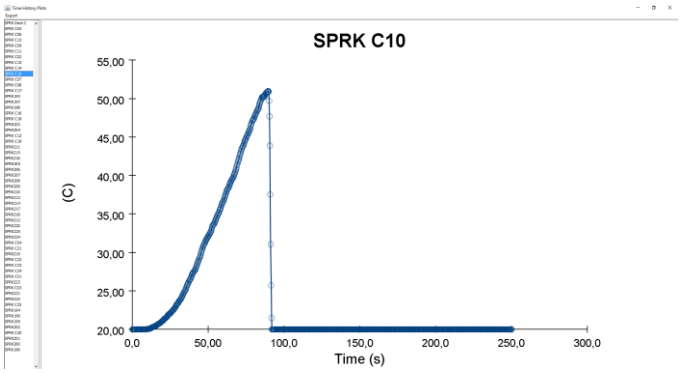

Figure 5. Temperature Sprinkle on Deck C

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.

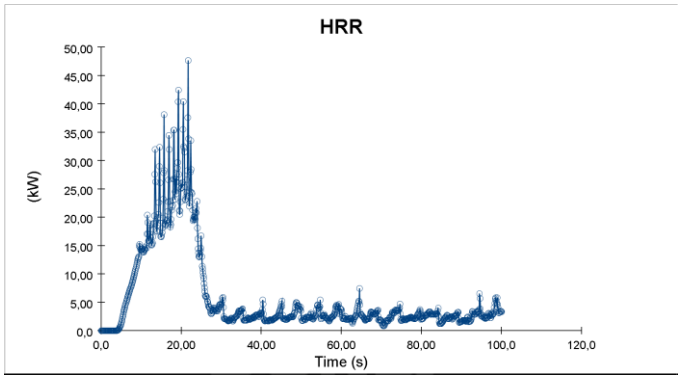

Figure 6. Heat Release Rate (HRR) on Galley

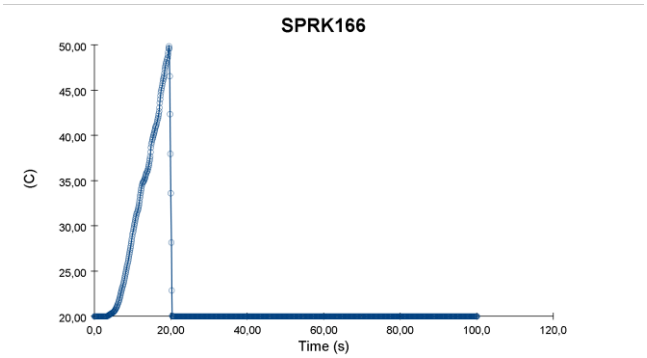

Figure 7. Temperature Sprinkle on Deck Galley

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.

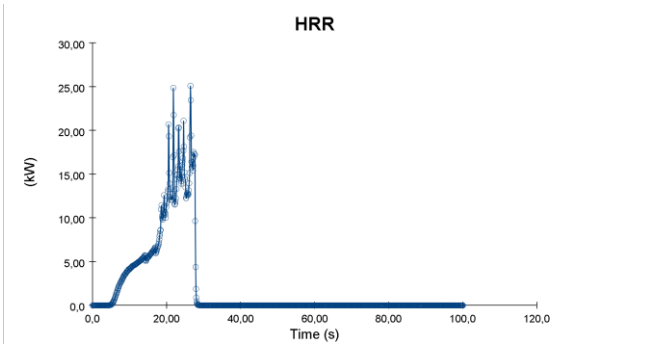

figure 8. Heat Release Graphic source on Engine Room

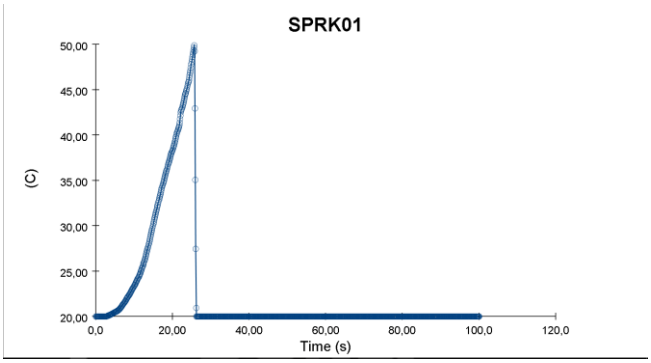

figure 9. Temperature Sprinkle (CO2) on Engine room

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.

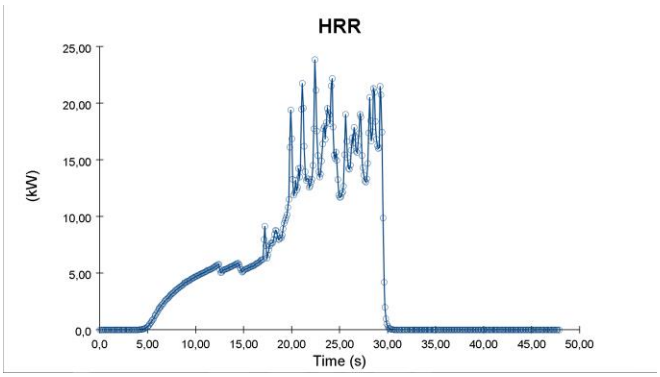

Figure 10. Heat Release Rate Graphic on Car Deck

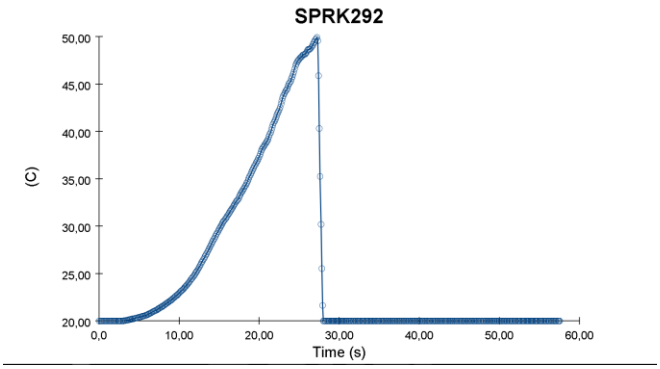

Figure 11. Temperature Sprinkle on Car Deck

III. CONCLUSION AND SUGESSTION

A. 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.

B. Suggestion

The suggestion from the result of this final project for the next research is :

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

BIBLIOGRAPHY

[1] Zaman, Muhammad Badrus, 2015.sistem *Keselamatan Navigasi Kapal*, Jurusan Teknik Sistem Perkapalan FTK-ITS, Surabaya

[2] *Failure Modes and Effects Analysis.* R.R. Mohr February 2002 8th Edition

[3] *Failure Modes and Effect Analysis.* 2004 Institute for Healthcare Improvement Review of Hazard Identification Techniques

[4] Kevin McGrattan, R. M. S. H. J. F., 2010. *Fire Dynamic Simulator (Version 5) User's Guide.* version 5.5 ed. s.l.:National Institute of Standards and Technology (NIST).

[5] Kevin McGrattan, R. M. (2010). *Fire Dynamics Simulator (Version 5) User's Guide*. Maryland USA

[6] Komite Nasional Keselamatan Transportasi . (2011). *Analisa Data Kecelakaan dan Investigasi Transportasi laut Tahun 2007 - 2011*.Jakarta: Kementrian Perhubungan

[7] Badan Klasifikasi Indonesia., 2004. *Rules and Regulation.* s.l.:BKI.

[8] Taylor, D., 1996. *Introduction to Marine Engineering.* revised second edition ed. s.l.:Elsevier.

[9] Agency, M. a. C., 1998. *Ro-Ro ship The Carriage of Dangerous Goods in ships with ro-ro cargo spaces.*

[10] Nemirow, S. B., 1994. *Marine Fire Prevention, Firefighting and Fire Safety.* s.l.:DIANE publishing.