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SAFETY MANAGEMENT ON LOADING PROCESS WITH RUBBER TYRED GANTRY CRANE: CASE STUDY AT PORT OF TANJUNG PRIOK

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ABSTRACT

Loading and unloading process are the main activity that operated by PT. Pelabuhan Tanjung Priok. The operational activity occurs during fully 24 hours with very high flows. This condition affects the accident level of the area, the accident report of PT. Pelabuhan Tanjung Priok shows there are 75 case of accident by December 2015 and 45 % of the accident took place in container yard. Rubber tyred gantry crane is a tool operates in the container yard . The mobility of this tool is quite high due to wear rubber tires Thus, to prevent the study of risk assasement and its control plan of lift off process using ruberr tyred gantry crane are needed by using fault tree analysis to trace the root of the problems of each risk. the results obtained that there main activity have a highest risk, the risk is sling broken with value about 300, because of that the Lift off activities having A class from qualitative risk assesment. researcher making management recommendations of recruitment , training , tools, testing and commissioning tools, then recommendations to RTGC safety features Standard and Chart of safety report.

KEY WORDS

Risk assesment, safety management, fault tree analysisis, port, loading, rubber tyred gantry crane.

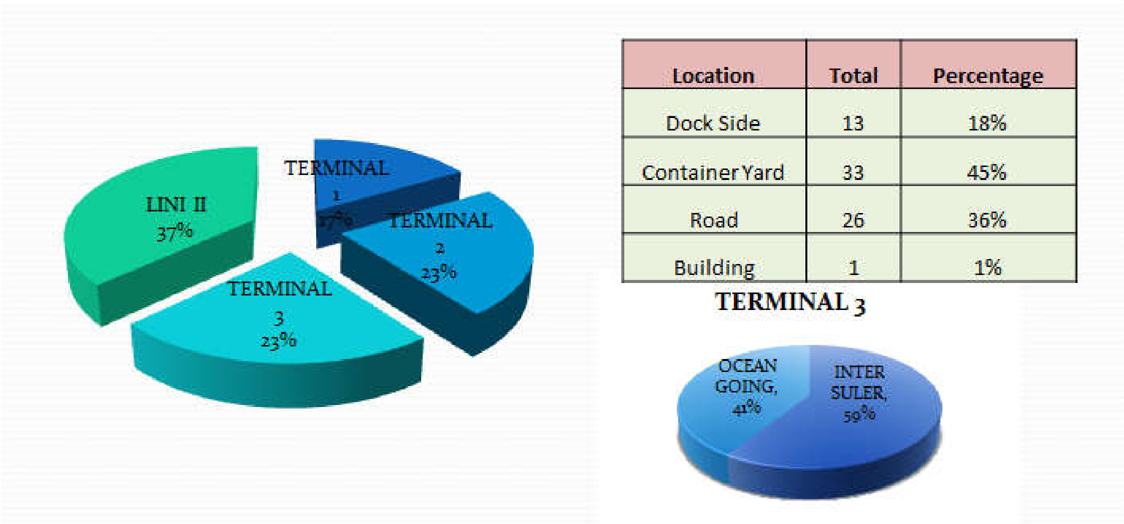
Safety performance has traditionally been measured by ‘after the loss’ type of measurements such as accident and injury rates, incidents and dollar costs. However, there is a growing consensus among safety professionals and researchers that these “lagging” indicators, which means that an accident must occur or a person must get injured before a measure can be made, may not provide the necessary insights for avoiding future accidents. A low reported accident rate, even over a period of years, is no guarantee that risks are being effectively controlled, nor will it ensure the absence of injuries or accidents in the future (Lindsay, 1992). Moreover, in many safety-critical settings, the likelihood of catastrophic events or accidents is low; thus, the absence of unlikely events is not, of itself, an indicator of good management (Van Steen, 1996).

Safety has often been considered as a critical feature in almost all marine operations. The hostile environment set many challenges not only to the ship itself, as a technical artefact, and the people onboard, but also to the higher levels of safety management. The management of an organization should be arranged to be able to keep sufficient control of the safety and make plans to overcome the hazards, i.e. be prepared for all foreseeable situations that can be encountered and that may possibly cause harm to the organization, to its customers and other stakeholders. The risk should be below the limits set by the regulators and concurrently as low as reasonably acceptable, taking into account the relevant stakeholders (Jalonen et al, 2009).

In this case the factors not only provided accessable information, costs, facilities for consuments used container loading services but amount of accident and extent of damage to materials that happened in the work area,to prevent emerging risk and loss it required a system that can controls the risk (i.e risk management) (Wang, 2008). Leading indicators, one type of risk management activity, are conditions, events or measures that precede an undesirable event, and that have some value in predicting the arrival of the event, whether it is an accident, incident, near miss, or undesirable safety state (Grabowski, Et al).

Leading indicators are associated with proactive activities that identify hazards and assess, eliminate, minimize and control risk. Lagging indicators, in contrast, are measures of a system that are taken after events and assess outcomes and occurrences. Examples of leading indicator measurement programs include near hit reporting in anesthesia management (Pate-Cornell, 2003).

Operational activity in PT. Pelabuhan Tanjung Priok runs for 24 hours with fairly high unloading traffic. This high traffic of unloading affects to the high risk of safety of the Port of Tanjung Priok working area. This can be seen from the accidents report owned by the Port of Tanjung Priok in 2015 up to September where 98 cases were recorded. Most of the accidents happened in container yard CY. One of the activities in CY is unloading using Rubber-Tyred Gantry Crane (RTGC), a heavy equipment to load with flexible mobility.



Location	Total	Percentage
Dock Side	13	18%
Container Yard	33	45%
Road	26	36%
Building	1	1%

Figure 1 – Number of Accident Cases Based on The Area
Source: Accident Report PT. Pelabuhan Tanjung Priok

If it is seen from the number of accidents data based on the location, it can be seen that terminal 3 has the most accidents, however if it is seen from the area, activities in hoarding field shows the biggest number of percentage as many of 45%.

Table 1 – Accidents Data Based on the Damage Inflicted

Damage to	Total	Percentage
Environment	5	7%
IPC Property	19	26%
Client Facility	36	49%
Cargo	12	16%
No Damage	5	7%

Source: Accident Report PT. Pelabuhan Tanjung Priok.

The table above shows that the partners' facility have 36 facility damage from 75 accidents happened and this can cause the increase of dwelling time and also causes the excess of operational spending during the activity. It can be seen also from the data that the accident impacts that is not causing accident is only about 5%.

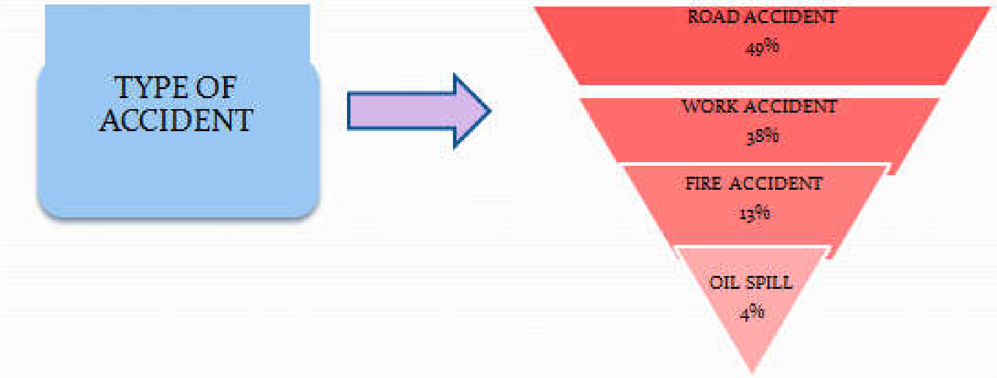


Figure 2 – Number of Accidents Based on The Accident Types
Source: Accident Report PT. Pelabuhan Tanjung Priok

From the type of accidents, the biggest accident in the Port of Tanjung Priok is a traffic accident where inside the terminal, this activity often happened in the hoarding field, which involves drivers and customers and also unloading factory. This can change the stereotype of citizen outside that assume that the accidents were caused by the people of PT. Pelabuhan Tanjung Priok.

Now, the Port of Tanjung Priok have had risk management system for their operational activity. However, the problems based on the accident report shows that there are still many infringements such as the use of non-standardized equipments, unlicensed RTGC operators who do not have operator licensed, and also unclear warning sign mainly in RTGC operstion area in container yard. Many non-internal guests of PT Pelabuhan Tanjung Priok and non-loading contractors that are coming in and go out the areas without complete personal safety equipment. That indicates the problems in the implementation of risk-management system in the Port of Tanjung Priok which will cause loss if it is not addressed properly.

This research aims to find out the accident risk in all activities in container yard of PT. Pelabuhan Tanjung Priok by designing risk management system after knowing the core of the problems from the risks that later can be the recommendations for the betterment of safety management system in unloading process using RTGC.

THEORETICAL FRAMEWORK

Container yard is a container hoarding field that contains FCL (Full Container Load, which all the containers owned by the sender and the load recipients) and the empty ones that are going to be shipped. The field is situated on the land and the surface has to be covered by pavements in order to be able to support the lifting gear or carrier and also the load of the container.

Risk and Hazard. Hazard is a potential source that endangers and harms the surroundings such as causing accidents, injury or illness to human, building damage, environmental damage, or the combination of them (Goestch, 2008). While risk is chance/possibility of the occurrence of something that causes impacts of something; incidents or events as well as the consequences that arise from them; is a combination from the consequence of an incident and possibility of the occurrences that have positive and negative impacts (Colling, 1990)

Semi-Quantitative Analysis. Semi-quantitative analysis uses qualitative scale that has been given a value that has meaning of the degree of consequences and probability from the risk (Chybowski .2012).

After existing hazards are identified and given scoring based on the tables above, Probability, Consequence, and Exposure components are multiplied to calculate the risk level that can be beneficial to help overcome the risks.

Table 2 – Semi-Quantitative Probability Table

Factor	Levels	Description	Rating
Probability	Almost Certain	The most common occurrence	10
	Likely	The change of an accident 50% - 50%	6
	Unusual but Possible	Unusual but possible	3
	Remotely Possible	Very small possibility of incident	1
	Conceivable	No accident in years of exposure but may occur	0.5
	Practically impossible	Very unlikely to happen	0.1

Table 3 – Semi-Quantitative Factor Consequence Table

Factor	Levels	Description	Rating
Consequence	Catastrophic	Discontinued activities, irreversible damage to the environment	100
	Disaster	Death, permanent damage that is local to the environment	50
	Very Serious	Permanent disability, non-permanent environmental damage	25
	Serious	Serious but resulted in non-permanent disability or morbidity, adverse effects on the environment	15
	Important	Medical treatment needed, exhaust emission occurs in the location but resulting in damage	5
	Noticeable	Injuries or minor illness, a little production loss, small loss or interruption of working process	1

Table 4 – Semi-Quantitative Factor Exposure Table

Factor	Levels	Description	Rating
Exposure	Continuously	Often occurs in a day	10
	Frequently	About once a day	6
	Occasionally	Once a week to once a month	3
	Infrequent	Once a month to once a year	2
	Rare	Known the occurrence	1
	Very Rare	Not known occurrence	0.5

After the value of hazard level is found, the comparison between hazard level criteria is done.

METHODS OF RESEARCH

This research is a Semi-Quantitative Risk Assessment that is a development of risk assessment by using a modeling to particular event to obtain rate event. The modeling aims to obtain data accuracy based on initial information that is processed by considering existing parameters.

Figure 3 – Operation Terminal III Location of PT. Pelabuhan Tanjung Priok
Source: Terminal III Profile (2016)

This research was done in PT. Pelabuhan Indonesia II, PT. Pelabuhan Tanjung Priok, precisely in Ocean Going Operational Terminal III sailing area that in Figure 3 is marked with blue, the location is in Jl Raya Pelabuhan, Tanjung Priok, Jakarta Utara 14310.

Data Collecting. From the observation and the data collection from the research location, the scheme of unloading operation in RTGC process in order are as follows: truck obtains permission to enter; truck is guided by the system to enter into CY; truck parks by the guidance of the staffs; RTGC operator is guided by the staffs; RTGC performs container lift off from the hoarding field (container on the deck above the hatch); RTGC's hoist locks the container; RTGC performs container lift on to the top of the trailer; truck from CY goes to the check point; from the check point, truck goes to the gate out; repositioning of RTGC if needed.

RESULTS AND DISCUSSION

Risk Control. From the result of fault tree analysis, the basic event for each hazard has been specified and therefore the researcher was helped in making corrective and preventive actions in order to prevent the danger from the biggest risk, which is the off sling of trucks. The corrective and preventive ways can be seen in Table 5.

Table 5 – Risk Control Hierarchy Based on AS/NZS 4360, Year 2004

№	Risk Control Hierarchy
5	Eliminate Source a Hazard
4	Change the Device/Machine/Methods
3	Modify the Device/Machine/Methods
2	Procedure, Rules, Training, Working Hours, Alarms, Signs, Labels
1	Personal Protective Equipment

Risk Assessment and Control. Risk assessment was done by using qualitative method and semi-quantitative method where the researcher would interview the operators and made the result of interviews as a value that can be used as a guidance to understand various activities that can be controlled. The activities that the cause and the safety management would be made were determined through qualitative method based on the interview using HIRAC method Based on the field observation and the result of interviews, the researcher only took the samples that have A class so that the research would only be focused on the danger and the corrective and preventive actions for the obtained risks can relate to one another in which it can help reducing the potential danger from the activities. The researcher sees that lift off has the highest risk because there are still worries from the operator regarding the conditions applied from top management that lead to the unsafe actions and are possible to cause human error accusation to the operators' side if the accidents happen.

Seeking for Root Cause through Fault Tree Analysis Method (FTA). In off-sling case, the hazard was caused by 3 conditions namely, the lifting equipment tools, work and human environment, several root cause from the problems were obtained from the FTA, for the RTGC, the basic event was the sling which was fragile, the leaking oil from the pulley, and the strong winds that cause shaking spreader. The basic event from human condition were illness, fatigue, and disobedience to regulations due to productivity reason, lack of knowledge and experience and also lack of additional features of RTGC that provide specific information for the operators.

For the off-sling case, the corrective action is to do the checking using visualization during the shift change and make sure that the load that is being lifted is less than SWL, whereas the preventive action is to conduct training for operators and also conducting maintenance and treatment for RTGC.

Table 6 – Risk Assessment of Loading Activity

№	Activity	Hazard	Consequence	Probability	Exposure	Risk Score	Priority	Number Of Hierarchy
1	Lift off	Risk of hoist falls	50	0,5	1	25	priority 3	1,2
		Risk of container dislodged from the twist lock hoist	25	1	1	25	priority 3	1,2
		Risk of transported containers crashed into piles of containers	50	0,5	1	25	priority 3	1,2
		Risk of broken sling	50	0,5	1	25	priority 3	1,2
		Risk of container fall on the truck	50	1	1	50	priority 3	1,2
		Risk of container fall on a person	50	1	3	150	substancial	1,2, 3
		Risk of RTG with excessive voltage on the column	50	0,5	1	25	priority 3	1,2
		Risk of lift off container not fit with the trailer	25	1	3	75	priority 3	1,2
		Risk of broken sling	50	2	3	300	priority 1	1,2, 3, 4
2	Operation in The Cabin	Risk of sudden illness attack on the operator	25	0,5	1	12,5	acceptable	1
		Risk of burning cabin	25	0,5	1	12,5	acceptable	1
		Risk of high temperatures during the day in the cabin	1	6	10	60	priority 3	1,2
		Risk of falling cabin	50	0,5	0,1	2,5	acceptable	1
3	RTGC Maneuver	Risk of RTG crashed into four-wheeled vehicle	25	1	1	25	priority 3	1,2
		Risk of RTG crashed into two-wheeled vehicle	50	1	1	50	priority 3	1,2
		Risk of RTG crashed into RTG	50	1	0,1	5	acceptable	1
		Risk of RTG crashed into piles of container	50	1	1	50	priority 3	1,2
		Risk of RTG run over people	50	1	1	50	priority 3	1,2
		Risk of RTG crashed into rmbc	50	1	0,1	5	acceptable	1
		Risk of RTG crashed into container office	50	1	0,1	5	acceptable	1
4	Employees Go Up to The Cabin	Risk of falling lift	50	1	1	50	priority 3	1,2
		Risk of shut down lift	15	3	1	45	priority 3	1,2
		Risk of employee falling from RTG	50	1	1	50	priority 3	1,2
		Risk of jammed lift	50	1	1	50	priority 3	1,2
		Risk of employee falling down from the RTG stairs	50	1	1	50	priority 3	1,2
5	Maintanance Activities	Risk of mechanic being electrocuted	50	1	1	50	priority 3	1,2
		Risk of mechanic slipped	15	1	1	15	acceptable	1

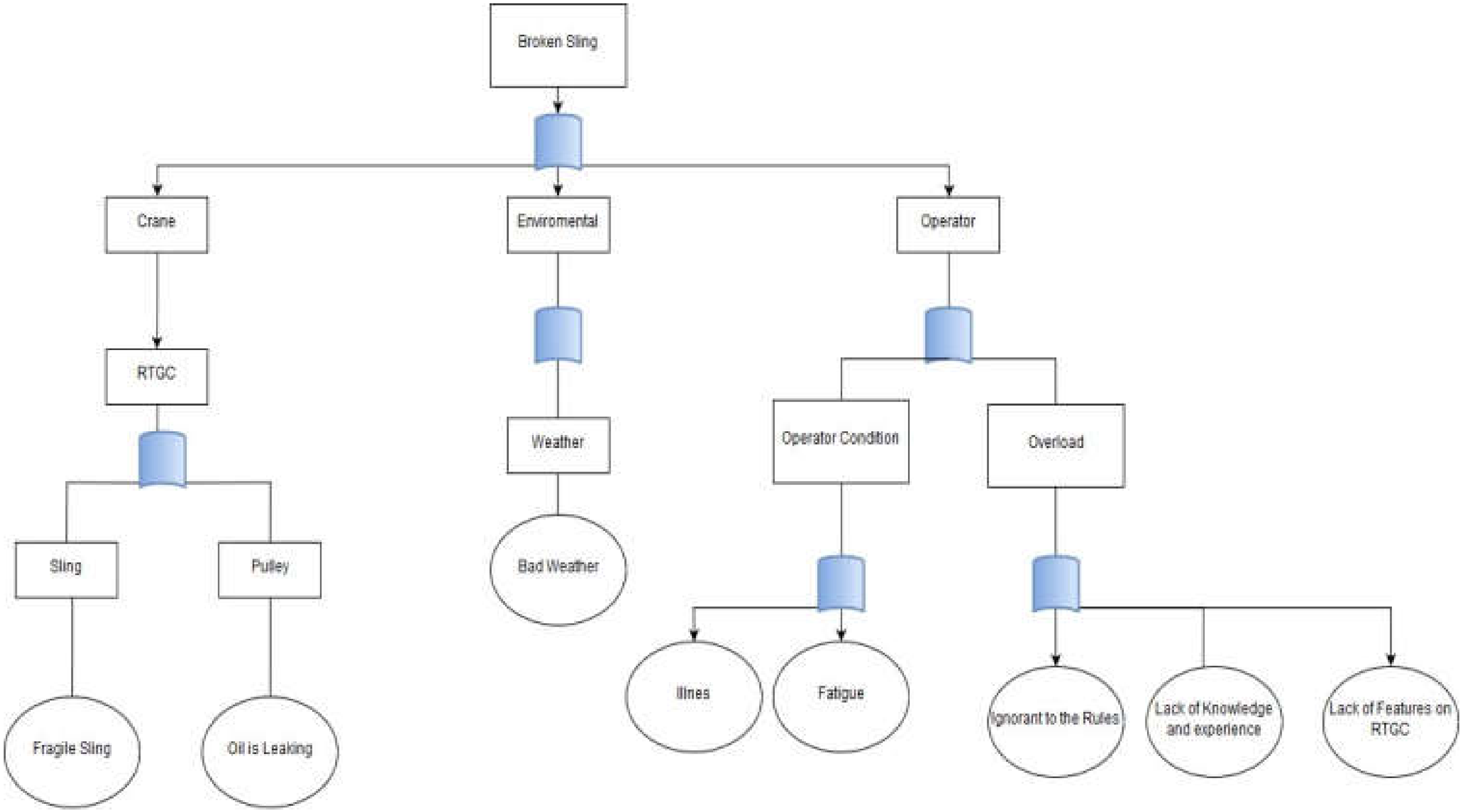


Figure 4 – Off- Sling FTA

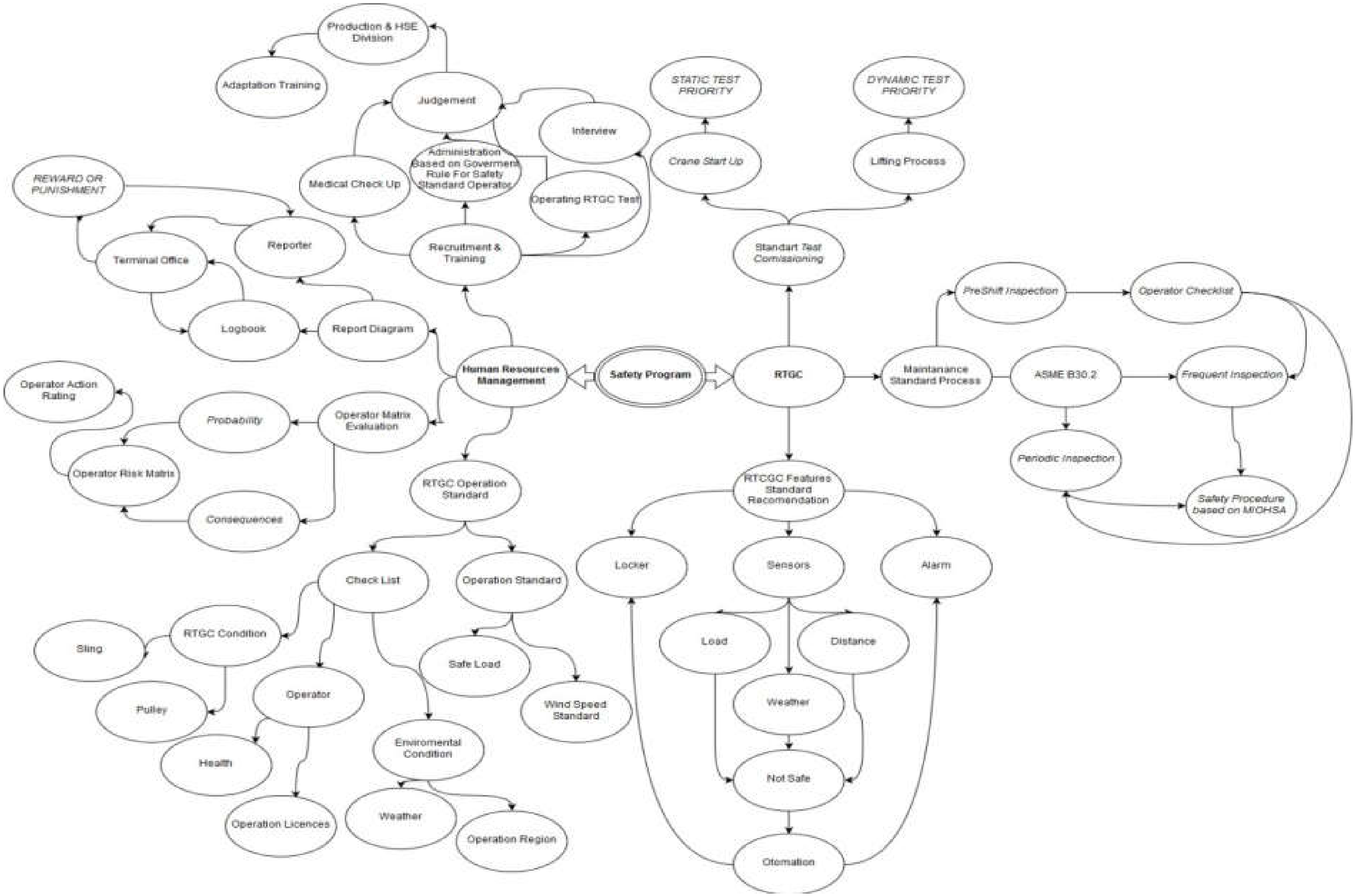


Figure 5 – The Establishment of Safety Management Diagram

Safety Management of Unloading Process Using RTGC. This work safety management is in the form of suggestions that will be proposed to the authority of the port, the suggestion will be divided into two categories: suggestion for human resource management and suggestion for the RTGC itself. For human resource management, the proposed things are: operating process standard, recruitment and training standard, and reporting flows. Then, for the RTGC there are 3 (three) suggestions namely: test commissioning process suggestion, maintenance process standard, and the additional safety features for RTGC.

Safety management for lifting process will be divided into two kinds: for operator and for RTGC. For RTGC, the researcher will made standard operational procedure for test commissioning and for maintenance, and for the operator, the researcher will set standard operational procedure for shift change, as well as setting protection ways correctively while the operational activity is running. Other than two things above, the researcher will also make recruitment standard for RTGC operators and the development of knowledge of the RTGC operators.

Standard Operational Process of RTGC. The lifting process using RTGC has high risk for failure that will be causing fatality, property damage and also environment pollution. According to Brinkmann (2011), there are two system disadvantage factors that can cause failure in lifting process specifically:

1. Container transports between STS crane and yard area require two handover procedures due to the use of different terminal equipment for transport and stacking Tasks
2. Disturbance of TTU operations by trucks being also loaded/unloaded in the stacking area (mixed traffic).

Lifting Plan. The researcher create an outline for the standard operating procedures in the plan of unloading using RTGC into six phases namely: Operator Examination; Tool Condition Checking; Lifting Operations; Termination of Operations; Equipment Testing by Mechanics; Substitute Operator Stands-by.

Operator Examination includes:

1. Identity Checks;
2. Is not under the influence of alcohol and drugs;
3. Checking of dangerous goods in operator's pocket;
4. Checking of Personal Protection Equipment.

At start-up condition, the operator is recommended to perform a technical inspection such as:

1. Make sure the work site is safe and comfortable, never operate the appliance when danger is visible;
2. Perform a visual inspection to ensure a safe operating condition of the tire gantry and ensure that each holder of tires is removed from under the wheels of the gantry;
3. Make sure the E-stop is in the reset state (not pressed/ locked);
4. Ensure there is no door panel in an open state;
5. Make sure the entrance to the cabin (the walkway) is closed;
6. Make sure the engine oil level, radiator and hydraulic oil "OK" and the volume of fuel sufficient for operations;
7. Ensure anti-collision Crane-to-Crane or Crane-to-Container is in perfect condition.

In lifting operations there are some things that must be considered by the operator, namely;

1. Sling;
2. Wind velocity;
3. The poor condition of the engine/crane;
4. Machine configuration is not in accordance with specifications;
5. The suitability between RTGC with loads that are being lifted;

Termination of the operation needs to be done if:

1. Shift of the operator on duty has been completed;
2. The occurrence of a problem in the equipment to prevent an imminent danger, the dismissal of the operation can be done as well;

3. When there is work accident while operating RTGC;
4. The weather is not friendly during operation.

At the time of the termination, the operator must fill in the check list provided by PT. Pelabuhan Tanjung Priok Operation Terminal 3 so that at a later stage the mechanic who will be checking on the tools can give appropriate and efficient action in improving the tools.

After the operator goes down, the mechanic will check on RTGC's condition very thoroughly either through a check list or through the standard procedure set by the company.

Based on MIOHSA Standard Safety officer is required to perform pre-lift meeting prior to the execution on the field, do a brief meeting with the crane operator, rigger, and all involved parties such as area supervisors and security. In this meeting, give directions regarding safety procedures in the appointment process, appeals on security to provide information on any person associated with the process of the lifting in the area or even shut down the driveway area of lifting, and checked the mental health condition of operator is required before the operation, this is already done by the employees of the operating terminal 3 when the shift change starts.

Recruitment and Training Process of Operator. The researcher creates an outline for the standard operating procedures in the plan of loading using RTGC into six phases namely:

1. Spreading the job vacancy;
2. Administration selection;
3. Tool operation test;
4. User & HRD Interview;
5. Medical checkup;
6. Operator acceptance;
7. Training;
8. Operator is ready to work.

The Risk Matrix for Crane Operator. Special risks matrix for operator is made to set the standard treatment given to operators in the lifting process using the RTGC, these numbers are based on probability and consequences of accidents that have been experienced by operator.

The consequence is the impact of hazards that have been carried out by the operator, consisting of five kinds of very high, high, medium, low, negligible, while the frequency is a level of frequency that occurs in accidents.

All officers including the operator should be aware of the risk matrix because it can increase the sense of attention and caution on work safety in the operating area of loading process (Gamboa, 2011)

Punishment Reward Overview System. Review system is created and recommended so that the relevant parties in unloading position of port can provide a sense of attention to hazardous conditions in the area of operations, as well as the review system and reward and punishment given which is described in the figure below. Reported party is a source of risk which will be reported to the hotline number, the source of risk can be human factor and non-human factors such as equipment or infrastructure damage located around the location as well as in the form of particular conditions. Concerning safety management, no matter the reward or punishment, the safety professional must be committed to fulfill their task successfully because it can avoid an accident on the operation area (Calixto, 2015).

RTGC: Standard Test Commissioning. As we know, this phase must be led by the commissioning engineer and also a very important phase in the manufacturing of RTG by suppliers before they are handed over to the customers. According to Olufuwa (2013), commissioning phase involves two major steps which is the start-up and testing phase as seen in the picture above. Inspection activities carried out during the commissioning phase is divided into two types: start up check and lifting process check:

1. Static checking: RTGC checking on the conditions in which no energy is channeled into RTGC so RTGC does not move at all;
2. Dynamic checking: RTGC checking on the conditions in which the energy is supplied to the engine so that all partitions of RTGC can move.

Start-up phase which is the first phase of commissioning tests involved activities like checking and turning the RTG on. During this stage, the activities carried out in most of the static checking type is already mentioned earlier. According to Olufuwa (2013), Start-up phase consists of several steps that can also be done in parallel with others. During start-up, activities undertaken are: examination of the pre-start-up, RTG power-up, fiber connections and program download.

The second phase of the commissioning phases is testing the lifting process that can also be referred to internal testing phase. According to Olufuwa (2013), the main activity during this stage includes: operational testing, set-up and interlock and safety test. The main objective of this phase is to examine and standardize the commissioning phase to improve product quality and safety standards that are owned by RTGC.

Table 7 – Description Table

Consequences		
Very High	Death, irreversible damage to the environment	
High	Severe loss of operational capability highly damaging and extremely costly but survivable	
Medium	Operational impact very costly	
Low	Noticeable But Limited Operational Impact	
Negligible	minimal if any operational impact, negligible cost	
Frequency		
Rare	No accident report	
Unlikely	once every two year	
Possible	once every one year	
Likely	once every six month	
Certain	once every one month	
Color Explanation		
	=	Reasonable Action
	=	Caution
	=	Alert
	=	Fired

Table 8 – Risk Matrix for Operators

Probability	Consequences			
	Low	Medium	High	Very High
Rare	2x1	3x1	4x1	5x1
Unlikely	2x2	3x2	4x2	5x2
Possible	2x3	3x3	4x3	5x3
Likely	2x4	3x4	4x4	5x4
Certain	2x5	4x4	4x5	5x5

Maintenance. According to the ASME B30.2 (2005) regulations, inspection and maintenance on Gantry Crane is divided into three kinds:

- Frequent inspections: performed once a month
- Periodic inspections: performed once a year

Inspections are carried out with a standard that is owned by the manufacturing industry that produces the Rubber Tyred Gantry Crane.

The Recommendations of Minimum Additional Features on RTGC. Recommendations of these features is a list of additional equipment that are required based on the observation, interviews with operators, and hazard identification which were done on the lifting process using RTGC.

Based on recommendations are placed in positions that support the RTGC function, for example, in measuring wind speed, anemometer position is placed on the RTGC bridge to determine the maximum wind conditions which exerts a force on RTGC, because if the position of the anemometer is on the bottom part, the measured wind will be restrained by piles of container. Results of fault tree analysis show the presence of some event that trigger the accident scene: overload; physical factors of operator; fragile sling; oil leaking on pulley; weather conditions.

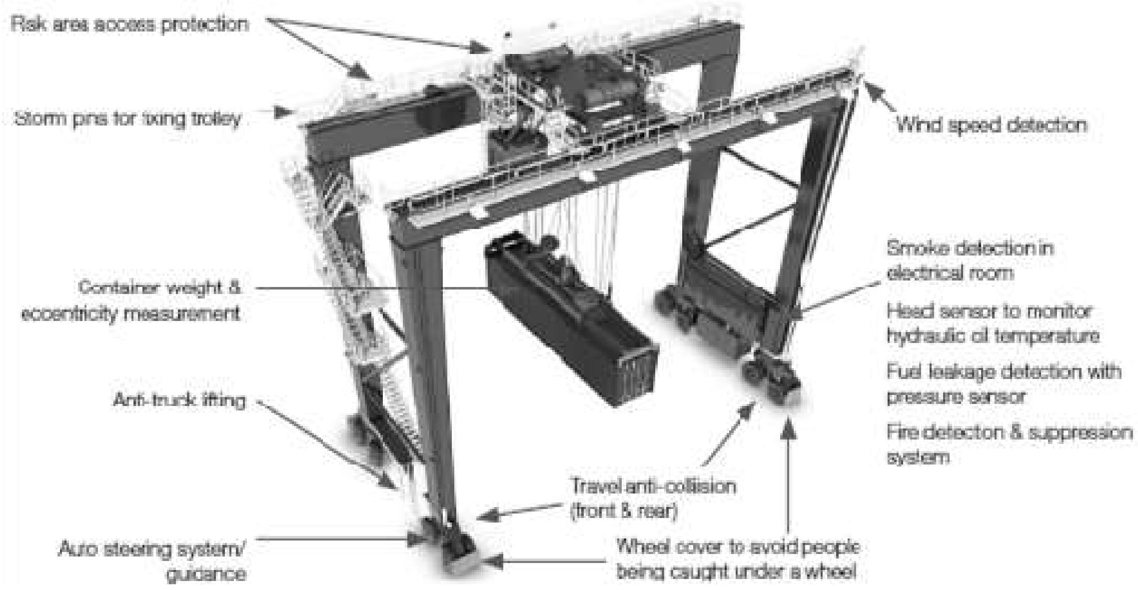


Figure 6 – Recommendations of Safety Features (Source: Port Equipment Manufacturers Association, TT Club and ICHCA International)

From these conditions, the event simulation will be created using ETA to find the worst possibility that would happen if the management suggestions are executed or not executed, This Technique may be applied to a system early in the design process to identify potential issues that may arise rather than correcting the issues after they occur (Ericson, 2005). Supported by the calculation of fuzzy logic on ETA, so that it can determine the numerical value of the likelihood of the initiating event's greatest consequences up to the hazard probability consequence.

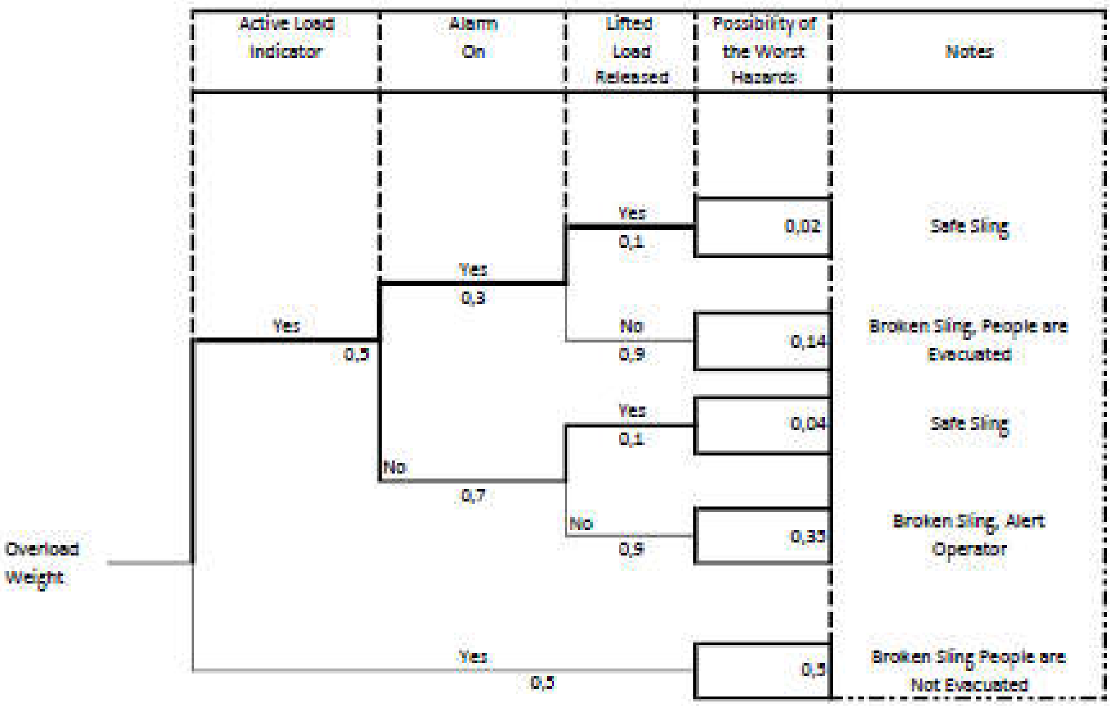


Figure 7 – ETA with Overload Initiating Event

Figure 7 shows that if there is excess in the load on the sling, then if the safety features proposed in the proposed safety management is implemented, it can reduce the possibility of danger up to 0.02.

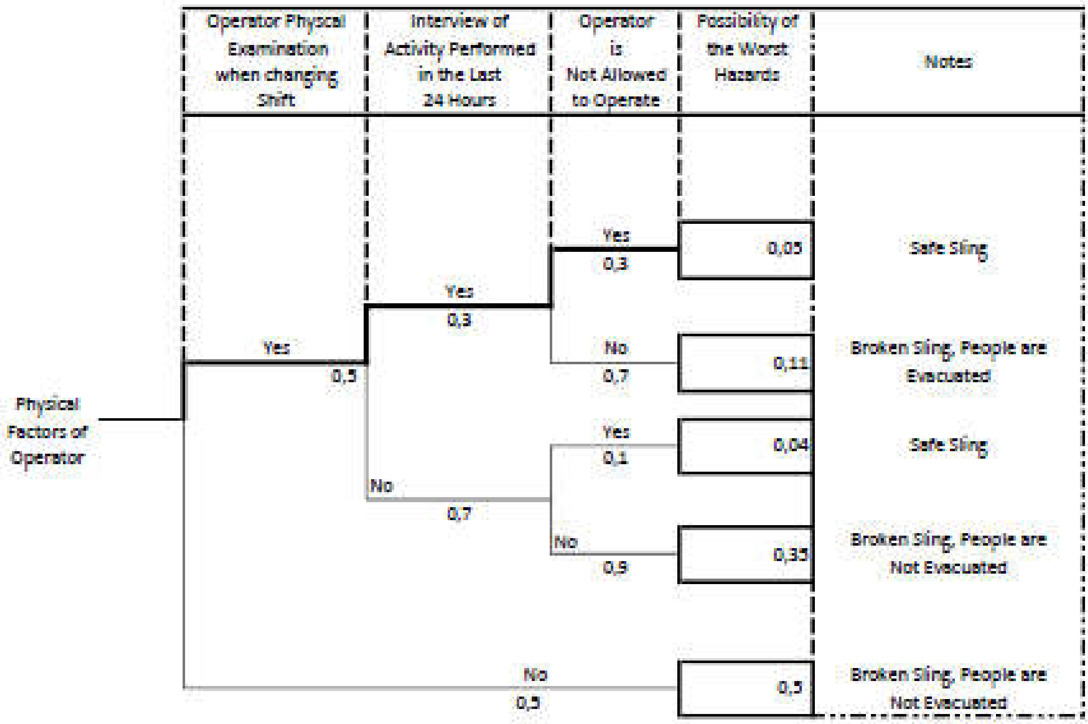


Figure 8 – ETA with Operator's Physical Factor Initiating Event

Figure 8 shows that if the operator experiences pain or fatigue, then if the proposed safety management is implemented, it can reduce the possibility of danger up to 0.05/year.

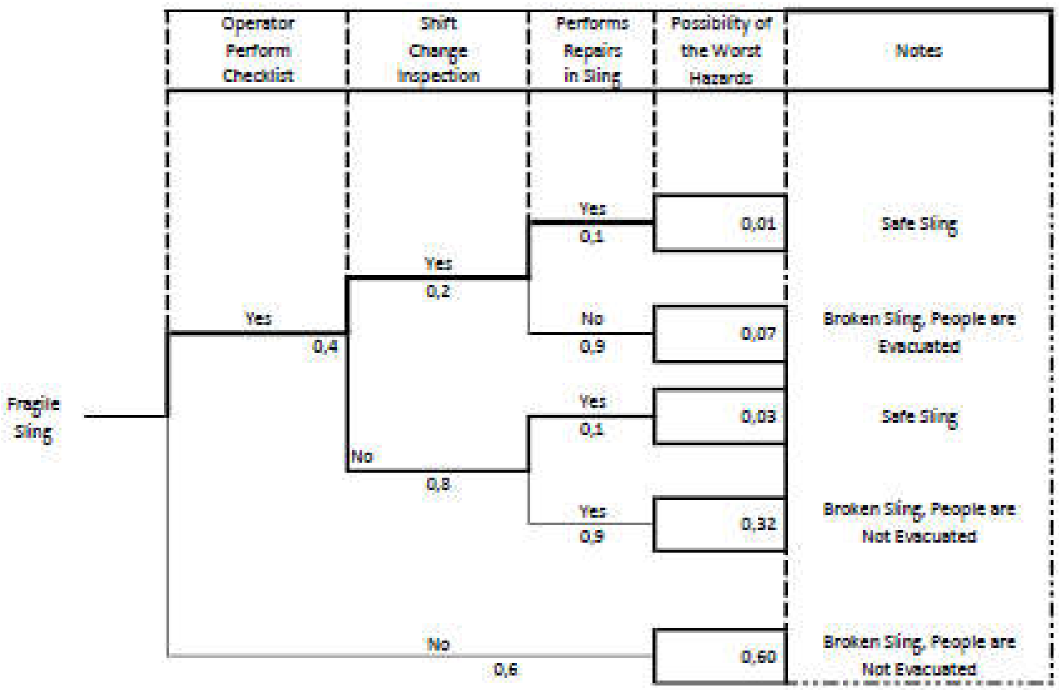


Figure 9 – ETA with Fragile Sling Initiating Event

Figure 9 shows that if the sling is fragile and if the proposed safety management is implemented, it can reduce the possibility of danger up to 0.01.

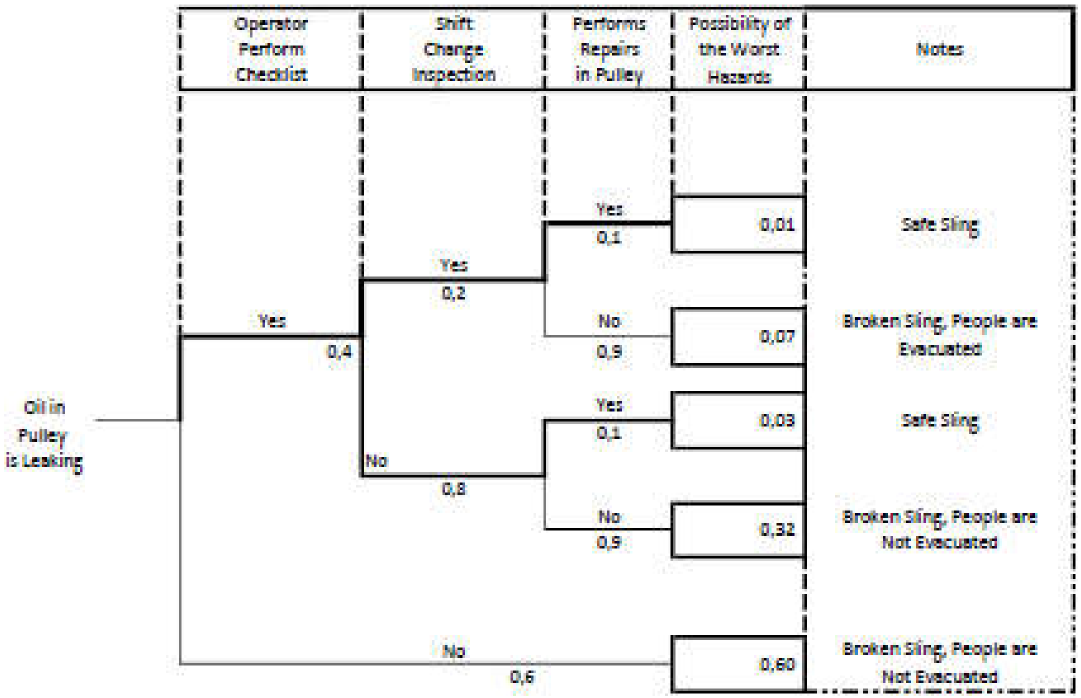


Figure 10 – ETA with Oil Leaking on Pulley Initiating Event

Figure 10 shows that if there is oil leaking on the pulley system and if the proposed safety management is implemented, it can reduce the possibility of danger up to 0.01.

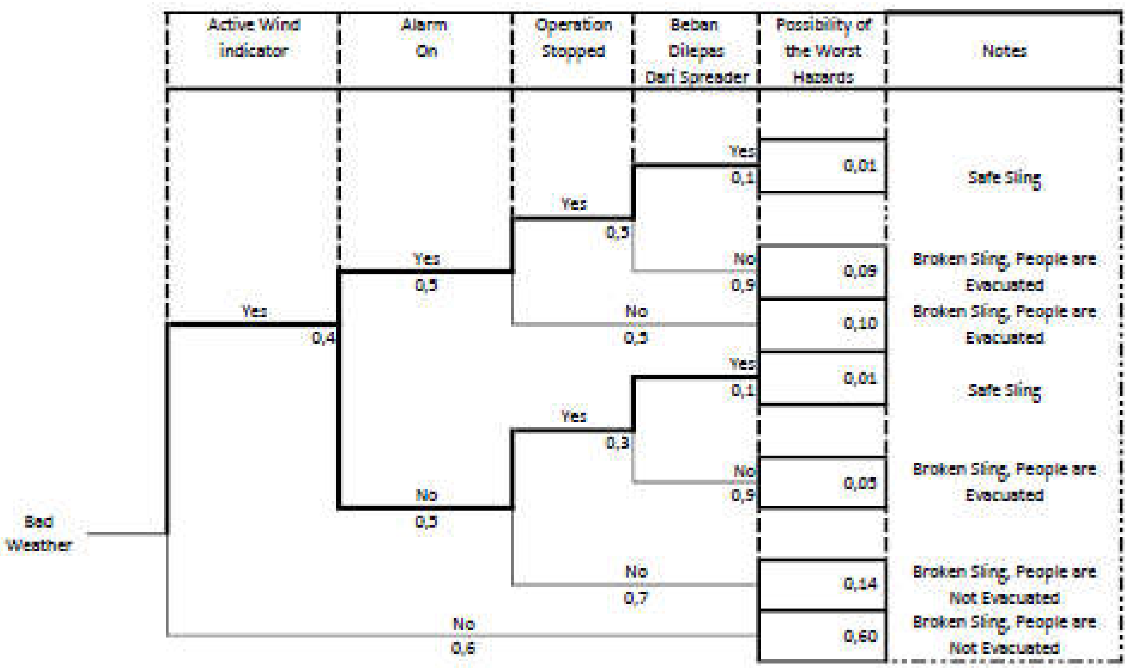


Figure 11 – ETA with Bad Weather Initiating Event

Figure 11 shows that in case of bad weather in the area of operation, with the implementation of proposed conditions of safety features on the safety management proposal, it can reduce the possibility of danger up to 0.01.

CONCLUSION

The proposed safety management system to decrease hazard risk of RGTC operations is divided into two main of standardization, i.e. standardized treatments on RTGCs and operators, for RTGC standards test commissioning, standards of maintenance, standards of safety feature on RTGC and for operators are operator acceptance standards, reporting flow standards, recruitment standards and operator assessment matrix standards. Simulation analysis of field conditions using ETA simulation shows if the proposed safety management system is well implemented then the worst state possibility of top event can be reduced to <0.003/year.

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