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Relationship between Potential Hazards towards Safety Impact at Malaysian Floating Storage Facility

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ABSTRACT

Floating storage facility nowadays are increasingly become the preferred solution for new installation in offshore industry. The facility has ability to handle changes of oil reservoir and process as well as offering storage and offloading at the same time. With the straight forward of building and conversion based on the ship building technology, the system easily contributes to the potential hazard or risk that is difficult to quantify due to short of experience if compared to shipping industry. The paper gives an overview of the potential hazards during normal activity and the safety impact to personnel, asset & environment. The list of potential hazard is taken during reviewing of the literature from journals, conference proceedings, databases and guidelines related to offshore operation safety. The research study applies Risk Assessment approach by using Risk Matrix as a tool to measure the level of potential hazard. Survey data is analysed through statistical method of analysis using SPSS. The analytical tools, particularly ANOVA One Way & T-Test are applied to analyze further the significant differences of demographic facility towards potential hazards. Pearson Correlation analyzes the data for the relationship of the potential hazard towards safety impact of the facility. The study describes the potential hazards mainly from marine activities that should be considered at the floating storage facility operated in Malaysia. This work forms better understanding on the level of potential hazard onboard the floating storage facility and also highlights the impact from the potential hazard to the personnel, asset & environment. Findings from the collected experience-based and research survey data facilitates the development of rationalized approaches for top management in decision-making for the safety guideline, policy making and investment towards the floating storage facility.

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INTRODUCTION

Many oil & gas processing equipment which utilized on offshore facilities is similar to the equipment used onshore for oil production activities or in chemical process plants. Therefore, many of the hazards associated with the process equipment are well known. However, the inherent space constraints on offshore structures have resulted in the application of some new process equipment and more importantly, making it difficult to mitigate hazards by separating equipment, personnel and hazardous materials. Due to the facilities are located at remote locations, personnel who operate or service at offshore facilities typically live and work at offshore for extended periods of time. In many ways, these aspects of offshore operations are similar to those found in shipping industry. However, the operations that take place on offshore oil and gas production are different than those which take place on trading ships.

Another difference between offshore and onshore oil and gas production is the relative complexity of drilling and construction activities, which contributes significantly to the risk setting. Due to the remoteness of most offshore facilities and the challenges presented by marine environment, drilling and construction projects are typically major undertakings which require the use of large and expensive marine vessel (drill ship, derrick barges, supply vessel, diver-support vessels, etc). These non-routine operations dramatically increase the number of persons onboard a facility and the level marine activity, material handling and other support activities over more routine production activities.

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Transportation of personnel and material to and from the offshore locations presents significant potential hazards; i.e., helicopter transport, marine transport and loading and unloading operations are a routine part of offshore life.

The design of offshore facilities – multi-deck platform above the water or floating system, can expose personnel to falling and drowning hazards which are not encountered onshore.

In addition to the factors described above, the fact that offshore facilities typically have higher concentration of manpower, higher operating costs and revenues and higher initial capital investment than their onshore counterparts make the an obvious place to apply an assessment and measurement for the potential hazards being identified. The main hazards of offshore installations are the process fluids and processing operations, the sea environment and the process link between the reservoir and other installation (Khan *et al.*, 2004)

Offshore floating storage facility present a unique combination of equipment and conditions not observed in any other industry. Although there are few aspects of the industry which are completely new, the application in an offshore environment can result in new potential hazards which must be identified and controlled.

The hazard can be explained as unintended incidents occurring which may threaten the safety of personnel's, the environment and facility's assets.

Floating Storage Facility:

Floating storage facility nowadays is increasingly becoming the preferred solution for new installation of oil & gas fields. Oil industry seeks better economic solutions to its new challenges. The facility is suited for both small marginal fields and large deepwater reserves (Wilne, 1998). The floating storage facility is the most commonly used as the floating facility due to cost reasonable and practical advantage if compare with fixed installation. With the straight forward of building and conversion, based on the ship building technology, the expensive offshore works can be kept to a minimum as most of the construction, hook-up and commissioning can be completed inshore with significantly less cost (Alford, 1997). The floating facility has the ability to handle changes of oil reservoir and process as well as offering storage and offloading facilities. With this significant and comprehensive system, it easily contributes to the potential hazard or risk which is difficult to quantify due to shortage of experience if compared to shipping industry.

For the construction of floating facility, two options can be considered. One approach is the conversion of an existing vessel. With the condition of the vessel and accepted by the Classification Society, the selected tanker is converted to become floating storage and offloading facility. Such equipments are installed to suite for the facility to receive oil and gas from designated well via subsea pipeline. Figure 1 showing one of the example FPSO Kikeh that converts from existing sailing vessel to floating storage and offloading facility. Other approach is new building or purposely built the floating facility. The concept is same with the converted vessel. Both facilities are expected to remain on location for up to 20 years with the all environmental conditions are taking into consideration. Some of the facility is designed to suite the process of the hydrocarbon which located on top of the vessel. The floating facilities are designed to avoid any dry docking as practise from conventional sailing vessel. This poses new challenges as repair in situ can become very difficult plus equipment failure may have adverse consequences for vessel safety (Wilne, 1998).



Fig. 1: FPSO Kikeh anchoring picture.

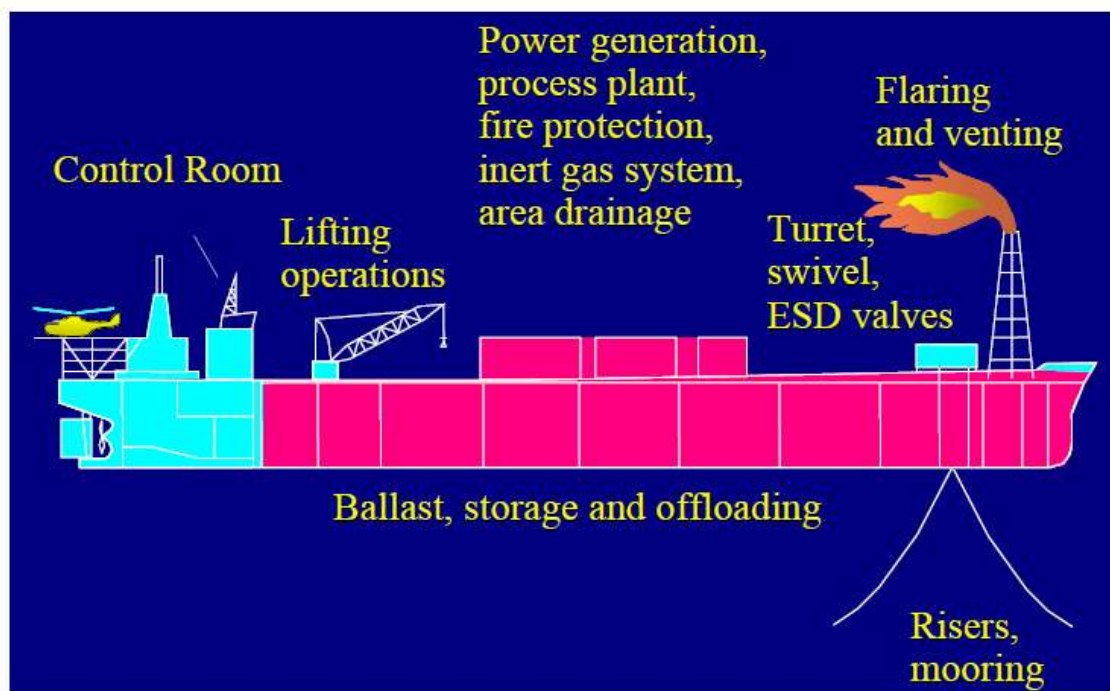


Fig. 2: FPSO compartmentalizing of the ship.

It's important to know the basic arrangement of the facility to understand more on the operations that currently occur before studying the potential hazards surrounding the area. The facility is divided to several compartment and equipment such as process, storage, mooring system, utilities and offloading equipment. Figure 2 showing the example of FPSO compartmentalizing of the ship. The basic arrangements of facility can be divided to the following areas:

1.0 Process area:

The process plant is usually placed on the frame structure elevated at a height of about 3.5 metres above the main deck. Equipment modules most sensitive to motions are likely to be placed towards midships. The modules are assembled in such a way to allow easy implementation and also fulfil the production requirements of the field.

2.0 Hull:

2.1 Tank arrangement:

2.1.1 Storage tanks:

Several tanks are dedicated to store the processing crude depend on the ship design capacity. Each of the tanks is equipped with heating coil system to heat up the crude to maintain the viscosity of storage crude.

2.1.2 Slop tanks:

The existing slop tanks are maintained to collect oily water from open drains, deck drains, stripping water from cargo tanks and piping and etc. Initially, the oily water accumulated in slop tanks where oil will be separated from water. Water in slop tank is discharged overboard via Oily Discharge Monitoring Equipment (ODME) system to ensure contain less than 40 ppm of oil content according to MARPOL Regulation.

2.1.3 Ballast tanks:

The tanks will be filled up by sea water during ship is empty and will be discharged out when storage tanks are full. The purposes of these tanks are to avoid any bending moment & stress to ship hull also to maintain the stability of the floating vessel.

2.1.4 Fuel oil tank:

The tanks are dedicated for Marine Gas Oil (MGO) normally remains at the same place during conversion. The location normally at aft wing tank and double bottom tanks in engine room area.

2.1.5 Fresh water tank:

The fresh water tanks located at aft side are designed to cater for total number of personnel onboard and boilers usage.

2.1.6 Lubricating oil tank:

The lubricating oil tanks are designed for the equipment and separate from each others. These tanks normally remain during the conversion stage.

3.0 Upper deck:

3.1 Mooring system:

The vessel is permanently moored in position to its field. Majority of the vessel in Malaysian waters are using External Bow Turret System with Single Point Mooring and is connected to the seabed by mooring lines attached to anchor piles or drag anchors. This design will tolerate the vessel to rotate 360⁰ depend to sea current condition. And some of the vessel also install with Spread Mooring System to fix the position permanently. Each of the system is designed to withstand to 100 years environmental condition.

3.2 Shuttle tanker mooring system:

The shuttle tanker is moored to floating vessel by tandem mooring system during offloading. The facility is able to moor above 150,000 DWT shuttle tanker with offtake parcel more than 100,00 bbls. The main components of this system are hawser and Quick Release Hook (QRH). QRH which commonly located at centre line of aft upper deck is provided with hydraulic operating system to ensure hawser is released under maximum load condition under monitoring system. The QRH is remotely controlled from CCR as well as local control.

3.3 Deck crane:

The deck crane which is located at upper deck, serves for supply/sector boat requirements, personnel transfer services and Meter Prover maintenance. The crane is diesel hydraulic driven, full revolving pedestal mounted type. The deck crane support structure is designed such that under deck reinforcements are as much as practically possible avoided.

3.4 Lay down area:

The lay down area is located strategically on upper deck area and can reach to maximum of boom crane. The area must be cleared off any piping and deck equipment. The bollards are relocated on upper deck and placed at strategic locations around the lay down area to facilitate maximum control on lifting and lowering of heavy items on the lay down area.

3.5 Custody metering system:

A custody metering skid installed on an elevated platform on upper deck for metering during offloading activity. The height of the metering skid is to comply with the statutory requirement. The custody metering skid is designed for a nominal offload capacity up to 20,000 bbls/hr.

4.0 Marine & Utilities system:

4.1 Ballast system:

The dedicated ballast pumps is designed for ballast and de-ballasts operation for ship stability and reduce the bending moment of ship hull during offloading to shuttle tanker.

4.2 Drainage system:

In normal tanker designed, two drain valves are fitted of the accommodation port and starboard side to drain into the slop for collection if accidental of oil spills. These valves are maintained to its position during the conversion of the facility as to comply to MARPOL regulations.

4.3 Sewage system:

The sewage unit is designed and installed to accommodate the total number of person onboard facility. The unit will comply with relevant MARPOL Annex IV Regulations.

4.4 Steam generation system:

Most of the facilities are equipped with the boiler. The unit is normally for power generation and heating purpose. Majority of the boiler is refurbished and converted to duel fuel firing (MGO and fuel gas). The fuel gas is taken directly from production platform via turret system.

4.5 Fuel system:

Marine Gas Oil (MGO) is utilized in the boilers, diesel generator, deck crane and emergency generator. The MGO tanks are designed to storage the fuel for all the necessary items with all safety aspect are taken into consideration. For the fuel gas line, the gas is taken direct from production platform via turret system to the equipment. The knock out pot system is install at upper deck to drain any condensation occur.

4.6 Lubricating oil system:

Each equipment having their own lubrication oil system depend on the equipment designed. The separate oil system is not mix to prevent any malfunction due to viscosity changes.

4.7 Fresh water system:

Every vessel is equipped with the equipment called Fresh Water Generator. The evaporation method is adapted to produce the distilled water. This water is suitable for boiler use and other washing usage. This water is not fit for personnel consume thus the fresh water is taken from shore via sector boat become necessarily.

4.8 Sea water system:

Sea water is the main cooling medium is drawn from sea chest through suction strainer. It supplies cooling water to the engine room equipments as well as on main deck. As the cooling water demand increases, the existing system is modified during conversion. Additional seawater pumps are installed to provide 100% redundancy and as a backup.

4.9 Inert gas (IG) and tank venting system:

The existing system is normally retained and is modified in accordance with SOLAS 74/2000 requirement and national regulations. The flue gas from exhaust boiler is directly through IG cooling system before entering cargo tanks.

4.10 Cargo system:

The cargo system comprises of crude oil and fuel gas from turret swivel system to production process and distributed to storage tanks. The offloading is carried out at the stern of the facility via floating flexible hose monitoring by a metering skid. This line is equipped with a double closure marine break away coupling to minimize accidental oil spills. Additional, it protects oil transfer system from tensile overloading when tanker drifting away shuttle and prevent surge pressure in case of incorrect valve control a shuttle tanker.

5.0 Power generation & distribution:**5.1 Main power generation:**

Main power supply on the facility is generated by either gas turbine or steam turbine generators depend on the design capacity. The generators having suitable for parallel operation which allows load sharing of different diver and rating. Emergency diesel generator is installed will initiated automatically soon after blackout.

5.2 Emergency power generation:

The emergency power source is modified/scales up to utilize for emergency lighting as well as for emergency consumers

5.3 Main power distribution system:

The Main Switch Board (MSB) is located in engine room together with all the switch gear and motor starter breaker.

5.4 Emergency power distribution system:

A 440V AC, 3 phases and 60Hz electrical emergency distribution system is located in the emergency generator room. The system comprise of the vessel Emergency Switch Board (ESB) which modified as required.

5.5 Lighting and small power distribution:

The AC lighting distribution system is expanded to accommodate all the lighting and small power required throughout the facility. High pressure sodium type lighting is used for elevated flood lighting. At indoor areas, fluorescent tubes are utilized for custody metering skid, walkways and accommodation areas.

5.6 Un-interruptible power supply system (UPS):

The main UPS system consists of an independent system to supply complete load. It is provided for supplying critical systems as follows:

- Metering monitoring
- Offloading monitoring
- Fire and gas system
- ESD system
- Boiler control
- Communication system
- Lighting
- CCR work station

5.7 Navigation aids:

The navigational aids battery is rated to an appropriate operating hours. The charger/rectifier is integrated in the navigational aids central control panel. At least one navigation lantern is installed and the marking of the facility is done according to International Association of Lighthouse Authorities (IALA).

6.0 Safety system:

6.1 Escape and evacuation system:

The muster areas are designated at strategic places with adequately posted for the personnel evacuation during emergency. The escape routes are provided with proper illumination and signage on every level leading to the muster areas.

6.2 Active fire protection system:

The purpose of active fire protection systems onboard floating facilities are to:

- Control fires and limit escalation.
- Reduce the effects of a fire to allow personnel to undertake emergency response activities or to escape and evacuate if necessary.
- Extinguish the fire where it is considered safe to do so.
- Limit the damage to structure and equipment.

The normal active fire protection systems provided onboard floating facilities are as follows:

- Fire deluge and water curtain system
- Engine room fire extinguisher system
- Main deck foam system
- Helideck fire protection system
- Galley fire extinguisher system

6.3 Passive fire protection system:

For normal operation and design, the floating facilities are equipped with passive fire protection to control and mitigate the hazard. The passive fire protection systems provided onboard floating facilities are as follow:

- A60 fire insulation wall at control room, fire control station and accommodation.
- A0 fire insulation wall at deck plate and deck head.

6.4 Fire and Gas detection:

The Fire and Gas (F&G) system is designed and installed to provided detection of fire or a leak of flammable vapour onboard the floating storage facility, in a rapid and reliable way.

The F&G system function as below:

- Provide early and reliable detection of the presence of fire or flammable vapours.
- Alert the personnel.
- Initiate protective action.

The F&G system will receive input signals from end devices such as flame detectors, heat detectors, smoke detectors, gas detectors and manual fire alarm call points. These will protect personnel and equipment by providing automatic equipment shutdown and activation of fire suppression equipment.

6.5 Life saving appliances:

Life saving equipments for personnel evacuation and rescue are distributed strategically around the floating facility. Life saving appliances is designed in compliance with SOLAS requirements and Flag Administration.

The totally enclosed self-propelled survival crafts lifeboats, with 100% capacity for persons onboard are installed in suitable type davits at ideal location on port and starboard side of boat deck.

In addition, the other life saving system, the life rafts are installed and located at port side, starboard side and main deck with 100% capacity for persons onboard if lifeboats are fail to engage. The life buoys with flame proof illumination are located at the various and strategic place for man overboard.

7.0 Communication system:

Radio and communication onboard facilities are considered critical since it's operating far away from onshore facilities that provide various communication systems in case of emergency. All of the communication systems and radio system are located at Radio Room that operate by Radio Operator.

7.1 Communication panel:

The communications panel in the communications room will comprise the following:

- Telephone (Inmarsat ID)
- Public Alarm and General Alarm (PAGA) control panel
- Non Directional Beacon System (NBD)
- Very High Frequency (VHF) Translator
- Satellite Phone
- Local Area Network (LAN)
- Very Small Aperture Terminal System (VSAT)
- Navigation Aids and Helicopter Lights

7.2 Radio System:

Radio system provided comprises of:

- Very High Frequency – FM Marine Radio System
- Very High Frequency – AM Aeronautical Radio System
- Private Automatic Branch Exchange System (PABX) and Telephone System
- Satellite phone
- Ultra High Frequency (UHF) Radio system
- WIMAX Radio system

7.3 Control and monitoring system:

The basic monitoring systems provided for the facilities are as follow:

- Cargo Control Room (CCR) to control loading/offloading operation
- Engine Control Room (ECR) to control all machinery in the engine room
- Boiler Management System (BMS) for boiler control operation
- Local controls to control equipment instrumentation
- Emergency Shutdown System (ESD)

8.0 Manpower philosophy & responsibility:

Each facility having difference numbers of manpower depend on the respective duties and responsibilities. This mainly consists of the regular crew for operation and maintenance as well as contractor for various activities onboard.

Literature Review:

The floating storage structure has been used widely and reliably throughout the oil industry for many years. The floating storage facility was primarily installed as for storage and offloading activity. Nowadays, with the modern technology, the facility becomes offshore producing installation, storage facility and offloading terminal all rolled into one unit. Moan *et al.* (2002) describe that the floating storage and production unit is a vessel that receives oil and gas from subsea wells through flow lines known as risers. The vessels can purpose-built ship or semi-submersible, or a converted tanker. This facility is commonly known as floating, production, storage and offloading (FPSO). The vessel without production system is known as floating, storage and offloading (FSO). Moan *et al.* (2002) explain that the vessel should perform five functions:

- Process oil and gas through the production processing facilities;
- Receive oil and gas through the riser system;
- Discharge oil, gas and water through the riser and/or offloading system;
- Store oil onboard the vessel, using tanks, piping and inert gas system;
- Remain on position by means of a mooring system or station-keeping system.

The major hazard to the offshore oil and gas facility is not much different to another as describe in lesson learn of the offshore accidents. They are clearly categorized as: loss of well control or blowout, fire from the process plant, explosion from the process plant, H₂S and naturally occurring radioactive materials from reservoir, extreme weather, ship collision, seismic events and helicopter or other aircraft impact (Galbraith & Terry, 2008). For the past few years the major accidents happen involving multiples fatalities, equipment

damage and environment impact that will require high cost to overcome the situation. The lesson learned is part of the process to identify the hazards and mitigate to a minimum as possible. This happened to 'Alexander L Kjelland – structure failure during adverse weather condition', 'Ocean Ranger – capsized due to ballasting', 'Piper Alpha – pipeline failure' and 'Super Puma crash at Cormorant' as described in *The Offshore Industry – Learning from Accidents* by Galbraith & Terry (2008).

Hazard identification is a formal activity to examine all aspects of the operation under consideration using a pro-forma approach. It depends on the quality of the input data available and is typically performed as a table-top exercise led by an experienced facilitator and the participation by representatives covering the full range of design and operational expertise for the system under consideration (Spires, 2001). As pointed out by Spires (2001), the hazard identification has considered a total of 11 different hazard categories that will be present during the production phase of development. The hazards considered were categorized as listed below:

- i. Blowout
- ii. Riser and pipeline leaks
- iii. Process leak
- iv. Non-process fire and explosions
- v. Cargo storage events
- vi. Marine accidents on the FPSO
- vii. Offloading accidents
- viii. Tanker transportation
- ix. Non-process spill
- x. Ship collision
- xi. Transportation (supply vessel and helicopters)

Vinnem (2000) explained from the operational safety of FPSOs: initial summary report; although the facilities are becoming more common, operational safety performance may still be considered somewhat unproven, especially when compared to fixed installations. Furthermore, floating installations are more dependent on continued operation of some of the marine control systems, during a critical situation. There is accordingly a need to understand the aspects of operational safety for the facilities, in order to enable a proactive approach to safety, particularly in the following areas:

- Turret operations and flexible risers
- Simultaneous marine and production activities
- Vessel movement/weather exposure
- Production, ballasting and offloading

The floating facility has the ability to handle changes of oil reservoir and process as well as offering storage and offloading facilities. With this significant and comprehensive of the system will easily contribute the potential hazard or risk that difficult to quantify due to short of experience if compared to shipping industry. The hazard is defined as a situation with a potential source of harm that causing human injury, damage to the environment, damage to property or any combination of such event (BS EN ISO 17776:2002). It may be a physical situation (e.g. a shuttle tanker is a hazard because it may collide with the production installation), an activity (e.g. crane operations are a hazard because the load might drop) or a material (e.g. fuel oil is a hazard because it might catch fire). The essence of a hazard is that it has a potential for causing harm, regardless of how likely or unlikely such occurrence might be.

Although crude handling of the facility is similar in many aspects to crude oil handling tanker, the facility is continuously loading the product whilst carrying out the other operations as well. Concurrent operations and the sequence of these operations can differ greatly from conventional tankers and result in the greatest risks to be managed through procedures and system design. As described by Vinnem (2000) that there are some differences with respect to how the contributions of hazards are categorized. But, there are nevertheless some clear observations that the hydrocarbon associated risk from process, turret and riser are the highest contribution for all floating storage facility considered. Khan *et al* (2004) also mentioned that the source of major hazard in offshore processing are the inventories of flammable materials in the risers, associated pipelines of the reservoir, slug catchers, separators, heat exchanger and high speed rotating equipment such as turbines, compressors, export pumps and reinjection pumps. Therefore, these items should be the main targets for inherently safer approaches.

In the records of history there have been a number of catastrophic accidents on offshore facility and causes of such accidents have become lessons to operators and this has shed more light on the subject matter. While such accidents are undesirable and should be avoided at all costs, the world has benefited in no small measure from these experiences (Omogoroye & Oke, 2007).

Methodology:

Biasotto & Rouhan (2004) explained that each hazard identified is analysed in terms of its functional failure, failure mode, consequences (including the possible different scenarios), existing barriers, control

methods and repair strategies. The identified hazards are qualitatively classified on the basis of the likelihood and the related consequences regarding risks to personnel, to environment and to asset and production (Biasotto & Rouhan, 2004). For this research study, all the data collected is used for academic purpose only. It also analyzes all the information from demographic of the facility that currently operates in Malaysia. The list of potential hazard is taken during reviewing of the literature from journals, conference proceedings, databases and guidelines related to offshore operation safety. The quantitative method will be used to collect all the data for this study. This will known as survey data. Several questionnaires are finalize and sent out to respective floating storage to gather all required data and information. The actual data from the number of incident or accident for the past few years are collected as a reference and guidance for this study.

This research study emphasizes on floating storage facility that currently been operated in Malaysian waters. Basically there are 4 field owners which operate the floating facilities. They are Petronas, Murphy Oil, Talisman & Petrofac. Base on these, 4 facilities are selected which represent the field owner and their facility in Malaysia. These facilities demonstrate the level of potential hazards, significant differences between the demographic of facility towards the potential hazards and the relationship between potential hazards with safety impact.

This study describes the potential hazards from normal activities that should be considered at the floating storage facility in order to achieve an overall safe and reliable design to personnel, asset & environment. The conceptual diagram is developed and shown in figure 3 to show the entire demographic of floating facility, potential hazard and safety impact that were covered in this study. The potential hazards cover to 4 main sections such as hydrocarbon release, ship collision, hull failure and occupational accidents. From the potential hazard, the study shows ongoing towards the relationship of safety impact from multiple injury/fatalities, structure damage and oil pollution. This will show the impact of potential hazards towards the personnel, equipment asset and environment. The significant differences focus on Malaysian floating storage facility that covers all the year built and converted, manpower, storage capacity and the mooring system.

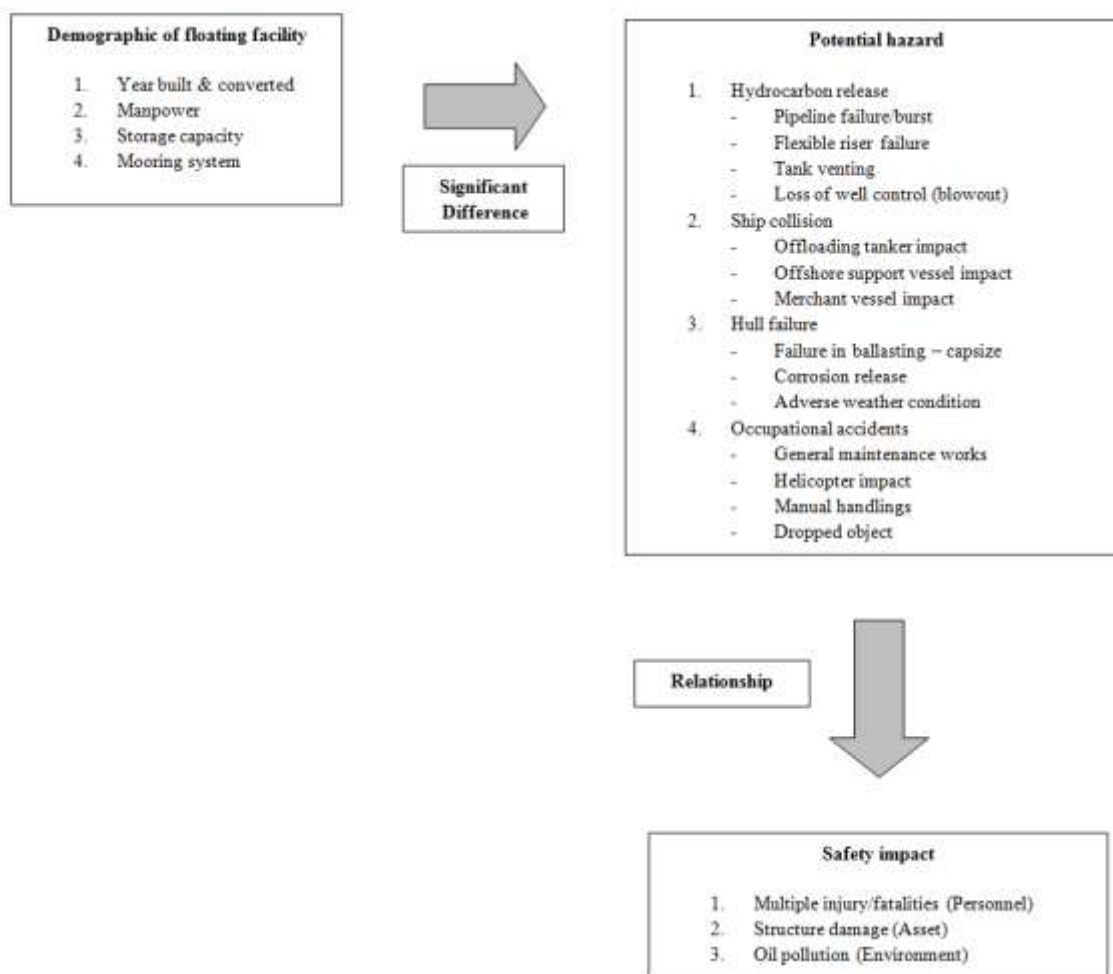


Fig. 3: The conceptual diagram of relationship between potential hazards towards safety impact at Malaysian floating storage facility.

This research study applies the risk assessment approaches. Risk assessment is a step in a risk management procedure. It's a process of gathering data and synthesizing information to develop an understanding of the risk of a particular activity. The main purpose of risk assessment is to identify and rank the risks so that they can be adequately managed.

The use of risk assessment techniques in major hazard industries has grown significantly in recent years. This is particularly true in the offshore industry in the UK where many aspects are subject to full risk assessment (DNV, 2001).

The method of risk matrix is used to measure the level of potential hazard whether is 'low', 'medium' or 'high'. A risk matrix is a convenient method of ranking and presenting the result. Risk matrix provide a traceable framework for explicit consideration of the frequency (also known as likelihood or probability) and consequence (or severity) of hazards (DNV, 2001). Risk matrix is defined to measure health, safety, environmental and financial impacts from floating storage facility. The end point matrix selected is: fatalities, oil spill, capital loss and business interruption (Wolford *et al.*, 2001).

Table 1: ISO 17776 Risk Matrix (DNV, 2001).

Consequences				Increasing Likelihood/Probability				
				1	2	3	4	5
Severity	People	Assets	Environment	Never heard of incident in offshore industry	Heard of incident in offshore industry	Incident has occurred in M'sia Floating Facility	Incident happens several times in M'sia Floating Facility	Incident happens once/ several times at your location
0	No Injury	No Damage	No Effect	RR=0	RR=0	RR=0	RR=0	RR=0
1	First Aid Injury	Slight damage to equipment	No significant environmental impact.	RR=1	RR=2	RR=2	RR=2	RR=3
2	Medical Treatment / Restricted Work case	Limited damage to essential equipment	Short term environmental impact.	RR=2	RR=2	RR=3	RR=3	RR=4
3	Temporary/permanent partial disability	Significant damage to equipment	Localised pollution giving rise significant impact.	RR=2	RR=3	RR=3	RR=4	RR=4
4	Single Fatality, Injury resulting in & severe disability	Damage extending to several equipment	Uncontrolled release & significant environmental impact. Recovery requires external assistance	RR=2	RR=3	RR=4	RR=4	RR=5
5	Multiple Fatalities/ Multiple serious Injuries	Extensive damage or loss of facility	Massive & uncontrolled release with chronic pollution to environment	RR=3	RR=4	RR=4	RR=5	RR=5

RR= Risk Rating

LOW= 0-2

MEDIUM=3-4

HIGH=5

Table 1 showing the table of risk matrix as a tool that is applied in this study. The potential hazard measures base on the frequency of each facility ranging from '1= Never heard of incident in offshore industry', '2= Heard of incident in offshore industry', '3= Incident has occurred in Malaysia Floating Facility', '4= Incident happens several times in M'sia Floating Facility' and '5 = Incident happens once or several times at location'. The cross reference will focus on the consequences of the people, asset and environment. The severity criteria ranging from '0=no severity', '1=slight', '2=minor', '3=moderate', '4=major' and '5=catastrophic'. The cross reference of the consequences and the frequency will show the risk rating that represent 'low', 'medium' and 'high' of each of potential hazard.

The questionnaire survey data also is analysed through statistical method of analysis using SPSS. The tools from ANOVA One Way & T-Test are used to analyze further the significant differences of demographic facility

towards potential hazards. Tools from Pearson Correlation is used to analyze the data for the relationship of the potential hazard towards safety impact of the facility.

Research questions are the process of gathering data and synthesizing information to develop an understanding of overall study which consists of the following elements:

1. What is the level of hydrocarbon release, ship collision, hull failure and occupational accidents at the floating storage facility?
2. What are the significant differences between the elements of demographic facility towards the element of potential hazards?
3. Is there any relationship between potential hazards and the safety impact of the facility?

Discussion:

The floating storage facility present many of the same hazards to personnel and environment, although the inclusion of production facilities on the facility increases the risk associated with many marine incident. There are many different types of floating storage facility including, for example, weather-vane designs with internal or external turrets, or spread moored designs that maintain a fixed position and orientation. The facility allows oil companies to produce oil in more remotes areas in deeper water than would have been economically possible with other technology. The facility allows storage of crude oil and offloading of tankers in the field rather than requiring a pipeline to transport oil to onshore terminal facility. The provision of storage and offloading has introduced additional hazards; however, require the wisdom and experience to manage the associated risks.

In associated to hazard or risk that contributed at the facility, the main aim of this research is to focus on the following objectives:

1. To measure the level of potential hazard that consists element of hydrocarbon release, ship collision, hull failure and occupational accidents at floating storage facility.
2. To study the significant differences between the element of demographic floating facility towards element of potential hazard.
3. To investigate the relationship between potential hazard towards the safety impact of the facility.

Conclusion:

The floating storage facility in generally is the combination of offshore traditional process technology and marine technology. Thus it is quite dependable on overall operational safety control. It is essential that scenarios involving potential hazards are assessed at an early stage in the design of new facilities, in order to optimise technical and operational solutions. This study establishes the research survey data of potential hazards for floating storage facility, together with hazards level, significant differences from demographic facility towards potential hazards and the relationship between potential hazards towards safety impact. The measurement of hazards level can be categorized as low, medium and high by using Risk Matrix from Risk Assessment approach.

This study describes the potential hazards mainly from marine activities that should be considered at the floating storage facility operated in Malaysia. This forms better understanding on the level of potential hazard onboard the floating storage facility and also the impact from the potential hazard to the personnel, asset & environment. The findings from the collected experience-based and research survey data facilitate the development of rationalized approaches for the top management in decision-making for the safety guideline, policy making and investment towards the floating storage facility.

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