THE RELATIONSHIP OF POTENTIAL HAZARDS TOWARDS SAFETY IMPACT AT MALAYSIAN FLOATING STORAGE FACILITY

SALEHUDDIN BIN MD FADZIL

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DEDICATION

To my lovely wife, my kids, my father and mother, relatives, friends....

I also want to dedicate it to my Supervisor....

To everyone who I know, and all people I will know them in future....

For their genuine pride. To all these loving people, this thesis is dedicated.

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All praise is to ALLAH, the most exalted the most high to which we all depend for sustenance and cherishment.

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ABSTRACT

Floating storage facility is increasingly becoming the preferred solution for new installation in offshore industry. The facility has the 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 will easily contribute to the potential hazard or risk that is difficult to quantify due to short of experience, if compared to shipping industry. This thesis gives an overview of the potential hazards during normal activity and the safety impact to personnel, asset and environment. The list of potential hazard is generated and compiled during reviewing of the literature from journals, conference proceedings, databases and guidelines related to offshore operation safety. The research study followed Risk Assessment approach by using Risk Matrix as a tool to measure the level of potential hazard. Survey data also analyzed through statistical method of analysis using SPSS. The tools from ANOVA One Way and T-Test were used to analyze further the significant differences of demographic facility towards potential hazards. Tool from Pearson Correlation is used to analyze the data for the relationship of the potential hazard towards safety impact of the facility. The research study described the potential hazards mainly from marine activities that should be considered at the floating storage facility operated in Malaysia. The findings reported that the age of facility has significant difference for ship collision, from the perspective of facility's demographic. The result also shows mooring system having significant difference for hull failure since the statistical finding is significant. For the level of hazard, it shows that on the first ranking is hydrocarbon release followed by occupational accident, ship collision and hull failure. The result shows positive, significant and yet low extent for the relationship of potential hazards towards safety impact of the facility. The findings from the collected experience-based and research survey data can be applied to 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.

ABSTRAK

Fasiliti penyimpanan terapung sedang berkembang pesat menjadi penyelesaian kepada pemasangan yang baharu dalam industri luar pesisir pantai. Fasiliti ini berkemampuan mengendalikan perubahan kepada takungan minyak dan proses disamping menawarkan penyimpanan dan pemindahan pada masa yang sama. Dengan terus kepada pembinaan dan penukaran berdasarkan teknologi pembinaan kapal, sistem tersebut dengan mudah terdedah kepada potensi bahaya atau risiko yang sukar diklasifikasikan kerana pengalaman yang singkat jika dibandingkan dengan industri perkapalan.Tesis ini akan memberikan pandangan terhadap potensi bahaya semasa aktiviti biasa dan impak keselamatan terhadap pekerja, aset dan persekitaran. Senarai potensi bahaya ini dihasil dan disusunkan semasa semakan terhadap karya dari jurnal, pembentangan persidangan, pangkalan data dan garispanduan yang berkenaan kepada operasi di luar persisir pantai. Kajian penyelidikan ini telah menggunapakai pendekatan dari Penilaian Risiko yang menggunakan Risiko Matriks sebagai alatan untuk mengukur paras potensi bahaya. Data penyelidikan ini dianalisis melalui penggunaan statistic daripada analisis SPSS. Peralatan analisis tersebut adalah ANOVA One Way dan T-Test yang digunapakai untuk menganalisis seterusnya perbezaan yang signifikan dari fasiliti tersebut terhadap potensi bahaya. Korelasi Pearson pula menganalisis data untuk perhubungan potensi bahaya terhadap impak keselamatan di fasiliti tersebut. Kajian tersebut menerangkan potensi bahaya daripada aktiviti marin yang diambil kira di fasiliti penyimpanan terapung yang beroperasi di Malaysia. Hasil kajian melapurkan umur fasiliti mempunyai perbezaan signifikan terhadap pelanggaran kapal dari segi perspektif fasiliti. Keputusan juga menunjukkan sistem tambatan mempunyai perbezaan yang signifikan kepada kerosakan badan kapal di mana statistik menunjukkan ia adalah signifikan. Paras potensi bahaya yang menunjukkan tahap pertama adalah perlepasan hidrokarbon dan diikuti oleh kemalangan pekerjaan, pelanggaran kapal dan kerosakan badan kapal. Hasil dapatan korelasi adalah positif, signifikan, namun pada tahap rendah terhadap perhubungan potensi bahaya terhadap impak keselamatan fasiliti. Keputusan daripada pengumpulan data, pengalaman dan kajian penyelidikan akan menentu ukuran terhadap

perkembangan pendekatan yang rasional untuk pihak atasan mengaplikasikannya dalam membuat keputusan bagi garis panduan keselamatan, pembentukan polisi dan pelaburan terhadap fasiliti penyimpanan terapung.

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LIST OF SYMBOL and ABBREVIATIONS

ABS	-	American Bureau of Shipping (classification society)
BV	-	Bureau Veritas (classification society)
BOP	-	Blowout Preventer
BS	-	British Standard
Bbls	-	Barrels
DNV	-	Det Norsk Veritas (classification society)
FVSB	-	FPSO Ventures Sdn Bhd
FandG	-	Fire and Gas
FPSO	-	Floating Production Storage and Offloading
FSO	-	Floating Storage and Offloading
HSE	-	Health Safety and Environment
IG	-	Inert Gas
ISO	-	International Standard Organization
MARPOL	-	Marine Pollution
MISC	-	Malaysian International Shipping Corporation
MT	-	Metric Tonne
OGP	-	Oil and Gas Producer
OSV	-	Offshore Support Vessel
PMO	-	Peninsular Malaysian Operation
QRH	-	Quick Release Hook
SOLAS	-	Safety of Life at Sea
SWL	-	Safe Working Load
SPSS	-	Statistical Product and Services Solutions

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CHAPTER 1

INTRODUCTION

1.1 Overview

Offshore floating storage facility presents 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.

Much of the oil and 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 which separate the 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. 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.

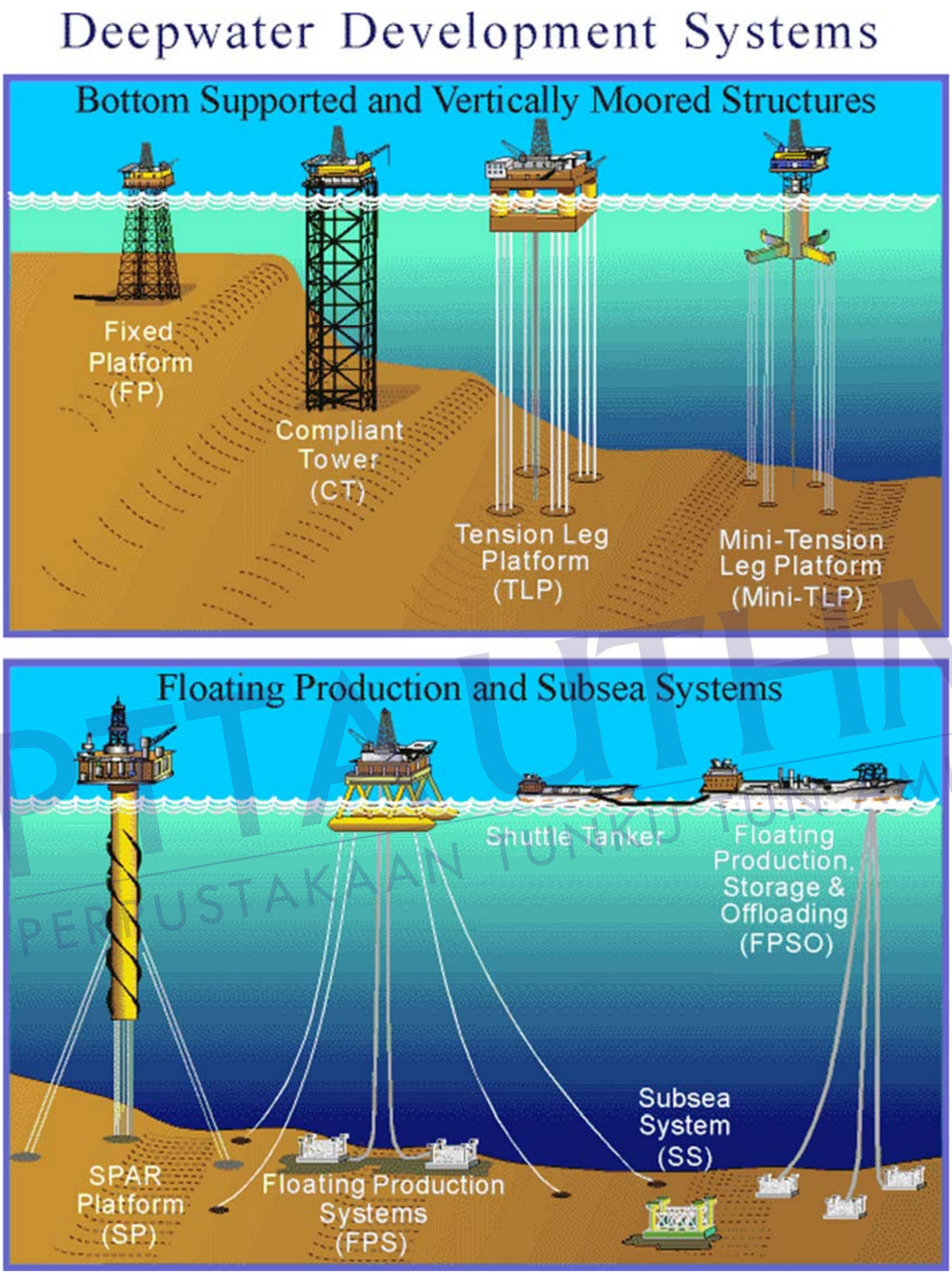

Figure 1.0: Deepwater development system (Wikipedia)

As shown by Figure 1.0, the offshore facilities can be divided into several types along with their respective functions:

i. **Fixed Platform (FP)** consists of a jacket (a tall vertical section made of tubular steel members supported by piles driven into the seabed) with a deck placed on top, providing space for crew quarters, a drilling rig, and production facilities. The fixed platform is economically feasible for installation in water depths up to 1,500 feet.

ii. **Compliant Tower (CT)** consists of a narrow, flexible tower and a piled foundation that can support a conventional deck for drilling and production operations. Unlike the fixed platform, the compliant tower withstands large lateral forces by sustaining significant lateral deflections, and is usually used in water depths between 1,000 and 2,000 feet.

iii. **Tension Leg Platform (TLP)** consists of a floating structure held in place by vertical, tensioned tendons connected to the sea floor by pile-secured templates. Tensioned tendons provide for the use of a TLP in a broad water depth range with limited vertical motion. The larger TLP's have been successfully deployed in water depths approaching 4,000 feet.

iv. **Mini-Tension Leg Platform (Mini-TLP)** is a floating mini-tension leg platform of relatively low cost developed for production of smaller deepwater reserves which would be uneconomic to produce using more conventional deepwater production systems. It can also be used as a utility, satellite, or early production platform for larger deepwater discoveries. The world's first Mini-TLP was installed in the Gulf of Mexico in 1998.

v. **SPAR Platform (SPAR)** consists of a large diameter single vertical cylinder supporting a deck. It has a typical fixed platform topside (surface deck with drilling and production equipment), three types of risers (production, drilling, and export), and a hull which is moored using a taut caternary system of six to twenty lines anchored into the seafloor. SPAR's are presently used in water depths up to 3,000 feet, although existing technology can extend its use to water depths as great as 7,500 feet.

vi. **Floating Production System (FPS)** consists of a semi-submersible unit which is equipped with drilling and production equipment. It is anchored in place with wire rope and chain, or can be dynamically positioned using rotating thrusters. Production from subsea wells is transported to the surface deck through production risers designed to accommodate platform motion. The FPS can be used in a range of water depths from 600 to 7,500 feet.

vii. **Subsea System (SS)** ranges from single subsea wells producing to a nearby platform, FPS, or TLP to multiple wells producing through a manifold and pipeline system to a distant production facility. These systems are presently used in water depths greater than 5,000 feet.

viii. **Floating Production, Storage & Offloading System (FPSO)** consists of a large tanker type vessel moored to the seafloor. An FPSO is designed to process and stow production from nearby subsea wells and to periodically offload the stored oil to a smaller shuttle tanker. The shuttle tanker then transports the oil to an onshore facility for further processing. An FPSO may be suited for marginally economic fields located in remote deepwater areas where a pipeline infrastructure does not exist.

1.2 Floating Storage Facility

Floating storage facility nowadays are becoming the preferred solution for new installation of oil and gas fields as oil industry seeks better economic solutions to its new challenges. The facility is suited for both small marginal fields and large deep-water reserves (Wilne, 1998). The floating storage facility is the most commonly used as the floating facility due to cost reasons and practical advantages if compared to fixed installation. With the straight forward of building and conversion, based on the ship building technology, the expensive offshore works can be kept to 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 comprehensiveness of the system, it will easily contribute the potential hazard or risk that is difficult to quantify due to short of experience if compared to shipping industry.

Figure1.1: FPSO Kikeh anchoring picture

For the construction of floating facility, two options can be considered. First option 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 equipment is installed to suite for the facility to receive oil and gas from designated oil well via subsea pipeline. Figure 1.0 shows one of the examples, FPSO Kikeh which was converted from existing sailing vessel to floating storage and offloading facility. Another option for oil storage is by building a new purposely built floating facility. The concept of this huge oil storage is rather similar with the converted vessel. Both facilities are expected to remain on the designated location for up to 20 years with all the environmental conditions taken into consideration. Some of the facilities are designed to suite the process of keeping the hydrocarbon which is located on top of the vessel. The floating facilities are designed to avoid any dry docking as compared to the practice of conventional sailing vessel. This poses new challenges as on-site repairing can become very difficult and equipment failure may have adverse consequences for vessel safety (Wilne, 1998).

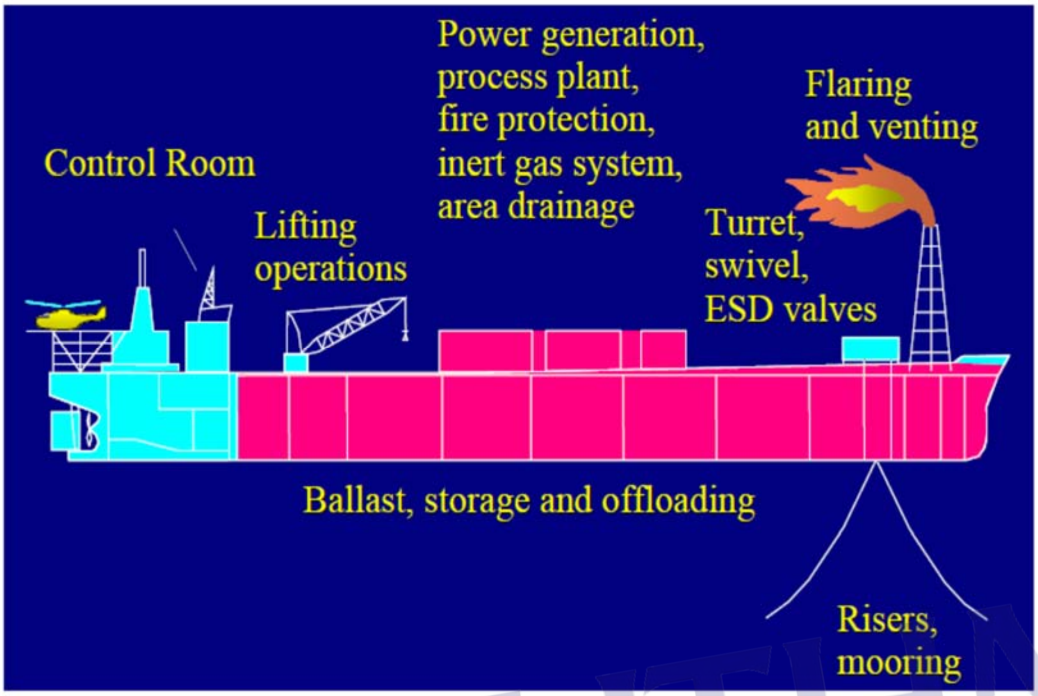

Figure 1.2 : FPSO compartmentalizing of the ship (Gilbert and Ward, 2001).

It is important to know the basic arrangement of the facility to understand further 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 1.1 shows the example of FPSO compartmentalizing of the ship, according to Gilbert and Ward (2001). The basic arrangements of facility can be divided to the following areas:

i. Process Area

The process plant is usually placed on the frame structure elevated at a height of about 3.5 meters 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 fulfill the production requirements of the field.

ii. Tank arrangement

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

iii. 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. This type of mooring is connected to the seabed by mooring lines which is attached to anchor piles or drag anchors. This design will tolerate the vessel to rotate 360^0 depending upon the sea current condition. And some of the vessels are also installed with Spread Mooring System to fix the position permanently. Each of the system is designed to withstand up to 100 years environmental condition.

iv. 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 100,000 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.

v. 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.

vi. Inert gas (IG) and tank venting system

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

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