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Risk Analysis of Decommissioning Process: Case Studies of Lima-Compresor Platform

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ABSTRACT

The process of petroleum exploration and exploitation is a crucial activity in the fulfillment of energy needs in the world. The process of petroleum exploration and exploitation is currently centred on shallow water regions in the continental shelf. In the process of petroleum exploration and exploitation in shallow waters, the structure of which is commonly used is the jacket structure. In Southeast Asia there are about 1300 platforms, of which 80% is over 20 years old. When the platform has reached its operational limit, according to the ministerial regulation of ESDM number 1 year 2011 The platform must be decommissioning in accordance with existing technical standards. In the process of demolition, there are certainly risks and hazards that can interfere with the process of decommissioning. It is necessary to do a risk analysis to map the risks that can occur while preparing the mitigation steps. In this study, risk analysis arel conducted by determining the activity that has a significant degree of hazard where it is concluded that activities that have a significant risk level are activities related to construction, lifting, maintenance, well service, and maintenance. From each activity that has a significant hazard level, there was a process of determining the cause of risk using the Fault Tree Analysis (FTA) method while determining the barrier that serves to prevent a risk occurring. The next is to determine the impact that can be inflicted from risk by using the Event Tree Analyis (ETA) method while determining the barrier that serves to prevent and reduce the impact that occurs when there is a peril. These two FTA and ETA diagrams are combined to create a Bowtie diagram to explain in detail the risk management performed at each stage of the decommisiioning process.

Keywords: *Decommissioning, Fault Tree Analysis, Event Tree Analysis, Bowtie Analysis*

1. INTRODUCTION

The process of exploration and exploitation of oil and gas is a very important process when the world's energy needs are at a very high level. Exploration in shallow water continues to be done to meet the needs of the oil and gas. Currently there are more than 7500 installations of oil and gas where most of these installations are in the shallow waters surrounding the continental shelf of 53 countries where 40 of them produce significant amounts of oil and gas [1]. There are about 1300 platforms located around the sea of southeast Asia, of which 80% is over 20 years old. Other Data obtained from SKK MIGAS in 2019 is that Indonesia itself has 613 offshore reservoir, which 54.65% of them are over 20 years old and 24.65% are in the age between 16-20 years, besides there are also six platforms around the sea of Java that is ready to be disabled [2]. With the number of platforms that will be left in many, it is necessary to be arranged how the government requires the process of demolition (decommisioning). The process of decommisioning or platform removal process is a procedure that is currently required to all companies that have been celery passed then the most common working step is to comply with the platform in Indonesia through the Ministerial regulation of ESDM number 1 year 2011.

The demolition of structures that are in the area of shallow water, the reproduction of existing structures is Jacket. The demolition process begins with the foot cut of the structure for the next to be brought ashore to be recycled, or made artificial corals [3]. The process of project work in the offshore area is certainly vulnerable to the risk of accidents that could harm the safety of work. Where we can read any indication of danger in every process. Indications of this danger that can eventually cause accidents when in working condition [4]. In 2016 there were 101,367 cases of occupational accidents in which 2,382 cases include the death of workers (BPJS Manpower, 2016). Safety is something that should always be a priority in every job. A work accident can be interpreted as an activity that can cause harm during the ethical process.

Risk analysis is a procedure to recognize a threat and vulnerability. So it can be concluded that the product of risk analysis is a list of the risks that exist in a system of work. From the list of risks, there needs to be risk management. Risk management can be interpreted as a continuous process aimed at controlling the risks in which these activities are always audited regularly to ensure that all things found in the system are in place and functioning as-should [5].

Limacompressor (LCOM) Wellhead Platform is an offshore structure with jacket structure type. The jacket structure that supports the platform has four legs and consists of three decks. This structure is functioning as an oil and gas production facility where the platform has been installed since 1973-1974. The Limacompressor Wellhead Platform is owned by Pertamina Hulu Energi Offshore North West Java (ONWJ). The Platform is located above the Parigi Bay in the Lima Flowstation area with a water depth of 102.88 ft from the mean sea level (MSL). LCOM Well Platform has a period of operation until the year 2026. [6].

2. LITERATURE STUDY

2.1 Decommissioning

Demolition of offshore structure or Decommisioning is the process of demolition of structures that are under the surface or above the surface of the sea or rivers when the structure is no longer used [7].

2.2 Risk Definition

Risk is a combination of possible occurrence of dangerous occurrence or exposure to the severity of a injury or illness that can be caused by such incident or exposure.

2.3 Risk Assesement

The principle of the risk assessment process or risk assessment process has five general stages:

1. Hazard identification
2. To determine which hazard can threaten and how threats can arise
3. Evaluating existing risks and determining countermeasures
4. Implementing countermeasures
5. Review the risk assessment and make updates as needed.

2.4 International Oil & Gas Producers (IOGP) Safety Data

The International Association of Oil & Gas Producers, IOGP, is an associate of a company engaged in the oil and Gas industry. The association collects accident data related to the safety of oil and gas exploration process and production of all the companies that are members. The Data produced in this report is the largest database of safety incident statistics in the oil and gas industry. In the report issued by the IOGP, there are several categories of incidents that summarize incidents with the classification that has been adjusted to the conditions and experiences that have been obtained. These incidents occur in some common types of general activity that are commonly run in oil and gas industry activities.

2.5 Bowtie Analysis

Bowtie Analysis is a diagramatic method used to describe and analyse the path of risk from the failure factor to the impact. This method is often regarded as a combination of fault tree analysis and event tree analysis where fault tree analysis is displayed on the factors that cause a risk and event tree analysis as an event tree that displays about the impacts or consequences that must be borne when a failure occurs.

3. METHODOLOGY

3.1 Flow Chart

The steps taken to enforce this final research assignment are as follows:

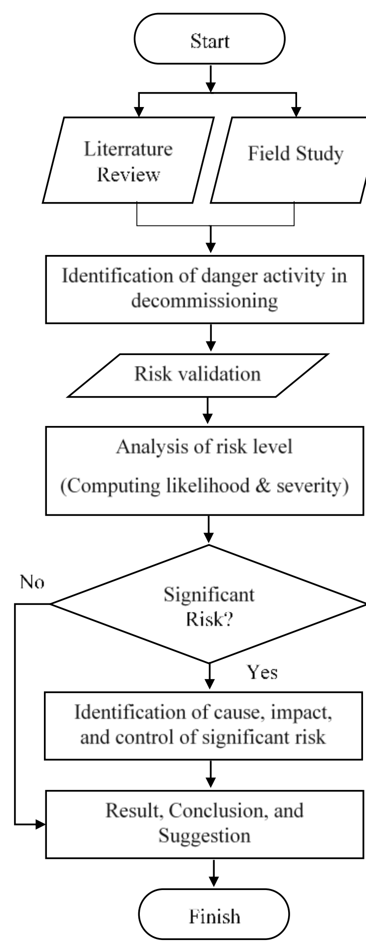

Figure 1. Flowchart of Research Methodology

3.2 Data Lima-compressor Platform

The following is a data from the Lima-compressor Platform as well as the modeling of the Lima-compressor Platform structure.

Table 1. Structural data of Lima-compressor platform

Description	Data
Water depth	102.88 ft / 31,37 m
Number of Legs	4
Number of deck	3
Total deck weight	1974.12 kips
Total jacket weight	1722.93 kips

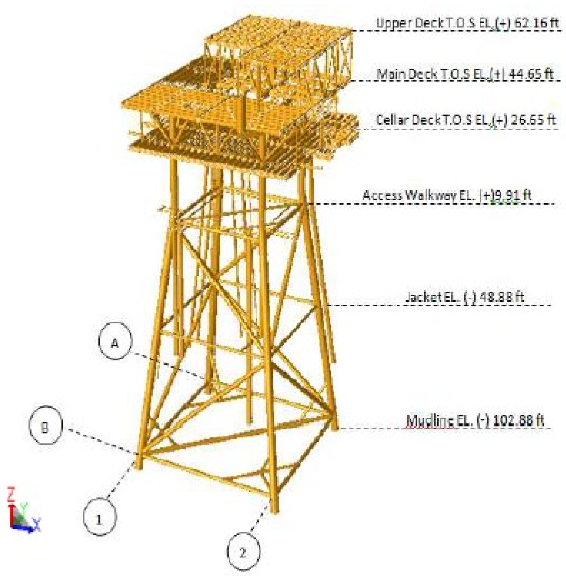

Figure 1. Flowchart of research methodology

4. RESULT AND DISCUSSION

4.1 Proposed Decommissioning Program

a) Jacket Leg
   Jacket Leg will be cut 5 meters below Mudline, hereinafter removed and loaded in upper barge to be taken ashore.
b) Top side
   Top Side will be separated from the jacket structure by cutting the joints between the jacket and Top Side. Next the top side structure will be raised and loaded-in to the top of the barge to take ashore
c) Conductor
   The Conductor will be cut 5 meters below the Mudline, further cut into segments with a maximum length of 12 meters before being taken ashore.

4.2 Work Breakdown Structure (WBS)

To run the process of demolition of structures, it is necessary to be prepared with systematic work to ensure that the work is done effectively and efficiently. The following is a Work Breakdown Structure of the over process that divides the process into several stages of work.

a) Structure Preparation Phase
   i. Preparing the Platform
   ii. Demolition of riser and pull tube cable
   iii. Equipment Demolition on Deck
   iv. Structure preparation
b) Demolition Structure Phase
   i. Doing well dismantling
   ii. Dismantling the upper structure
   iii. Doing the demolition jacket
   iv. Seafastening and transport to land

4.3 Work Task

The following is a list of work to be done in the decommissioning process.

Table 2. Work task list on decommissioning process

Activity	Description
Rope Access	Rope Access is a work done to reach locations that are difficult to reach with conventional access, this process will place a worker that is applied to the harness to reach the hard-to-reach locations. This activity will include the preparation of the rope, and the work of the Rope access itself
Lifting Operation - Platform Crane Lift	Lifting Operation-Platform Crane Lift is a standard lifting work used to move goods from or towards offshore shore using the offshore pedestal Crane, in this case usually the raised goods have a weight of about 50 T. This work includes the preparation of lifting (rigging, hooking), lifting processes and derigging
Lifting Operation - External Crane Lift	Lifting Operation-External Crane Lift is the same work as on the Platform Crane Lift process, where the goods that will be transferred are goods originating or going to the platform. The difference between these two types of activities is the weight of the objects transported at the range of 50 T-500 T
Lifting operation - Heavy Lifts	Lifting operation-Heavy Lifts is an offshore lifting work for structures weighing more than 500 T. This process requires a separate planning of the methods and tools used in the lifting process. This process covers the process of lifting topside structures and jackets
Scaffolding	Scaffolding covers such activities as constructing scaffolding and moving scaffolding after use.
Equipment Decomissioning Operation	Equipment Decomissioning Operation Sand Blasting, discharge insulation, cleaning. Steaming, demolition of electrical equipment,

Activity	Description
	general workshop activities, and other activities that are mostly hand-held tools. This work usually has an activity related to over equipment and has similarities with the maintenance work
Marine Operation	Marine Operation includes several marine operation processes with various types of vessels and with specific objectives.
Diving	Diving This work covers the total process of direct dives and through the chamber. This process includes work such as inspections, and manual operations under water
Management and Administrative Activities	Management and Administrative Activities include various types of office activities, operators of control rooms, catering personnel, and supervision activities.
Helicopter Transport	Helicopter Transport is a process of transporting personnel and certain goods to the offshore platform using a helicopter.

4.4 Work Accident Data on Offshore Jobs

The following is a data accident that caused death in Oil & Gas work process issued by the International Association of Oil & Gas Producers (IOGP). This data was collected from 2014 to 2018.

Table 3. IOGP Data on occupational accidents that cause fatality based on activity

Activity	Number of Fatalities				
	2014	**2015**	**2016**	**2017**	**2018**
Construction, commissioning, decommissioning	6	4	6	2	4
Diving, subsea, ROV	0	2	0	1	1
Drilling, workover, well services	16	12	6	10	12
Lifting, crane, Rigging, deck Operation	6	5	3	3	5
Mainteance, inspection, testing	4	3	6	6	3
Office, warehouse, accomodation	0	1	0	0	0
Production operation*	3	14	3	4	1
Seismic / Survey	1	2	1	0	1
Transport	8	8	25	6	4
Unspecified/Others	1	3	0	1	0
Overall	**45**	**54**	**50**	**33**	**31**

4.5 Risk Assessment

There are many possible risks that occur when the entire risk is mapped in a bowtie diagram, it will be something ineffective. It is necessary to do a mapped risk determination, where the risks that are mitigated are only risks that have a significant level of risk. Based on the value of risk value (R) which is the multiplication value of the probability index (P) with the severity index (C). This risk value value will then be plotted in the risk matrix to determine the level of risk.

$$\boldsymbol{R} = \boldsymbol{P} \times \boldsymbol{C} \quad (1)$$

R : Risk Value
P : Probability Index
C : Severity Index

Table 4. Risk Matrix

Likelihood	Severity Level				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Table 5. Likelihood index description

Likelihood Level	Description	Probability Frequency
5	*Frequent*	Potentially occurring multiple times a year
4	*Occasional*	Potentially happening once a year
3	*Moderate*	Potentially occurring in special occasions; Once or twice in the facility age
2	*Unlikely*	Can happen; It never happens in similar systems but it has little possibilities to happen.
1	*Remote*	Never happened; Most likely not happening

Table 6. Severity index description

Severity Level	Desription	Definition
5	Serious	Fatalities.
4	High	Inflict injury resulting in disability.
3	Medium	Mild injuries.
2	Low	There are no injuries.
1	Minor	No worker is injured.

Table 7. Recapitulation of risk value value and description of risk level

Activity	Probablity index (P)	Severity Index (C)	Risk Value (PxC=R)	Comment
Construction, commissioning, decommisioning	5	5	25	Significant
Diving, subsea, ROV	2	5	10	-
Drilling, workover, well services	5	5	25	Significant
Lifting, crane, Rigging, deck Operation	5	5	25	Significant
Office, warehouse, accomodation	3	5	15	-
Seismic / Survey	4	5	20	-
Transport - Water	5	5	25	Significant
Unspecified/ Others	4	5	20	

4.6 Threat Measure dan Consequences

To compose a bowtie diagram, it is necessary to specify the cause and impact that is packaged in fault tree analysis and event tree analysis. In both analyses are also determined regarding the barrier to prevent and reduce the impact that can be inflicted from a risk of danger. In this research process risk management is conducted for two stages of the decommissioning process, namely the dismantling and preparation phase.

Table 8. List of threat on Bowtie diagrams based on problems in the preparation phase of the decommissioning process

No	Threat	Barrier
1	Operator condition less prime	Trained worker recruitment and has good working experience
		Orderly and balanced work scheduling
2	Bad weather	Weather predictions based on data from accurate sources
		Stopping jobs when the weather deteriorates
3	Acidents in the process of Rope-Access work	Rope Access is done by trained and experienced workers
		Preparation and inspection of equipment used in the process of Rope-Access
4	The less-than-perfect demolition of the Process-Engineering equipment	Ensures the entire demolition equipment is in good condition
		Ensure that there is no residual hydrocarbons in equipment
5	Accidents in dismantling instrumentation equipment and electrical	Shutting down power generators before starting the demolition
		Ensure that demolition is done in accordance with existing procedures
6	Divers accidents on structure intervention process	Ensure that all divers are well-trained and certified divers
		Ensuring that all scuba equipment is in good condition
7	Equipment suffered damage due to the lack of good maintenance process	Appoint an operational head running the maintenance function
		Run maintenance programs according to manual equipment
		Preparing spare parts according to equipment needs
8	Failures in the process of lifting inventory platform that has been demolished	Ensures that the equipment to be used in the lifting process is in good condition
		Ensuring a raised object has a burden that matches the equipment's capacity and properly distributed load
9	Harmful gas leaks	Do a monitoring of the abandonment well
		Installing harmful gas detection tools
10	Mistakes Engineering methods	Appoint an experienced operational head
		Ensure that all workers are doing their work with existing procedures
11	Workers are not prepared with the danger conditions that occur	Conduct HSE training to each field operator
		Safety Induction before starting work
		Conducting a thorough risk analysis of each activity
		Installing a hazard alert alarm

Table 9. List of consequences on Bowtie diagrams based on problems in the preparation phase of the decommissioning process

No	Consequences	Barrier
1	Worker suffered an accident that caused death	Application of HSE culture on each worker
		The presence of hazardous area zoning and evacuation routes
		Use of personal protective equipment as the last protectionr
2	Schedule of over process is hampered due to equipment that has suffered damage	Perform tool repair and replacement of spare parts when problems occur
		To change the equipment when malfunction

No	Consequences	Barrier
3	Power-stung workers at the time of demolition of electrical equipment and instrumentationi	Perform final inspections after the process of demolition of electrical equipment and instrumentationi
		Use of insulating personal protective equipment
		Turn off the power source when unwanted conditions occur
4	Waste of oil experiencing fire	Ensure all unpacked process equipment are cleaned perfectly
		Distancing equipment that still contains hydrocarbons from the possibility of Sparks
5	Workers crushed by falling objects	Zoning hazardous areas during the lifting process
		Building a protective structure when there is a job in hazardous areasa
		Use of personal protective equipment
6	Environmental pollution due to poor hydrocarbon clearance	Ensure that equipment has been dbongkar cleaned properly before being moved
		In the event of hydrocarbon leakage, intervention should be needed
7	Workers falling from altitude	Performing safety procedures in the event of dangerous conditions
		Use of double safety straps at altitude and rope-access
8	Lost of Assets during the lifting process	Doing the process of re-assesement the condition of the lifting process that is experiencing obstacles
		Doing a redesign and readjusement of the rigging configuration

Table 10. List of threat on Bowtie diagram based on the problem of demolition process decommissioning

No	Threat	Barrier
1	BOP failure due to error on conductor cuting process	Perform conductor cutting in accordance with procedures
		Check the conductor after the cutting process is complete
2	Bad weather disrupts the over processg	Weather predictions based on weather data from related authorities
		Perform insitu weather monitoring in real time
		Stopping jobs when the weather deteriorates
3	Cutting tool breakage	Monitoring cutting process
		Ensure that the cutting process is performed according to the existing procedures
4	Engineering design Mistakes on lifting process	Performs accurate design data retrieval process
		Process design and planning lifting work is done by experienced parties
		Engineering design has been approved by the relevant authorities
5	Failure of the load-in process on barge	Ensures that the barge used is in a condition ready to receive the load from the structure
		Make communication between crane operator and operator above Barga to ensure structure position to finalize load-in process
6	Seafastening failure structures that have been in load-in	Configuration design process seafastening done by experienced parties
		The seafastening configuration has been approved by Marine warranty Surveyors
		Ensure that field conditions correspond to planned design
7	The maintenance process does not go well	Appoint an operational head running the maintenance function
		Run maintenance programs according to manual equipment
		Preparing spare parts according to equipment needs
8	Miss-Communication between Operator	Ensures all workers speak in one language
		Preparing equipment for resistant communication in various conditions
9	Crane Barge in the process of unstable heavy lifting	Perform the design and modeling process of heavy lifting in accordance with the condition of the field
		Doing the ballasting process according to the existing design
10	Problems on mooring line from support vessels	Process design and modeling station keeping done by experienced parties
		Perform design validation with existing field practice conditions
11	Mistakes Engineering methods	Appoint an experienced operational head
		Do a briefing before starting work
		Ensure that all workers are doing their work with existing procedures
12	Safety Awareness of workers are low/declining	Conducting HSE training to each field operator
		Safety Induction before starting work
		Conducting a thorough risk analysis of each activitys
		Installing a hazard alert alarm

Table 11. List of consequences on Bowtie diagram based on the problem of demolition process decommissioning

No	Consequences	Barrier
1	Worker experiencing an accident that caused the death	Enhancing HSE culture in each worker
		The presence of hazardous area zoning and evacuation routes
		Use of personal protective equipment as the last protectionr
2	Lost of Assets in the process of load-in	Doing re-assesement of lifting and load-in process
		Performs process redesign and re-adjusement of lifting and load-in processes
3	Lost of Assets on seafastening process	Re-assesement seafastening condition
		Redesign and re-adjusement of seafastening process
4	Inter-ship collision or collision between ship with structure	Controlling using internal and external propulsionl
		Application of fenders to reduce the impact of collisions
5	Workers crushed objects falling	Zoning hazardous areas during the lifting process
		Building a protective structure when there is a job in hazardous areas
		Use of personal protective equipment
6	Support vessel experienced addrift which causes uncontrolled moving vessels	Do re-assesement the mooring line in damage condition
		Perform a redesign configuration of mooring line
		Readjusement Mooring line is based on a design that has been modified
7	Crane barge unstable to cause crane barge drowning	Perform re-assesement of unstable barge
		Ballasting the barge crane to make the ship's position back
8	Schedule of over process is hampered due to equipment failure	To perform repair tools and replacement of spare parts when problems occur
		Substitute the equipment when the equipment are malfunction

5. CONCLUSIONS

Based on this final project study, the conclusions are:

1. Activities that have a significant level of risk are as follows:
   a) Activities related to the process of construction, commissioning, and decommissioning
   b) Activities related to drilling process, workover, and well services.
   c) Activities related to lifting, crane, rigging, deck operation
   d) Activities related to Transport.
2. Cause (Threat Measure) of significant risk at each stage in the process of decommisioning is as follows:
   a) Threat Measure on the preparation phase of the decommisioning process
      i. Poor Operator's condition
      ii. Bad weather
      iii. Accidents in the process of rope access.
      iv. The process of demolition of less-perfect process-engineering equipment
      v. Incident when uninstalling instrumentation and electrical equipment.
      vi. Diver accident during process intervention structure.
      vii. Failure in the dismantled platform lifting process
      viii. unproper engineering methods in the field
      ix. Equipment suffered damage due to ungood maintenance process
      x. Workers are not prepared with any hazard conditions
   b) Threat Measure on the demolition phase of the decommisioning process
      i. Bad weather disrupts over process
      ii. BOP failure due to error on conductor cuting process
      iii. Cutting tool breakage
      iv. Engineering design fault for lifting process
      v. Failure to load-in above barge
      vi. Sea-fastening failure structures that have been loaded-in
      vii. Barge Crane for unstable heavy lifting process
      viii. Mooring line from support vessel having problems
      ix. Fault engineering methods in the field
      x. Equipment maintenance process does not work properly
      xi. Safety awareness of low/declining workers

3. The impact (Consequences) of the significant risk at any stage in the process of decommisioning is as follows:
   a) Consequences at the preparation stage of the decommisioning process.
      i. Workers are experiencing accidents that cause death
      ii. Schedule of over process is hampered due to damage equipment
      iii. Electrically stung workers during the process of demolition of electrical equipment and instrumentation
      iv. Waste oil results in fire
      v. Workers are affected by falling objects
      vi. There is environmental pollution due to poor oil clearance
      vii. Workers fall from altitude
      viii. Lost of assets in the process of lifting platform inventory.
   b) Consequences at the stage of demolition decommisioning process
      i. Workers have an accident resulting in death
      ii. Lost of assets during lifting process until load-in
      iii. Lost of assets during seafastening process
      iv. Workers under falling objects
      v. Support vessel experiencing adrift which causes the ship to move uncontrollable
      vi. Inter-ship collision or collision between vessels and structures
      vii. Barge Crane unstable until Barge Crane sinking
      viii. Schedule of over process is hampered due to damage equipment
4. Controlling the risk of the over process is done using the method of analysis using Bowtie diagram. This process of risk control will display a barrier to the cause (threat) and impact (consequences). Where the list of causes and impacts in this bowtie diagram can be seen in Table 8 through Table 11.

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