WGP 107 (18)

Participants:

Eric Brault – AXA Corporate Solutions - Chairman
Martin Kauth - Partner Re
Alain Padet - AXA Corporate Solutions
Doug Scott - Charles Taylor Consultant
Mike McMahon - Charles Taylor Consultant
Eve Ong – Helvetia
Mark Mackay - AXA Corporate Solutions
Mohamed F. El-Ailah - Qatar General Ins
Javier Rodriguez Gomez - Reinsurance Consultancy Mexico
Roman Emelyanov - SOGAZ Insurance Group
Thomas Friedrich – Munich Re

Stephan Lämmle – Munich Re – Sponsor

Executive Summary

Writing this document, group members decided to issue a first overhaul view of the risks concerning the construction of offshore platforms. They deliberately did not focus on subjects such as covers for the drilling of wells, covers of the underground searches and methods for the discovery of new oilfields.

The operation of the platforms was also regarded as out of focus as were the topside processes for NG and oil, including different modules, such as pressurizing, storage separation etc.

The document which follows is a general overview of the different type of platforms, the inherent risks to anticipate and manage, the construction issues, weather condition impacts, consequences on claims, importance of the safety systems, the detailed MPL scenarios during the construction, putting in place of the platform and starting of operations. The MWS role and its importance is also detailed. Underwriting considerations with specific perils and wordings are proposed. The last chapter is focussed on the capacities, markets, and the tracking of accumulations. Example of losses which may occur during construction and starting operations as well as ramp up of production as the commissioning of the different units is undertaken.

At the end of document a list of sources with thanks is provided to be used by the reader to go further in detail. This being a wide, complex activity involving different techniques, diverse knowledge and always pushing the limits of the engineering firms. Complementary studies looking forward to new techniques including, wells and drilling systems and their specific challenges, and operations on long range and permanent exposures, will be necessary to have a comprehensive view.

Key words:
Fire, explosion, positioning, satellite, welding, modules, pipes, raw materials, seamless tubes, stainless steels, water resist, tightness, pressure, icing, lining, depth, environment, Tension Leg Platform, Spar Platform, Concrete Platform, Turret, Rig, Semi-submersible platform, Production and Drilling, Dynamic Positioning, Base camp platform, Servicing platform, Jackets, Jacket Leg Production Platform, Floating Production,, Storage and Offloading Vessel, Drill Ship, Floated/Field Support Semi-Submersible, Jacket Leg Wellhead Platform, Floating LNG with/without Regasification, Tender Rig Barge, Onshore Gas Separation Plant, Onshore Wellheads, MPL, blow out, valve tree, well, pool fire, leakage, terrorism, piracy.

Acknowledgments: We would like to acknowledge and thank all the people who worked on the document answering our questions and allowing participants to get a better view of the systems. Credit must also be given to all the literature existing on subject which can be read on the internet, and in paper documents (especially the historical perspective) and which shows the extent of progress of the industry in general has made, in particular engineering firms, engineers, controllers and others specialists, and for their commitment to upgrade levels of safety .

CONTENTS

I. Introduction

Offshore platforms present a wide and complex subject to analyse. The global offshore industry has always provided a testing environment for engineering firms which are always looking to push the limits of the design, raw materials, erection methods, security procedures, detection systems upgrades, range of the operation size of units, all this in an extreme challenging environment. The sea conditions at the platform locations condition the design, the water depths, then the potential thousands of meters bored under the sea bottom provide a daily peril for the men working above.

The development of a field is not the simple construction of the different units, which allow a field to start operations, it involves years of digging of wells with special equipment, closing them with caps, layering of pipes, and other works on processes which are done onshore. During the construction of the platforms, due to the size of investment and the possible uncertainty of when production becomes profitable, platforms can be partially sold to owners, leading to a complexity of following up of accumulation for insurance companies.

We have focused primarily on the technologies of the platforms, concentrating on their main role and function. We have not studied in detail the processes of oil and NG field industry which in our view would require more research and a separate specific working group paper. Due to the size of the topic, our paper is dedicated to general matters and key issues such as the MWS role, the MPL scenario during the construction and platforms connections. The drilling units are not studied here for their inherent risks, the pure operational risk at full capacity of the field and dismantling are also for the same reasons excluded. All these subject due to the specific nature of the risk could be developed in dedicated future working groups.

II. Technologies

A. General matters with limits and extend of concerned technologies

In the early 1930s, the first platform was developed in the Gulf of Mexico on the Texas coast, at a very shallow water depth. It then served as a wellhead, in the extension of the facilities lying on the ground. After the first oil shock in 1973, European governments decided to develop the exploitation of oil and gas fields in the North Sea. The UK and Norway were then developing offshore drilling and production techniques and building the first oil rigs in this particularly hostile sea. For the first time, these platforms needed to house men to ensure the exploitation of deposits. Safety standards related to the manufacture and installation of oil rigs were put in place in the 1970s and 1980s following accidents.

2.1. Definition of the platforms

An oil platform is a unit for extracting, producing or storing oil and / or gas located in seas at sometimes very large depths.

The average lifespan of a platform is approximately the same as that of an offshore oil field which is about thirty years. According to national and international legislation, oil companies have the obligation to dismantle oil platforms when they are no longer used. Hundreds of people can work on a platform. During periods of high activity, up to 300 people can live together. A good organization of this micro society and strict security rules are therefore essential to the smooth running of offshore life. It mainly supports the devices needed for the drilling or oil extraction phase. It may also include equipment to provide accommodation for operating personnel. Some platforms make it possible to transform the extracted oil to make it easier to transport. Fixed platforms are used in the shallow sea, to exploit deposits located within 300 m, while floating platforms are used mainly for the exploitation of oil fields in the deep sea.

2.2. Type of platforms

There are 3 types of platforms:

- **MODUs (Module Offshore Drilling Units)** used only for drilling and able to house personnel;
- **Production Platforms (PPs)** for the production and / or pre-processing of crude oil, but without housing;
- **Living Quarters (LQ)** used only for housing, and any storage / transit of hydrocarbons is prohibited for security reasons.

The construction of a platform begins when reconnaissance drilling confirms the presence of a deposit of oil and / or gas and when economic studies are favourable.

The assembly is made on land; the structure is then transported on giant barges to the site. The design of the supporting structure must take into account specific constraints related to the marine environment (tides, storms, swells, currents, wind), the corrosion related to this environment and the seismic risk.

Thousands of tons of materials are needed, for example, 245,000 cubic meters of concrete and 100,000 tons of passive steel were needed to build the "Troll A" platform in Norway (the largest platform man ever has moved). The construction of a platform requires 2 to 3 years of work for thousands of workers.

An oil platform consists of two parts:

- "**Topsides**": made up of prefabricated modules, they correspond to the process, accommodation and other parts above the surface. Each module consists of its own complete operation systems which interlock with the other modules. Modules are assembled together mainly on land and partially in sea depending on the offshore lifting capability.
- The "**Supporting Structure**": usually a steel tubular structure called a jacket (an assembly of metal tubes forming a triangulation),but may compose concrete columns or in the form of a floating barge in the case of an FPSO (Floating Production Storage and Offloading).The role of this structure, is to maintain the 'useful' part above the water. This structure is usually assembled on land.

The topside includes a processing unit which separates and processes harvested components (oil, gas, water) before they are transported by pipeline or tanker to a refinery.

The **Derrick** is the culmination of a rig. This metal tower, in the drilling phase, supports a very long rod at the end of which is a drill bit. This rod is lengthened as the bit crushes the different rock layers of the subsoil to reach the oil deposit.

The rods can dig to depths of 3 to 4 kilometres to reach the reserves just a few meters thick. The accuracy of the impact is therefore exceptional. The derricks are moveable and when it is necessary to dig another well to recover or inject fluids, the derrick is moved and new drilling is undertaken.
Modern techniques allow for horizontal drilling, using a rotary drill head to gradually tilt the curve operated by the rod. This type of drilling makes it possible to exploit areas of several square kilometres from the platform without having to move platform or derrick.

Beyond 300 m water depth, it is generally considered to date the exploitation is not financially viable with fixed platforms but with floating installations.

See below different types of platforms

Fixed platforms:

Most fixed platforms are used in shallow waters (<300 m). These platforms are bottom-based and can therefore be rigidly connected to wellheads and pipelines.

- Jacket deck: steel structure consisting of tubular frames and fixed to the ground by steel piles.
- Gravity platform: a concrete tower whose stability is due solely to its own weight on the ocean floor and on which the superstructures are erected.
- Compliant tower: a flexible structure consisting of a floating bridge anchored to the ocean floor by means of long pipes that are constantly stretched.
- Jack-up rig: self-elevating platforms consisting of a hull and legs, designed for shallow water operations. The structure can be moved but also raised or lowered. Thus these platforms can be deployed in multiple places while having a support on the ground.

Jack up structure
Topside element

Mobile platforms and floating units:

Floating platforms are mainly used for the exploitation of oil fields in the deep sea (more than 300 meters approximately). When the platform is floating, the wellhead facilities are connected to it by flexible pipes.

- TLP (Tension Leg Platforms): platforms with excessive buoyancy and held in place by stretched cables connecting them to the bottom.
- SPAR: more conventional platforms that only include production and are connected to pipelines for the export of gas and / or oil produced. The SPARs are based on a huge cylindrical float.
- Semi-submersible platforms: platforms ballasted by filling water when in position, then anchored. This makes them less vulnerable to swells.
- Floating Production Storage and Offloading (FPSO): Hull platforms, which produce oil, temporarily store it and load oil tankers. They are anchored to the bottom of the sea.

The challenges are adapting the platform to the offshore environment and conditions.

Shipbuilding engineering faces many obstacles (physical space limitations, extreme weather conditions, deep water, remote sites, etc.) while respecting the safety of personnel and the environment. These constraints make the platforms technical objects of very high sophistication. Maintenance and operation in a secure environment requires access to reliable and accurate data.

Major players in the construction and operation of platforms are, the large international on shore Petrochemical companies bringing together for the design, specialist groups, particularly from the offshore oil and gas industry.

In order to exploit the offshore deposits, oil companies such as Total, Exxon Mobile and BP are leasing to offshore-owned and offshore drilling groups like Transocean and others….

There are more than 15,000 platforms in the world. For example, the Gulf of Mexico alone has nearly 4,000 active oil platforms.

2.3 Concrete manufactured platforms:

Concrete manufactured platform can be considered as a specific material. Specific issues and challenges due to the raw material implementation need to be taken into account. Concrete offshore structures are mostly used as drilling, extraction or storage units for crude oil and natural gas. Those large structures house machinery and equipment needed to drill and/or extract oil and gas. But concrete structures are not only limited to applications within the oil and gas industry. Several conceptual studies have shown recently, that concrete support structures for offshore wind turbines are very competitive compared to common steel structures, especially for larger water depths. Generally, offshore concrete structures are classified into fixed and floating structures.

Fixed structures are mostly built as concrete gravity based structures (**CGS**, also termed as **caisson type**), where the loads bear down directly on the uppermost layers as soil pressure. The caisson provides buoyancy during construction and towing and acts also as a foundation structure in the operation phase. Furthermore, the caisson could be used as storage volume for oil or other liquids. Floating units may be held in position by anchored wires or chains in a spread mooring pattern. Because of the low stiffness in those systems, the natural frequency is low and the structure can move in all six degrees of freedom. Floating units serve as productions units, storage and offloading units (FSO) or for crude oil or as terminals for liquefied natural gas (LNG). A more recent development is concrete sub-sea structures.

Concrete offshore structures show an excellent performance. They are highly durable, constructed of almost maintenance-free material, suitable for harsh and/or arctic environment (like ice and seismic regions), can carry heavy topsides, often offer storage capacities, are suitable for soft grounds and are very economical for water depths larger than 150m. Most gravity-type platforms need no additional fixing because of their large foundation dimensions and extremely high weight.

B. Description of the construction of offshore platforms

The construction of offshore platforms is linked to the different technologies and depend on the nature, role and purpose of the platform. In the description below we summarize the big tasks which describe the construction, and give some details on precise example of a MODU for drilling wells and a production platform for natural gas with conventional fixed or compliant tower structures, and connected to the onshore terminal with pipelines. Main differences with CGBS and FPSO and other equivalent systems such as floating structures are the location of the storage and the connection systems to storage tanks. Difference can also be on the FO/NG treatment platform which can partially be also at sea. During the design of the floating structures the specific tasks which are referring to steel making or concrete structures shall be adapted in order to take care of the specific relevant loads and dynamic strengths, and construction methods, and varied for floating or fixed platforms, modified. Complementary and necessary tasks shall be also added and others withdrawn, such as concrete manufacturing, tasks, liners and concrete element manufacturing and for floating units the tasks which are referring to steel making or concrete structures shall be adapted including removal of the temporary foundation , and replacement by anchoring systems.

Main tasks for an offshore project:

- Onshore construction and commissioning of offshore and subsea facilities
- Drilling and completion activities (MODU and drilling)
- Platform installation, hook up and commissioning
- Installation, hook up and commissioning of subsea export and MEG pipelines
- Subsea infrastructure installation, hook up and commissioning
- Offshore operation and production and decommissioning at the end of platform life…

Generally the construction of the various elements and the start-up of the utilities takes 4 to 6 years and the commissioning and full production load a further 2 years after the commissioning of first production systems (see details in appendix).

Equipment for drilling wells shall be needed such as jack ups, semi-submersible systems or others. Well drilling is usually carried out as the same time as construction of modules.

Jackets and piles are then constructed with adequate legs, braced and necessary steel structures or with concrete elements, which will support the topsides. The foundation piles and the pin piles are assembled at the construction yard.

The topsides are steel structures erected from steel girders, steel stanchions, and trusses and cross beams, which form and enclose decks and modules. Equipment, both electrical and mechanical will be installed into the topside modules.

The topside module elements including processing equipment and utilities will be tested onshore and where practicable, pre-commissioned.

Below jacket load out picture

And Topside barged

After barging, the jackets and top sides are installed.

The foundation piles are driven simultaneously with necessary method, such as using an underwater hydraulic hammer and grouted to the jacket pile sleeves, or boring piles.

After the erection at sea of the main items then the final tasks are planned known as the hook up. Among them we have the connections of all electrical cables, pipes and umbilicals (including subsea cabling).
Commissioning will commence with living quarters and utility systems including the main power generators. These systems will then be started up, allowing workers to inhabit the platform during the subsequent commissioning and start-up of the process facilities. During commissioning many workers may work from temporary vessels as the manpower required during commissioning greatly exceeds that required during production. During commissioning pipelines and umbilicals are , cleaned and gauged, chemically treated, hydro tested, and a link test is also performed before full commissioning.

As well as the above surface platform hook up tasks, the subsea infrastructure connections which are designed to transport production fluids to platform complex are initiated. These systems includes production trees, manifolds, production flow lines including in-line Direct Electrical Heating (DEH) cables and Subsea Safety Isolation Valves (SSIVs); and Subsea controls, chemical distribution (including MEG) and umbilicals. After their installation they are pre-commissioned, tested, cleaned, hydro tested, dewatered.

The platforms are equipped with a firewater distribution system.

III. Insurance aspects

Taking into account all the indicated method of construction, a fair and good description of the project and platforms are key issue to analyse the risk.

A. Construction Risk

After initial pre-fabrication of the individual parts of a platform that have been carried out onshore, the towage or transportation on heavy lift vessels and the final lifts of the structure into place on the platforms represents a critical part of the project. After arrival at the intended location and once the main components are installed, the hook-up phase begins. Piping, electrical systems, ventilation and power supplies are installed. Finally, testing and commissioning are conducted before a rig starts to produce hydrocarbons.

Fig: Exxon Mobil's Ringhorne LQ Lifting by Asian Hercules II

First part of our concern should be the construction in the shipyard, nevertheless the risks involved are similar to traditional onshore module erection with the comment these modules tend to be much more compact than tradition onshore petrochemical modules. Nevertheless these exposures are well-known and common to all processes plants.

Another big exposure during the construction are those which are coming from moving large concrete or steel structures and their handling during the erection and construction.

The CGBS and the floating structures are very exposed to such risks. Sliding forms systems operation, operation of systems with jacks and big oil pressure driven systems which increase the fire risks are common. Heavy loads handling and moving and the risks link to the accumulation of big loads on same location, (dry dock overload) shall be controlled. The usual risks of construction on shipyards and dry docks are well-known, but we can note:

- Using of large cranes and handling equipment
- Design of specific items to move structures, which are partially finalized then do not stand final strengths and are sensitive.
- Sliding form operation at big height
- Sensitive equipment handling
- Ballasting (partial for transportation)

Following topics are typically representing the risk at sea. The topics are similar to on shore perils but exacerbated and reinforced by the marine environment. The typical marine operations which greatly reinforce the exposures and or create new ones are:

- Load out, float out, float on/off are common methods and specific to the construction of the offshore platform. Associated perils are the partial or total collapse of the platform which can be partially completed at that time. The use of specific faulty equipment can lead to delaying of the project.
- Towed and self-propelled transports (typically barges or ships) : Risks which are common to marine hull during transportation such as the natural catastrophe such as storm, but with the added complication of extremely unusual loads, and the use of tows so that the mechanical failure of the barge or tow, can lead to subsequent destruction or sinking of the platform.
- Launching, upending, positioning of jackets: These actions expose the equipment to specific consequences, during the launching, the weight can have a dramatic consequence if the dynamic stresses have not been enough taken into account, the risk of touching the bottom of the river or sea provoking overbalancing and destruction and sinking is common. The bad positioning of the jackets on softer soil is also a problem. New methods of positioning are reducing this risk, as far as the site manager follow the surveyor recommendations.
- Setting, piling, grouting of jackets and subsea structures: These risks are common to all sea works, bad positioning of piles, weakness of the supports lead to specific exposures.
- Foundation failure

  Collapse of the platform due to foundation failure could result as major loss however foundation failure by any event other than seismic is expected to be a low progressive collapse. In this case there would be sufficient time for remedy and evacuation of maximum personnel from the platform resulting major delaying of project. The case of an unexpected major seismic event may occur with an immediate result of global destruction in exposed areas. Nevertheless the more probable occurrence is settlement with progressive failure due to faulty design, workmanship and materials and the costly necessity to remedy with major reinforcement of foundations and loss of time.

- Marine lifting, lift-off or similar operations: As usual for transportation, failure of cables, hooks, winches, can lead to major consequences.

  Hazard is also presented from objects being dropped from various lifting activities carried out on the installation utilising cranes located on the platform. The cranes are fitted with inherent safety features to minimise the likelihood of a dropped load. Amongst these is a visual and audible alarm to prevent the crane operating outside the safe operating area or lifting a load not considered safe.

  During normal platform operation use of cranes is restricted in specific areas of offshore platforms identified as containing hazards which could cause harm to personnel or the structure if a load were to be dropped. Such areas may contain pipework or equipment which is exposed. During handling and construction, the lifting is a major risk , alarms are also used with complementary safety links. Floating objects are not considered as major hazard, but associated with severe weather conditions they can affect the platform structures.

  A further hazard would be a dropped load overboard impacting on a sub sea pipeline or a diver. As such crane facilities are not constructed in areas where a load could impact with a pipeline. It is required that all diving operations are suspended when crane operations are in use and vice versa to eliminate the risk of diver fatality due to a dropped object from a crane.

- Transit and positioning of jack-ups and semi-submersibles, then maintaining them at right place, with adequate systems: All perils to structures at sea are concentrated there.
- Ballasting for final positioning at big depth: The good operation of ballasting valves (opening and closing is key to avoid destruction.
- Rigid pipe & flexible/cable lay : The consequences can be immediately detected, but for pipes and cable the damage can occur later, due to damage on pipe or cable the system will not be commissioned safely and leakage or cable break will arise.
- Pipe/cable crossing & trenching : Breaking of CPE, sinking etc…
- Umbilical positioning : increasing of the distance then too small, destruction of the connection heads etc…
- Ship collisions:

  The potential impact from a boat or ship exists on all marine installations. Studies carried out for a typical Safety Case will indicate whether the likelihood of platform collapse following impact from a small vessel such as a fishing boat or a drifting shuttle vessel is highly unlikely or not. However it is possible that the platform could collapse following impact from a large passing vessel. A potential major consequence is damage to the utility shaft, causing flooding or collapse of the platform, due to loss of one of the concrete legs of the platform.

  In the event of collision with the shaft, there is the potential to cause severe cracking in a small area of the shaft wall. To mitigate against inflows originating from any ensuing cracks the shaft may be equipped with pumps to remove inflowing water.

- Helicopter impact:

  This hazard considers the consequences of a helicopter crash on the platform considering risk to personnel on the platform, not the risk to personnel during transport to and from a platform. The normal landing surface of the Helideck and the accommodation extension roofs are designed to withstand the impact of a helicopter impact. The worst case scenario would be an impact into the fuel storage area, causing fires on the Helideck. Sufficient safety measures such as foam sprays should be in place to consider the consequences of such an event. The platform layout needs to be designed to minimise the risk of severe damage to the platform and the TR and therefore any associated escalation potential is low.

- Transport of personnel:

  This hazard considers transport of personnel to and from the offshore platforms. To reduce the risk of helicopter incidents, transport should not be permitted when severe weather is forecast.

Tennet's Dolwin 1 Topside during Transportation in the Netherland

Topsides fabrication

- Human factor

  Platforms during construction but also operation, and decommissioning are exposed to the human factor, with all hazards occurring during working practice. Hazard management systems are in place on all erection sites platforms to reduce the occupational risks. Permits are issued for each task on board the platform and all hazards relating to that task are evaluated and prevention guide and tasks anticipated.

Taking into account the time schedule of the project implementation, erection and construction tasks are taking place simultaneously to the drilling of wells, drilling is carried out early in the project and continues them after the first petro product arrives into the platform systems, and process treatment areas, (see the load progression curve). In consequence it is difficult to separate the drilling from the construction.

The drilling risk is very exposed for the equipment but also for the well itself, including the specific equipment fitted to arrest the product until the pipes and umbilical will be in place with the platform to accept the product. The well re-entry and re-opening is the final task to allow production in the rig and a critical phase.

B. Offshore drilling and processing Risk

The main difference between onshore drilling and processing is

A) sub-water level or

B) deep-sea drilling.

The well will be located in areas of limited accessibility (20m to 1.500m+) and may only be reached by Remotely Operated Underwater Vehicles (ROVs) which will be used for surveys or external operation of a Blow-out Preventer (BOV). The topic of our document is not to analyze the drilling risk, but this one is present during the implementation of the construction and positioning of the structures and brings complementary exposure, whatever is the covered platform and works.

Apart from "general" property, BI and liability covers from Welcar, the Energy Exploration & Development Policy (EED) is an associated coverage which includes the following elements:

- Control of well: cost incurred in gaining control over the well/extinguishing and oil and gas fire
- Redrilling / restoration expenses: cost of re-drilling the well, but only to the depth of where control of well was lost and limited by the original costs incurred.
- Seepage, pollution, clean-up and contamination: clean-up costs for insured well and other properties, bodily injury, and defence cost.
- Important underwriting considerations:
- High-risk wells require drilling surveys: minimizing blockages
- Relief wells are rated individually: It is the major risk, then premium calculated individually.
- Horizontal drilling : Blockages
- Hydrogen sulphide : presence of this chemical element, is providing high exposure to explosion.
- The AFE to policy limit ratio (budget as indication of complexity)
- Wells with high in-hole pressure and/or temperatures
- Multiple wellhead locations

  During the construction and almost commissioning one of the main exposure is also when the reopening of wells are starting to allow natural gas or oil to get access to the pipes and platform raising up from bottom. The blow out risk is reaching its maximum during the progression of this task. During the start-up and commissioning, on the top of the perils which are impending over the platform, the fire is permanent as also the consequences of flooding the utility shaft.

- Non hydrocarbon fires during construction and starting operations:

  It is interesting to note that key area on offshore platform identified as potential locations for nonhydrocarbon fire are areas within the Human refuge, workshops and electrical equipment areas which are key during erection. A common practice is to keep the amount of flammable material outside of the accommodation modules minimal and to strictly control ignition sources.

  A fire in the electrical equipment areas would have the potential to affect a number of critical safety systems and as a result could cause a platform shutdown. The risk of fires within the accommodation modules is minimised by completely forbid smoking. Flame retardant materials would be used in order to minimize the spread of a fire.

- Uncontrolled Release of Non-Process Materials during the starting of operation or drilling platforms:

  Materials identified as presenting potential hazards on a platform are listed below:
  - Gas bottles, Chemicals and Paints, Battery Hydrogen.

  Each of these items has the potential to cause or escalate an incident.

- Flooding of the utility Shaft:

  The utility shaft on a platform contains process equipment required to operate the platform such as pipe work, heating and air conditioning controls, and with a gravity based structure is located within one of the legs of the platform. The following have been identified as potential origins for flooding of the shaft:
  - Loss of structural integrity of the shaft structure.
  - Failure of pipework or mechanical system components within the shaft.
  - Failure of pipework penetrations through the utility shaft walls.
  - Planned operation of a system within the utility shaft.
  - Abnormal operation of a system within the utility shaft (valve failure, operator error …)

  It is considered very unlikely that flooding of the shaft would result in a fire or explosion or in loss of the structural integrity of the platform. In the event of a flood in the shaft it would not be considered necessary to remove personnel from the platform however if the shaft was severely flooded, the platform would be shut down while the situation was rectified.

- Hydrocarbon fire

  A fire within a module has the potential to cause fatalities on the platform directly, or to impact on some other equipment or structure, causing escalation and indirect fatalities due to full or partial collapse of the platform. Immediate ignition of a high-pressure gas within any module has the potential to create a jet fire. A fire within an enclosed module would quickly become oxygen dependent, immediate shutdown of the ventilation system on detection of a fire accelerates oxygen depletion thereby extinguishing the fire. A fire occurring within an open module is not limited by oxygen but by the volume of inventory available. Function of the isolation and blowdown valves reduces the duration of the fire. Ignition of a liquid hydrocarbon release results in the formation of a pool fire. The fire is affected by the same limitations as a jet fire within closed and open modules. The safety systems in place can reduce the severity of a fire.

- Explosion

  A delayed ignition source occurring during a gas release has the potential to form an explosion, the results of which could potentially be failure of part or all of the platform structure. Following occurrence of an explosion it is the overpressure, the pressure loading caused by the explosion, is considered in assessing the level of damage.

- Blowout

  A blowout from one of the wells could result in a significant release of well fluids. During a well blowout on a platform oil could be expected to cover much of the Upper Deck area with residual amounts draining to sea. The likelihood of ignition of the oil depends on the well but if ignition should occur the resulting flame could light oil on the Upper Deck. If the blowout involves a well with a high gas content there is also a potential for explosion. Due to the high inventory available within the wells, on occurrence of a blowout the platform will be evacuated with all the possible consequences on the risk of total loss.

C. Natural Catastrophe (Nat. Cat.) / Accumulation Risk

Offshore installations are strongly exposed to windstorms of higher degrees. Not only the force of the wind as such but also the corresponding waves have a good potential to damage the installations in focus, and also other natural events such as winter tempests, icing, snow. Given the location of O&G fields, quite a large number of offshore platforms will be found in the Gulf of Mexico with its inherent Hurricane exposure, as are platforms in Asia Pacific, exposed to typhoons.

This hazard has the potential to impact on the safe operation of a number of activities on the platform. With the exception of some communications, Safety Critical Systems should not be affected by extreme environmental conditions until such time as the platform would be likely to collapse. Severe conditions causing collapse of the platform are considered to result in the loss of the "Temporary Refuge". A hazard not resulting in platform collapse however is assumed to not affect the TR.

Oil & gas platforms are located in the following regions, we highlight the exposed areas:

- North Sea, distributed in Great Britain, Norway, the Netherlands, Denmark (more than 450 platforms);
- Persian Gulf ;
- Gulf of Guinea, particularly in Gabon, Angola and Nigeria;
- China Sea in the territorial waters of Vietnam, Malaysia and China;
- Mediterranean Sea, mainly off the coast of North Africa (numbering 16);
- The Caspian sea ;
- Brazilian coastal region, whose huge Tupi deposit was discovered in 2007;
- Gulf of Mexico, along the US coasts and in Campeche Bay (Mexico);
- North-western and south-eastern coasts of Australia;
- Coasts of Malaysia, Brunei and parts of the Indonesian archipelago;
- Canadian Atlantic coast off Newfoundland (Hibernia, White Rose).
- Pacific Coast of Sakhalin island

The Berkut Oil Rig platform, a unit of 12b$

Seismic activity: In the origin, the preferred fields sector were located in areas of low seismic activity, however many older platforms are not designed to withstand seismic activity. And in coming days more and more sectors are explored and started with seismic peril. In the event of significant activity in the immediate area of a platform, the platform would be shut down and a full inspection be carried out before production restarted. The risk is more and more present and accumulation tools shall take into account the factor (erection and operation).

D. Underwriting aspects:

It is clear that taking into account the above mentioned risks, the underwriter shall have a balancing of the risks inherent to the upstream technical risk exposure, then set deductibles and retention level, and extensions which shall be carefully weighted.

In the analysis, the UW shall take into account the equipment itself. Safety critical items with their full operation available, reserve capacity to anticipate) are mandatory to reduce impact of fire and explosion.

- Blast and Firewall Systems
- Isolation and Blowdown Systems
- Deluge (sprinkler) System
- Fire and Gas Detection
- Emergency Power
- Heating, Ventilation and Air Conditioning Systems (HVAC)
- Blast and Firewall Systems

  In order to prevent escalation of a fire or explosion from within an enclosed module to an adjacent module, the module walls will have a level of protection against the event. Each wall will have a blast resistance, the maximum blast that can be withstood from an explosion and a flame resistance, the maximum time that a flame can impact on the wall before it will fail.

- Isolation and Blowdown Systems

  The Isolation and Blowdown systems work together to reduce the potential inventory available within the module. The primary function of the isolation valves is to effect isolation of all hydrocarbon sources on/or connected to the platform in order to minimise the inventory available to supply to the leaking section. Following isolation, potential ignition sources will be also shut down reducing the frequency of ignition. The function of the blowdown system in an emergency is to direct hydrocarbons to flare from inventories isolated by the isolation system.

- Deluge System

  The aim of this system is to suppress any fires and mitigate the consequences. The system is activated on detection of a leak or a fire in a module and will either be a water sprinkler, water or foam deluge, or foam system depending on the type of equipment and flammables present in the area. The foam systems are located primarily within oil processing modules as they extinguish pool fires by covering the surface area and eliminating the oxygen supply to the fire.
  The water systems are used within gas production modules as the water droplets aim to reduce the explosion overpressures should ignition occur.

- Fire and Gas Detection

  These systems work to detect a leak or a fire on the platform and activate the deluge and isolation/blowdown systems. Each platform has different methods of detection which depend on the platform design. The gas detection system is designed to detect a gas cloud forming in the module. Failure of a gas detection system results in a larger quantity of gas being released into the module and therefore increases the risk of an explosion. In the case of immediate ignition, there are detectors in place to identify the presence of a fire. These involve detection by infra-red and heat.

- Emergency Power

  The emergency power system is designed to keep essential systems operational, the fire pumps, emergency lighting and the heating, ventilation and air conditioning systems within the Refuge rely on the emergency power system in the event of loss of power from the platform. The remaining essential systems have individual back-up power supplies.

- Heating, Ventilation and Air Conditioning Systems (HVAC)

  On detection of a leak or a fire the HVAC within an enclosed process module will be shut down in order to limit the flow of oxygen to the module. A minimal flow of air will be expected to leak into the module following shutdown of the system. A system within the refuge will continue to operate following detection of a leak in one of the process modules to maintain pressurization in the TR to prevent smoke and gas ingress. However if smoke is detected at one of the HVAC inlet points the TR HVAC will be shutdown to minimize the likelihood of smoke entering.

Taking into account the transit road and locations, the natural peril exposure shall be analysed with possibility of limitation of access to sea road or sites, with consequences on direct exposure and also risk of sur-exposure after an incident which cannot be remedy. But the platform transit and location are generating other perils.

Winter conditions are provide a high exposure to complementary loads, the ice and snow weights shall be taken into account during design, as the wind forces are taken into account for typhoons.

The Underwriter shall also look at the human and political aspects in the region, poor and disaffected communities reinforce pirate activities, and terrorism can also be a consequence. Underwriter shall take these into account look for necessary protection systems that are fit to comply with the level of exposure.

The structure of the cover, with the possible XS layers, captive involvement, the shares from markets and also captive, shall be analysed, then company share shall be carefully sized, and portfolio impact in case of loss, anticipated taking into account the reinsurance structure.

Fig: Piracy maps

E. MPL considerations

The biggest peril on construction and commissioning is fire. Many studies have been carried out to model the scenarios and the accumulation of events which lead to the fire, explosion and destruction of the unit. The studies are based on the experience from different events that have occurred in the past. They take into account scales for incidents and classify the risks into categories. Risks below the acceptable limits, risks into the minimum and maximum acceptable limits, and risks above the maximum acceptable limits. For the risks below the limits, they indicate that no further actions are required, for the risks between the limits, resources shall be provided for a continuous monitoring, the risks above are not tolerable and shall be treated. The studies determine the necessary actions to issues and recommend then having a SMS (safety managing system). The systems are defined, and validated by the Authorities.

It is clear that to be in position to assess the scenario leading to MPL for Insurers and Brokers information on the nature on the parameters which are taken into account in the studies which define the “acceptable limit” is needed.

In 1998 the Health and Safety Executive in UK (HSE) defined the upper bound as 1 death in 10^3 years and the lower bound as 1 death in 10^6 years.
Risk was defined to be:
The probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge.
Identification of hazards in the workplace is a key element in assessing the risks involved in processing offshore. Current methods of hazard identification include Hazard and Operability Studies (HAZOP), rapid ranking, and Preliminary Hazard Analysis (PHA). According to the law in different countries, a full risk assessment involves the estimation of the frequency and consequences of a range of hazard scenarios including the magnitude of the events, (see in appendix typical risk assessment process). Studies use fault trees to define scenarios, the probability of the top event, T, can be evaluated from the probabilities of the minimal cut sets, C; using equation, where the fault tree has n minimal cut sets. P[T] = P[C1 +Cz +... +Cn].
Studies show that as testing and commissioning is deemed the biggest loss potential, in most cases the PML in offshore construction will be determined by a Vapor Cloud Explosion (VCE), the scenario in which gas floods a platform and ignites, finally causing a massive explosion and tremendous damage to the installation. But that is valid only if the method to develop the optimum configuration of safety systems has been identified and applied on the construction design of the platform or series of platforms involved for the field, and developed in order to minimize the number of fatalities that result from a hydrocarbon release.

A loss of well leads to uncontrolled rise of oil and gas, which once arrived the surface/platform, may ignite and cause serious damage to the installation. Depending on the ability to cut off any further hydrocarbons coming up the riser and depending , fire precautions and the success to control the fire by deployment of salvage teams, such an incident can lead to the full loss of a vessel or a platform.

Blow Out Preventer (BOP)

In short, the BOP is a valve located on the seabed which is designed to control the back flow from a well. Unlike an Onshore Oil & Gas processing installation, a BOP is not easily accessible but rather located on the seabed which easily could mean a depth of 2,000 meters and more. It is obvious that the activation of an offshore BOP may become a more complex operation and given the inherent risk of environmental pollution and strongly calls for extremely high security and redundancy measures.

The main features of a BOP are:

- **Annular preventer**
A larger rubber doughnut is squeezed inward to seal on either pipe or the open hole. Its flexibility is its big advantage over the ram blowout preventer.
- **Pipe ram**
Has a half-circle hole on the edge sized to fit around drill pipes. Do not close properly around drill pipe tool joints or drill collars.
- **Shear ram**
Hardened tool blades to cut the drill pipe or tubing and then fully close to provide full isolation or sealing to a wellbore. It is the last resort to prevent a blow as its activation makes further kill operations much more difficult.

Consideration of possible MPL scenarios is key, and the calculation of the MPL is taking into account: the concerned location, technical systems which are put in place, their complexity and values, safety systems, firefighting systems, human parameters such as experience and methods, codes and standards, vicinity, etc…, and duration of the exposure. Calculation tables are established to provide a global rating .

Generally, Vapor Cloud Explosion (VCE), Jet Fire (JF), Pool Fire (PF) impact direct damage and business interruption. Natural hazards MPL are principally winter or tropical storm effects, the risk of rogue wave is low, the total flooding is a low to moderate occurrence risk. Possible MPL is raised to values of 40 and 60%.

MPL jet fire: Jet fire is an ejection of a flammable liquid or gas from a vessel, pipe or pipe flange which rise to a jet flame if the material ignites immediately. Experiments carried out into the stability of jet fires show that a stable flame cannot be maintained by certain drive pressures when the release is from a hole size of less than 30mm. The most important geometric parameter is the flame length. Predictions of flame length tend to be one of two types. Major release with destruction of equipment for a radius over 10m.

MPL fire pool: A pool fire occurs when a flammable liquid spills onto the ground and is ignited. A pool fire burns with a flame which is often taken to be a cylinder with a height twice the diameter. In still air the flame is vertical however in the presence of wind or a ventilation system it is assumed to tilt. Pool fire are very dangerous due to the flame characteristics and heat radiated, which can have an impact on the structure of the platform, and destroy the retention pool , then take place in a tree conducting the platform to a more critical scenario. Major release with a leak mass over 9 tons.

A lot of scenarios include at different levels a leakage involvement. The table below indicates leakages occurring in the UK. These numbers show that leakages of products are usual and can be handled safely then reduced, or badly handled can lead to a main incident which can be major insurance claim.

Source: database 10/1992-03/2002 JL Lewthwaite thesis, 2312 releases with gas only 54. 8%; oil 17.4%; 2-phase 8.9%; condensates 4.3%

MPL VCE: An explosion is defined as a sudden and violent release of energy, the violence of the explosion being dependent on the rate at which energy is released . A leak of flammable gas has the potential to create a flammable atmosphere and give rise to an explosion following occurrence of an ignition source assuming the concentration of gas in air is between a set of flammability limits depending of the flow of gases, the overpressure initiated by explosion must be assess using TNT model or equivalent , over 340mb the materials have to be considered as destroyed or strongly damaged and MPL raise up 100% TSI.

IV. Risk Management:

A. Marine Warranty Surveyor

Historically, it was the Marine Surveyor's main role to inspect ships and to approve their classification. Organized in Classification Societies, the Marine Surveyor was involved in the design, construction and commissioning of respective ships. The focus of the Surveyor's job changed with the rise of the offshore industry respectively exploration and production of hydrocarbons. With the changed focus, the scope of the classification activity permeated towards offshore installation vessels and mobile offshore production facilities. It is worth pointing out that the utilization of more complex structures and floating facilities had a significant impact on the exposure, and the importance for an MWS increased particularly for activities like load out, towage, installation and hook-up of materials. Underwriters saw a strong need to protect their interests by employing a third party to survey and authorize such activities. Thus the MWS was borne.

The role of the MWS is the key for the coordination and connection of different parties, he or she shall conduct surveys throughout the platform's life (construction, regular, special) to ensure standards are maintained.

The MWS shall perform inspections required and in accordance with domestic statuses and international conventions by the International Maritime Organization (IMO). A MWS shall be skilled with the local laws and administration systems.

The MWS follows witness test and operation of emergency and safety machinery and equipment.
When necessary, attend court as an expert witness and assist in coroner's inquiries and Investigate marine accidents.

The role in the determination of "Fair Market Value", Damage Repair Costs" and "Replacement Value" can be done by constructors and the MWS knowledge as expert.

Check that satisfactory plans and procedures have been prepared for a given project and that plans are supported by suitable engineering calculation in accordance with recognised codes and standards.

Among others mission, the MWS shall check that the list of key and major equipment is suitable and suitably certified and operated by qualified personnel.
The surveyor can also conduct a risk assessment and mitigation.
Then follow testing carried out before the end of the project and that marine operations are carried out in accordance to approved procedures

To perform the mentioned missions, the surveyor shall have specific qualities and show according to references and experience that being independent is truly being independent, i.e. his financial interest is not aligned with the contractors' ones

He shall have a broader experience given his multiple involvements in how many projects. This allows him a high level of confidence in risk evaluation and mitigation

Skilled position is key to claims reduction: constant supervision of a project significantly helps to reduce the occurrence of losses. And then also for risk assessment, main principle in considering mitigation efforts stays, risk tolerance as low as reasonably practicable
MWS shall detect the « **Breach of warranty** ».

Breach of warranty leads to failure of the assured or their contractor to receive a Certificate of Approval from the MWS for the defined operation, either prior to works or due to breach of warranty incidents during the activities. The MWS will inform the assured if there is a potential breach of warranty and when the breach actually incurred, will notify the assured in writing.

Only after the cause for the breach of warranty is corrected, the MWS may allow to continue with the intended operation. If damages occurred, during the breach of warranty, a reservation to the result may be declared.

Main drivers of warranty breaches:

- Shortage of vessels and equipment
- Shortage of qualified (marine) personnel
- Too short project schedule
- Too restricted project budget
- Material and equipment quality & availability

B. National specific regulation, Safety and regulation systems

Historically offshore oil and gas activities started mainly in the Gulf of Mexico in 1940´s whereas in the North Sea, mainly the British and Norwegian sectors, it began about 15 years later. Early developments in both continents´ guidelines and regulations differed markedly because of climate, sea-state, a stronger regulatory tradition in Western Europe than in the United States and matured ship classification societies notably UK´s Lloyd´s Register and Norway´s Det Norske Veritas (DNV), both of whom were quick in extending experiences in offshore engineering. The US through its agency, American Petroleum Institute (API), established standards and recommended practices for the oil and gas industry, and widely referenced by offshore engineering professionals today.

Current regulatory regimes in the United States, UK and Norway are converging into a similar regulatory system with a combination of strict liability, command-and-control and management-based regulations for site specific risks according to Lori Bennear[1]. Countries outside these three countries have developed similar regulatory frameworks and designated technical standards selection e.g API or DNV, to the operators.

Regulatory changes are driven largely by disasters and accidents along the individual country´s maritime borders and industry practices. For example, management-based regulation requires that the operators develop a proactive safety plan, mainly reviewing production processes, identifying weaknesses and mitigation plans. Except the Bureau of Safety and Environmental Enforcement (BOEM) US, this approach is adopted by most western European and Asia Pacific countries.

As offshore fields mature, exploration have and will progress towards frontier regions requiring the need for international regulation or governance. Governance in the Arctic region, for example, needs to be strengthen in the area of oil spill prevention, containment and emergency response. Given its remote location, severe climate conditions and the need to protect its pristine environment, current regulatory framework and equipment standards are fragmented and not engineered to withstand its climatic challenges.

[1] Offshore Oil and Gas Drilling: A Review of Regulatory Regimes in the United States, United Kingdom, and Norway, Lori Bennear, Review of Environmental Economics and Policy Vol 9 Issue 1-1, 24 Jan 2015

C. Markets trends, (capacities, players, structures, wordings…)

The offshore energy industry and the re/insurance products to serve it developed in tandem over the last 60 years, driven by innovation in exploration and drilling techniques and the search for oil in ever more challenging locations* (*Swiss Re), each innovation and catastrophic damage was followed by Insurer and Re insurers answer. The main consistent topic which was driving the debates was always the drilling covering challenge from traditional OEE policy to the formation of the London Joint Drilling Rig Committee with issuance of the Drilling Rig Memorandum in 1960. The late 1960s was a period of rapid growth. Semisubmersible drilling rigs had been introduced enabling drilling in greater water depths. The insurance market responded to this challenge by introducing the London Master Drilling Rig Line Slip in June 1966, creating an insurance vehicle led by the six leading underwriters of the day and binding the rest of the market.

Initially 10m$ per unit but growing quickly with development of capacity players. OEE policy form was also extended to cover numerous additional risks and expenditures, such as Making Wells Safe Cover and Care, Custody and Control. In 1970 following the development of natural catastrophes and pollution costs, US insurers introduced pollution exclusions into liability policies, and market capacity for windstorm and pollution was rapidly reducing. 16 oil companies (15 North American and 1 European) formed OIL Insurance Ltd, a mutually-owned insurance vehicle based in Bermuda, to provide cover for assets, control of well and pollution. By the early 1980s, the values of the first generation of concrete platforms in the Statfjord oil field would reach USD 1.25 billion. Favorable loss experiences and the ever increasing demand for oil and gas enabled the global insurance market's capacity to grow in tandem with the industry expansion.

The London Market, by virtue of the LJDRC, was still providing the bulk of insurance coverage, but important centers of underwriting were beginning to develop in Europe, Scandinavia, North America, the Middle East and Asia. By 1982, capacity under the LJDRC had expanded to USD 875 million and shortly thereafter, an excess line slip was developed by the market, providing an additional USD 500 million capacity.

Today the International market is constituted of, Lloyd's of London with Catlin, Watkins, QBE, Hiscox, Ascot, XL, Talbot, Kiln, Chaucer, Aegis, Beazley, Travelers, Amlin. The Companies are providing also capacities, Chartis (AIG), ACE, Allianz, Zurich, Paris Re, SCOR, Munich Re, SwissRe, Axis, Berkley Offshore, Torus, Lancashire and Gard. The Lloyd's Singapore with branches' of Lloyd's London offshore Energy syndicates is also active. The major brokers are Aon, Marsh, Parisco, Willis.

C.1 Wordings:

As indicated in previous chapter, most of the front-end work for the installation of a fixed or floating platform is done onshore, in manufacturers 'yards, or in sites specifically established for the project. The transit involves towage or transportation on heavy lift vessels, and is a critical stage in the project that is particularly vulnerable to loss with the hock up and final handling of modules. The Construction All Risks (CAR) wordings were developed to address the specific risks inherent in these projects. Often at the inception of a policy, not all contractors are known, and the methodologies for installation may not have been worked out in detail. Finally, on many projects, the construction techniques and engineering are not fully established at project starting date. At the forefront of current technology the standard form applicable to all types of offshore construction risks is know as WELCAR 2001, named after a Lloyds syndicate that was instrumental in its introduction to the market. Section 1 insures against all risks of physical loss or damage to the project works, except as otherwise excluded. Inherent in the grant of coverage is the principle that the risk is fortuitous and accidental in nature, rather than the loss being inevitable, such as wear and tear. The word physical is important, the intention being to cover tangible loss that is physically evident, such as breakage, collapse, fracturing, fire, explosion and the like. The policy is not intended to insure faulty parts or latent defect.

Two additional coverages are also included:

- Offshore cancellation cost coverage responds to penalties that may be incurred by an operator under contracts relating to heavy lift barges, pipe-laying vessels and their spreads (the attendant vessels and equipment used with a large offshore construction vessel). If the circumstances prevent the using of these highly specialized vessels at the scheduled time, the operator will incur cancellation penalties.
- Defective part covers physical loss or physical damage to defective parts. The key element being that the defective part itself is physically damaged because of a default in its design or construction. Loss solely due to a part being unfit for its intended purpose is excluded, although a limited buy-back for an additional premium is commonly available.

Coverage under Section 1 of the WELCAR 2001 policy includes a maintenance period, which extends limited cover during contractual maintenance periods for physical loss or damage occurring during maintenance visits or the rectification of defects. The WELCAR 2001 form covers costs of repair or replacement on a new for old basis at the place of loss (ie costs of recovery and reinstallation of the damaged works); however, betterment or improvement in design is excluded. Policies may be extended to include expediting expenses, given the need to repair and replace items quickly to meet tight time schedules.

C.2 Warranties and conditions

As indicated in previous chapters, for all parties, there is an important express warranty in offshore CAR insurance that requires the assured to appoint an independent party, known as a warranty surveyor (MWS) , to monitor and issue certificates of approval for activities that are considered particularly vulnerable to catastrophic loss.

C.3 Limits, values and deductibles

CAR insurance is written for the estimated completed value (ECV) of a project, and will include an escalation provision that allows the ECV to adjust up or down at prorated premium based upon the final completed value. Adequate deductibles are also indicated in a schedule.

In appendix are noted chapters and key clauses of different covers.

D. Catastrophic Perils accumulation following up methods

Accumulation risk is one of the key challenges for re/insurers in underwriting offshore energy risks. Natural disaster events are especially prone to trigger multiple losses across a portfolio following a single event. At the same time, manmade events can trigger multiple losses across different policies. Accumulation risk is important, as re/insurers must retain enough capital for the extreme, worst-case scenario events. Risk aggregation is the process of defining, collecting, processing and reporting the potential accumulation in the portfolio. This enables re/insurers to: 1) set premium levels commensurate to exposure; 2) steer capacity and capital; 3) monitor risk taking; and 4) ensure exposures are within the defined risk tolerance limits.

The Solvency II Directive (2009/138/EC) addresses the amount of capital that re/insurance companies must hold to conduct their business activities in the EU.
Such capital requirement is driven by the sum of:

- property damage;
- removal of wreckage;
- business interruption / loss of production income;
- control of well;
- third-party liabilities

for the largest insured complex.

Risk aggregation is the tool to control accumulation. To gain a proper understanding of a risk's aggregation levels, information on the nature of the single asset, its location and the insureds involved in the undertaking (eg single owner or joint venture) is required.

The system then shall include:

- Insured Interest, (Limits, Extensions of cover etc…)
- Insured names
- Locations (to drive the natural exposures and /or manmade specific perils)

This risk aggregation process enables re/insurers to monitor accumulation per location.

V. Offshore Platform covers best practices

Construction and fitting the platforms are one part of the "offshore platforms" general subject, and the definition of best practices in the matter are done according to the concerned business and linked to the project details.

Nevertheless, if we have to look at such matter the basic rules are as General Golden Rules :

- Strong Technical approach of the risk, with different types of platforms, referenced construction companies involved, and recognized boring teams.
- Recognized MWS with strong references
- Good analysis and view of the site conditions with environmental data, above sea level and below sea level including subsoil studies…
- Strong project field analysis, with concerned lenders, owners, shares and interests
- Very good reliability of the data concerning the accumulation of the company exposure
- Golden rules on the mutualisation, which must not be in breach due to data quality lack.

Due to evolution in the design the access to complex and faraway oilfields become more and more possible. The price of the oil barrel or NG cubic meter, are driving investment in the research of new fields. As a consequence, platforms are more and more located in exposed areas to natural catastrophe , or wild weather condition, frozen, waves, hurricanes and permanent heavy wind speeds which exhaust the equipment in very short time. Evolution of Claims (in volatility) are reflecting the technical progress.

Schedule below is showing the major losses registered in the offshore business.

Example of losses:

- Hurricane Ivan, category 4, September 2004, GoM, insured losses USD 16bn. Massive losses to offshore installation although only 5% of platforms were hit. 1:100 waves and subsea mudslides in the Mississippi Delta.
- Hurricane Katrina, category 4, August 2005, GoM, insured Offshore Energy losses USD 8bn, economic losses USD 170bn. 46 destroyed and 30 damaged platforms.
- Hurricane Rita, category 4, September 2005, GoM, insured Offshore Energy losses USD 6bn, economic losses USD 18bn, 50% of that in the Energy sector. 69 structures destroyed and 32 damaged.
- Hurricane Ike, category 3, September 2008, Galveston-Houston, insured Offshore Energy losses USD 5bn, economic losses USD 45bn. Considerable damage to Texas oil operation, 25% of US's Energy production idled.

But not only platform in those relative big areas are to be considered. Looking into the matter in more detail, we will find out that in quite a few cases installations are neighbouring each other quite closely, sometimes only separated a few meters. Therefore, it turns out that not only Nat. Cat. Is to be considered in this situation, but moreover also the fire exposure to be evaluated.

VI. Conclusion

Offshore platform risks are complex; it is difficult to isolate the different aspects as the fields of operation are always under possible modification. The purpose of the modification can be the raising up of the construction and commissioning of the platforms, drilling of new wells, increasing of operation size. We enlightened in this document the basic perils concerning the construction as general matter, and give details on the method to cover, explaining the MWS role. The wordings are handling care of the particularities of the risks, and MPL scenariis are showing the volatility of the material and associated BI. Nevertheless a key point is the following up of the shares of the operation companies which are operating fields, that is also a challenge to manage for the Insurers and reinsurers for a good following up of the accumulation. A document on the accumulation system method can be an interesting development of knowledge in the field of cover of upstream offshore platforms.

Appendices

Appendix

Matrix of risks and perils

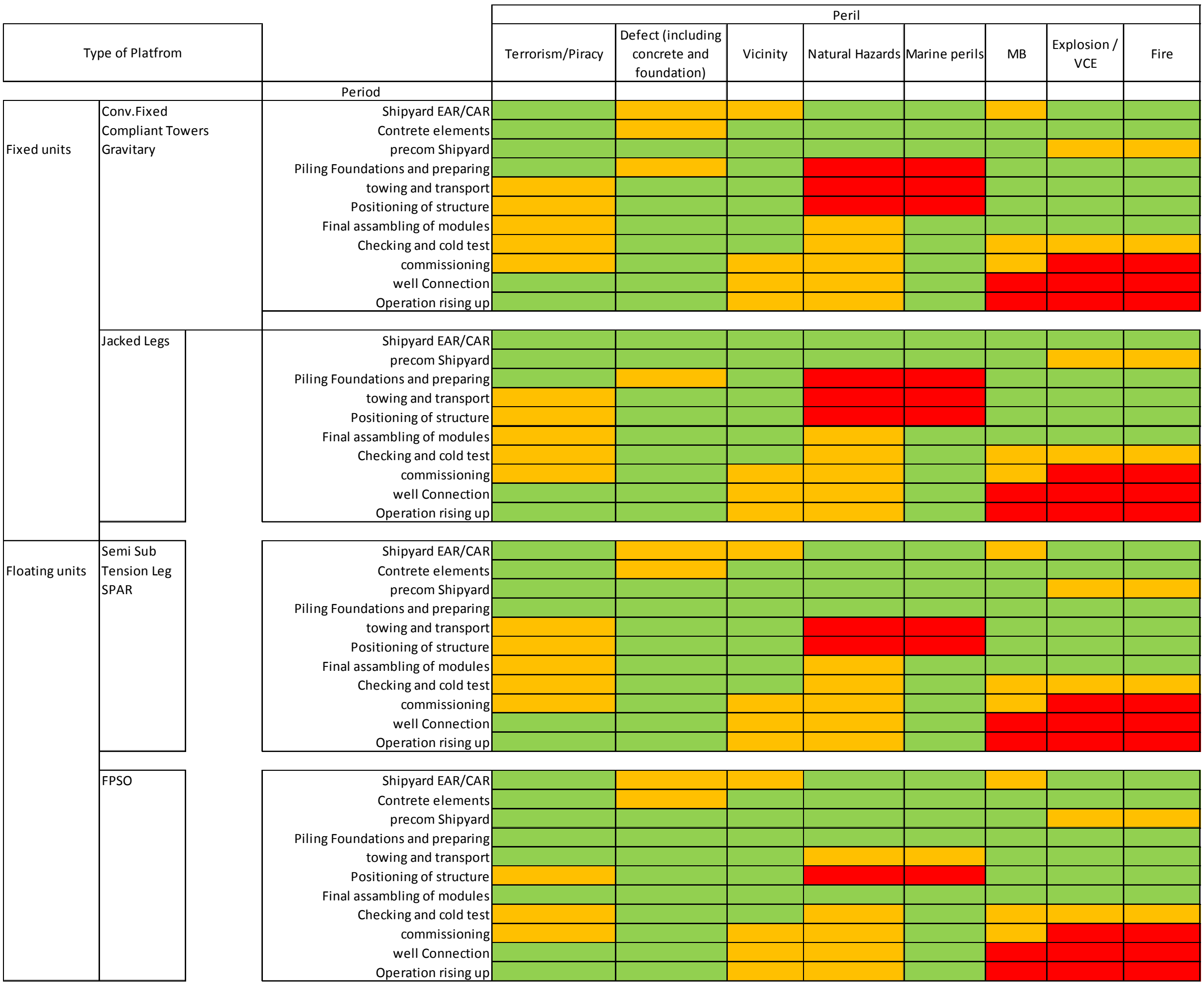
Root cause	Human/natural		
Risk / Grading	High	Moderate	Low
Fire	yes		
Explosion			yes
Machinery breakdown			yes
Marine			yes
Natural Hazards		yes	
Neighborhood			yes
Defect	yes		
Terrorism	yes		
CO2 impact		yes	
Total risk	Low		

Copie de
Riskgradingplatform.›

IMIA WORKING GROUP :

Offshore Oil and Gas platforms

Detailed Hazards	MPL or Loss Scenarios	Frequency			Severity		
		H	M	L	H	M	L
Terrorism, Piracy	Kidnap rancor or bomb destroy, Local attacks (e.g. explosive devices) to destroy platforms are most likely limited to restricted areas/sections.		X				X
Defect Material, Design, erection	Valve failure, linkage of NG or oil			X		X	
Lifting failure	Module colapse			X			X
Fundations, concrete,erection fault	Colapse of platformdue to fundations			X	X		
Launching,Positioning	bad positioning, impossible to connect			X		X	
Construction operations	Lifting, erection operations are intrinsically risky given special equipments and high rise structures (crane's jib failure).			X			X
Hazard due to Vicinity	Incident on another connected platform		X				X
EQ	undersea EQ, weakness of fundations, colapse		X			X	
Tempest	Typhon or winter strong tempest	X				X	
Flood	sunking			X	X		
Ice, snow,	Accumulation of ice on structures		X				X
Marine peril	Towing, colisions, helicopter impact			X			X
MB	Process failure, Blockages: shaft,ombilical			X		X	
Explosion	Blow out / VCE, Hydrogensulfide presence			X	X		
Fire	Leakages, Jet Fire / Pool fire			X		X	



Appendix

List of platforms, Major offshore concrete structures

Following table summarizes the major existing offshore concrete structures.

No.	Year Installed	Operator	Field/Unit	Structure Type	Depth	Location	Design by
1	1973	Phillips	Ekofisk	Tank - DORIS	71 m	North Sea (N)	DORIS
2	1974	Atlantic Richfield	Ardjuna Field	LPG Barge	43 m	Indonesia	Berger/ABAM
3	1975	Mobil	Beryl A	Condeep 3 shafts	118 m	North Sea (UK)	NC/Olav Olsen
4	1975	Shell	Brent B	Condeep 3 shafts	140 m	North Sea (UK)	NC/Olav Olsen
5	1975	Elf	Frigg CDP1	CGS 1 shaft, Jarlan Wall	104 m	North Sea (UK)	DORIS
6	1976	Shell	Brent D	Condeep 3 shafts	140 m	North Sea (UK)	NC/Olav Olsen
7	1976	Elf	Frigg TP1	CGS 2 shafts	104 m	North Sea (UK)	Sea Tank
8	1976	Elf	Frigg MCP-01	CGS 1 shaft, Jarlan Wall	94 m	North Sea (N)	DORIS
9	1977	Shell	Dunlin A	CGS 4 shafts	153 m	North Sea (UK)	ANDOC
10	1977	Elf	Frigg TCP2	Condeep 3 shafts	104 m	North Sea (N)	NC/Olav Olsen
11	1977	Mobil	Statfjord A	Condeep 3 shafts	145 m	North Sea (N)	NC/Olav Olsen
12	1977	Petrobras	Ubarana-Pub 3	CGS caisson	15 m	Brazil	?
13	1978	Petrobras	Ubarana-Pub 2	CGS caisson	15 m	Brazil	?
14	1978	Petrobras	Ubarana-Pag 2	CGS caisson	15 m	Brazil	?
15	1978	TAQA Bratani	Cormorant A	CGS 4 shafts	149 m	North Sea (UK)	Sea Tank
16	1978	Chevron	Ninian Central	CGS 1 shaft, Jarlan Wall	136 m	North Sea (UK)	DORIS
17	1978	Shell	Brent C	CGS 4 shafts	141 m	North Sea (UK)	Sea Tank
18	1981	Mobil	Statfjord B	Condeep 4 shafts	145 m	North Sea (N)	NC/olav Olsen
19	1981	Amoco Canada	Tarsiut Island	4 hollow	16 m	Beaufort	?

				caissons		Sea	
20	1982	Phillips	Maureen ALC	Concrete base artic. LC	92 m	North Sea (UK)	?
21	1983	Texaco	Schwedeneck A*	CGS Monotower	25 m	North Sea (D)	DORIS/IMS
22	1983	Texaco	Schwedeneck B*	CGS Monotower	16 m	North Sea (D)	DORIS/IMS
23	1984	Mobil	Statfjord C	Condeep 4 shafts	145 m	North Sea (N)	NC/Olac Olsen
24	1984	Global Marine	Super CIDS	CGS caisson, Island	16 m	Beaufort Sea	?
25	1986	Statoil	Gullfaks A	Condeep 4 shafts	135 m	North Sea (N)	NC/Olav Olsen
26	1987	Statoil	Gullfaks B	Condeep 3 shafts	141 m	North Sea (N)	NC/Olav Olsen
27	1988	Norsk Hydro]	Oseberg A	Condeep 4 shafts	109 m	North Sea (N)	NC/Olav Olsen
28	1989	Statoil	Gullfaks C	Condeep 4 shafts	216 m	North Sea (N)	NC/olav Olsen
29	1989	Hamilton Bros	N. Ravenspurn	CGS 3 shafts	42 m	North Sea (UK)	Arup
30	1989	Phillips	Ekofisk P.B	CGS Protection Ring	75 m	North Sea (N)	DORIS
31	1996	Elf Congo	N'Kossa	Concrete Barge	170 m	Congo	BOS/Bouygues
32	1993	Shell	NAM F3-FB	CGS 3 shafts	43 m	North Sea (NL)	Hollandske Bet.
33	1992	Saga	Snorre Concrete Foundation Templates (CFT)	3 cells suction anchores	310 m	North Sea (N)	NC/Olav Olsen
34	1993	Statoil	Sleipner A	Condeep 4 shafts	82 m	North Sea (N)	NC/Olav Olsen
35	1993	Shell	Draugen	Condeep Monotower	251 m	North Sea (N)	NC/Olav Olsen
36	1994	Conoco	Heidrun	Condeep	350 m	North Sea (N)	NC/Olav Olsen
37	1996	BP	Harding	CGS	109 m	North Sea (UK)	Taylor Wood Eng.
38	1995	Shell	Troll A	Condeep 4 shafts	303 m	North Sea (N)	NC/Olav Olsen
39	1995	Conoco	Heidrun TLP	Concrete TLP	350 m	North Sea (N)	NC/Olav Olsen
40	1995	Norsk Hydro	Troll B	Semisub	325 m	North Sea (N)	DORIS

41	1996	Esso	West Tuna	CGS 3 shafts	61 m	Australia	Kinhill/DORIS
42	1996	Esso	Bream B	CGS 1 shaft	61 m	Australia	Kinhill/DORIS
43	1996	Ampolex	Wandoo	CGS 4 shafts	54 m	Australia	Arup
44	1997	Mobil	Hibernia	CGS 4 shafts	80 m	Canada	DORIS
45	1999	Amerada Hess	South Arne	CGS 1 shaft	60 m	North Sea (DK)	Taylor Woodrow
46	2000	Shell	Malampaya	CGS 4 shafts	43 m	Philippines	Arup
47	2005	Sakhalin Energy Investment Company Ltd. (SEIC)	Lunskoye A	CGS 4 shafts	48 m	Sakhalin (R)	AK/GMAO
48	2005	Sakhalin Energy Investment Company Ltd. (SEIC)	Sakhalin PA-B	CGS 4 shafts	30 m	Sakhalin (R)	AK/GMAO
49	2008	ExxonMobil	Adriatic LNG	LNG terminal	29 m	Adriatic Sea (I)	AK/GMAO
50	2008	MPU Heavy Lifter (MPU filed for bankruptcy before completion, it was thereafter demolished)	Heavy Lift Vessel	LWA	n/a	na	Olav Olsen
51	2012	Exxon Neftegas Limited (ENL)	Sakhalin-1 Arkutun Dagi (Golden Eagle)	GBS 4 shafts	33 m	Sakhalin-1 (R)	AK/GMAO
52	2017	ExxonMobil Canada Properties	Hebron	GBS Monotower	109 m	Canada	KKC/GMAO

Appendix

Risk assessment process

Define study scope and objectives and risk criteria

Describe process and Plant

Identify hazards

Identify vulnerable targets

Develop hazardous incidents and source terms

Develop escalation scenarios

Identify mitigating features

Estimate consequences

Estimate frequencies

Present risks and compare with criteria

1. Accept system
2. Modify system to reduce risk
3. Abandon design

Figure risk assessment process Doctoral Thesis. By Jeni Louise Lewthwaite - April 2006

Appendix

Example of National Organization

Figure: National organization of the petroleum sector (Norway) (Gard AS Arendal Presentation October 2010)

Appendix

Wording lists of clauses and exclusions on different covers

.

Subsea construction risks CAR Market clauses:

Offshore field development projects

- Manuscript policy wording, incorporating Institute builders risk clauses 1 June 1988
- London Offshore Construction Clauses (L.O.C.C. 1985)
- Cefor Wording (Mid 1980's)
- Munish re wording
- Welcar 2001
-

Floating production & Mobile offshore units new builds or conversions

- NMIP chapter 19
- Institute builder risks clauses 01/06/1988
- MARCAR 2007

Clauses:

Escalation
Repairs replacement
Redesign/new design
Unrepaired/Unreplaced, on Total loss or on partial loss
Pre-hired vessels
Betterment/alteration in design increases excluded
Additional Insurance costs and re-certification costs
Defective part Endorsement and buy back
Additional Work
Test, leak or damage search costs (sub-limited)
Stand-by charges (sub-limited)
Claim surveying/adjustment clause
Warranty survey clauses:
    Conceptual survey and certification (Optional procedures)
    Physical survey and certification (high risk operation)
Terrorism Buy-back
Forwarding Charges (sub-limited)
Maintenance coverages
Definitions

Usual Physical cover Exclusions:

Vessel and other watercraft
Aircraft and helicopters
Temporary works, site preparatory works, property and equipment not owned by principal assured
Penalties for non-completion of or delay
Platforms and or structures placed in wrong locations

Loss of use or delay in start up
Performance Guarantees
Infidelity
Cost of repairing wear and tear etc…
Dumping of rocks placed in wrong position or location
Operation, temporary or permanent works, assets or equipment not included within the latest schedule
Repairing, renewing or replaced faulty welds
Loss or damages; liability or expenses directly or indirectly caused by or attributed to by or arising from radioactive, nuclear sources
War or perils, excepted derelict weapons

Liability coverage

Legal liability
Express contractual liability
Bodily injuries or property damage caused by an occurrence during the project period.

Exclusions

Violation of laws
War & terrorism
Employers liability or liability in connection with any persons representing any assured in any capacity.
Loss of well or hole and control of well costs.
Seepage and pollution unless an identifiable event
Subsidence or damage to subsurface substance
Fines, penalties, punitive and exemplary damages
Product's and completed operations liability
Damage to or loss of use of assured's owned or used properties, or in his care, custody or control
Removal, recovery, repair, alteration or replacement of any product (or any part thereof) which fails to perform its intended function
Professional errors or omissions
Asbestos or other hazardous substances
Radioactive or nuclear exposure
Products and workmanship warranties

Appendix

Examples of different type of Platforms, SPAR and Concrete platforms

A typical example of a semi-sub is as follows;

A typical example of a TLP is as follows:

A typical example of a Spar is as follows:

A typical example of an FPSO equipped with an integral turret is as follows;

Below is a typical example of a Concrete Gravity Based Structure;

Below is an example of a jack-up converted production platform which serves to support production from a nearby FPSO.

SPAR structures

Example of a fixed dock deck platform in the North Sea: Alwyn North (Scotland):

- Date of commissioning: 1987
- Lifespan: 30 years
- Length of the feet: 126 m under the sea and 31 m above
- Weight: 43,000 tons of steel
- Cost: 2.25 billion euros
- Number of wells: 47
- Depth of wells: approximately 4,000 m
- Production: 40,000 barrels of oil per day

Concrete platforms Structure Details

Fixed structures:
Since the 1970s, several fixed concrete platform designs have been developed. Most of the designs have in common a base caisson (normally for storage of oil) and shafts penetrating the water surface to carry the topside. In the shafts normally utility systems for offloading, drilling, draw down and ballast are put up.

Concrete offshore platforms of the gravity-base type are almost always constructed in their vertical attitude. This allows the inshore installation of deck girders and equipment and the later transport of the whole structure to the installation site.
The most common concrete designs are:

- Condeep and CG/CGBS (with one, two, three or four columns)
- C G Doris
- ANDOC (with four columns)
- Arup Concrete Gravity Substructure (CGS)

Condeep Type

Condeep refers to a make of gravity base structure for oil platforms developed and fabricated by Norwegian Contractors in Norway. Condeep usually consists of a base of concrete oil storage tanks from which one, three or four concrete shafts rise. The original Condeep always rests on the sea floor, and shafts rise to about 30m above the sea level. The platform deck itself is not a part of the construction. The Condeep Platforms Brent B (1975) and Brent D (1976) were designed for a water depth of 142m in the Brent oilfield operated by Shell. Their main mass is represented by the storage tank (ca. 100m diameter and 56m high, consisting of 19 cylindrical compartments with 20m diameter). Three of the cells are extended into shafts tapering off at the surface and carrying a steel deck.
Tanks serve as storage of crude oil in the operation phase. During the installation these tanks are used as ballast compartment. Among the largest Condeep type platform are the Troll A platform and the Gullfaks C. Troll A was built within four years and deployed in 1995 to produce gas from the Troll oil field which was developed by Norske Shell, since 1996 operated by Statoil.

CGBS types

Concrete Gravity Base Structures (CGBS) is a further development of the first-generation Condeep drilling/production platforms installed in the North Sea between the late 1970s and mid '90s.

The CGBS have no oil storage facilities and the topside installations will be carried out in the field by a float-over mating method. Most recent projects are:

- Sakhalin-II platforms (Molikpaq (Piltun-Astokhskoye A; PA-A) platform, Piltun-Astokhskoye B (PA-B) platform and Lunskoye (LUN-A) platform)
- Malampaya
- Wandoo
- Benjamin Nathanael

Sakaline Platform

CG DORIS Type

The first concrete gravity platform in the North Sea was a C G Doris platform, the Ekofisk Tank, in Norwegian waters. The structure has a shape not unlike a marine sea island and is surrounded by a perforated breakwater wall (Jarlan patent). The original proposal of the French group C G DORIS (Compagnie General pour les Developments Operationelles des Richesses Sous-Marines) for a prestressed post-tensioned concrete "island" structure was adopted on cost and operational grounds. DORIS was general contractor responsible for the structural design: the concrete design was prepared and supervised on behalf of DORIS by Europe-Etudes. Further example for the C G DORIS designs are the Frigg platforms, the Ninian Central Platform and the Schwedeneck platforms. The design typically consists of a large volume caisson based on the sea floor merging into a monolithic structure, which is offering the base for the deck. The single main leg is surrounded by an outer breaker wall perforated with so called Jarlan holes. This wall is intended to break up waves, thus reducing their forces.

ANDOC Type

To achieve its goal and extract oil within five years after discovering the Brent reservoir Shell divided up the construction of four offshore platforms. Redpath Dorman Long at Methil in Fife, Scotland getting Brent A, the two concrete Condeeps B and D were to be built in Norway by Norwegian Contractors (NC) of Stavanger, and C (also concrete) was to be built by McAlpine at Ardyne Point on the Clyde (which is known as the ANDOC (Anglo Dutch Offshore Concrete) design). The ANDOC design can be considered as the British construction industry's attempt to compete with Norway in this sector. McAlpine constructed three concrete platforms for the North Sea oil industry at Ardyne Point. The ANDOC type is very similar to the Sea Tank design, but the four concrete legs terminate and steel legs take over to support the deck.

Arup Concrete Gravity Substructure (CGS)

The Arup dry-build Concrete Gravity Substructure (CGS) concept was originally developed by Arup in 1989 for Hamilton Brothers' Ravenspurn North. The Arup CGS are designed to be simple to install, and are fully removable. Simplicity and repetition of concrete structural elements, low reinforcement and pre-stress densities as well as the use of normal density concrete lead to economical construction costs. Typical of the Arup CGS is the inclined installation technique. This technique helps to maximise economy and provide a robust offshore emplacement methodology. Further projects have been the Malampaya project in the Philippines and the Wandoo Full Field Development on the North West Shelf of Western Australia.

Floating structures:

Since concrete is quite resistant to corrosion from salt water and keeps maintenance costs low, floating concrete structures have become increasingly attractive to the oil and gas industry in the last two decades. Temporary floating structures such as the Condeep platforms float during construction but are towed out and finally ballasted until they sit on the sea floor. Permanent floating concrete structures have various uses including the discovery of oil and gas deposits, in oil and gas production, as storage and offloading units and in heavy lifting systems.

Common designs for floating concrete structures are the barge or ship design, the platform design (semi-submersible, TLP) as well as the floating terminals e.g. for LNG.

Floating production, storage, and offloading systems (FPSOS) receive crude oil from deep-water wells and store it in their hull tanks until the crude is transferred into tank ships or transport barges. In addition to FPSO’s, there have been a number of ship-shaped Floating Storage and Offloading (FSO) systems (vessels with no production processing equipment) used in these same areas to support oil and gas developments. An FSO is typically used as a storage unit in remote locations far from pipelines or other infrastructures.

Semi-Submersible:

Semi-submersible marine structures are typically only movable by towing. Semi-submersible platforms have the principal characteristic of remaining in a substantially stable position, presenting small movements when they experience environmental forces such as the wind, waves and currents. Semi-Submersible platforms have pontoons and columns, typically two parallel spaced apart pontoons with buoyant columns upstanding from those pontoons to support a deck. Some of the semi-submersible vessels only have a single caisson, or column, usually denoted as a buoy while others utilize three or more columns extended upwardly from buoyant pontoons. For activities which require a stable offshore platform, the vessel is then ballasted down so that the pontoons are submerged, and only the buoyant columns pierce the water surface - thus giving the vessel a substantial buoyancy with a small water-plane area. The only concrete semi-submersible in existence is Troll B.

Tension Leg Platform (TLP):

A Tension Leg Platform is a buoyant platform, which is held in place by a mooring system. TLP mooring is different from conventional chained or wire mooring systems. The platform is held in place with large steel tendons fastened to the sea floor. Those tendons are held in tension by the buoyancy of the hull. Statoil's Heidrun TLP is the only one with a concrete hull, all other TLPs have steel hulls.

Tension Leg platform

Barge/Ship Design:

FPSO or FSO systems are typically barge/ship-shaped and store crude oil in tanks located in the hull of the vessel. Their turret structures are designed to anchor the vessel, allow "weather vaning" of the units to accommodate environmental conditions, permit the constant flow of oil and production fluids from vessel to undersea field, all while being a structure capable of quick disconnect in the event of emergency.

The first barge of pre-stressed concrete has been designed in the early 1970s as an LPG (liquefied petroleum gas) storage barge in the Ardjuna Field (Indonesia). This barge is built of reinforced and pre-stressed concrete containing cylindrical tanks each having a cross-section perpendicular to its longitudinal axes that comprises a preferably circular curved portion corresponding to the bottom.

Appendix

Detailed Functions of Offshore Platforms

The following sections provide a brief overview of each of the production processes.

Produced Hydrocarbon Separation

Once the produced fluid from oil and gas wells arrive at surface on a production platform, the fluids are diverted to separators to divide the fluid into its basic components – oil, gas and water. Multiple separation stages may be necessary to sufficiently liberate the gas and remove water. The separated oil will be further dehydrated and sent to storage tanks on the platform, ready to be exported to refineries via pipeline or a shuttle tanker.

Gas Processing

The separated gas is also dehydrated to remove water vapour. The gas is then compressed and exported to shore by pipeline. In cases where gas is not the intended production fluid, the separated gas may be injected back into the reservoir through gas injection wells for potential future production and/or reservoir pressure support. If the separated gas is small in quantity, it may be flared but such practice is increasingly becoming unacceptable in many parts of the world.

Produced Water Processing

The produced water from the separator will be further processed and, depending upon the reservoir and the platform location, the processed water may be injected back into the producing reservoir using water injection wells for disposal and/or reservoir pressure support. In some cases, the produced water may be cleaned up and discharged overboard in accordance with the local government regulations.

Flow Assurance

Methanol and glycol injection is used in process lines where there is a risk of hydrate formation at low temperatures. Methanol and MEG injection are provided in a pump skid package with chemical storage tanks and high-pressure pumps housed on the platform. High pressures are required to overcome friction losses in subsea pipelines where the well head can be long distances from the platform. To reduce operating and environmental costs MEG is recovered as part of the Production Facilities. Rich MEG streams are processed in MEG Recovery Units (MRU) in order to be recovered as lean MEG to be pumped back and reinjected. MRUs include heaters, distillation columns, centrifuges, pressure vessels and pumps.

Organic and inorganic deposits that accumulate near the wellbore create flow restrictions. These restrictions result in significant losses of crude oil and gas production and are a serious concern for operators. Typical treatments use chemical inhibitors. Chemical injection skids can include wax inhibitors, scale inhibitors, defoamers and H2S Scavengers.

Other preventative measures taken offshore include:

Corrosion Inhibitors - Inhibitors, in the form of liquid solutions or compounds, can be injected into the flow stream in the flowline, manifold or productions system to inhibit to inhibit corrosion that would occur otherwise.

Pipeline Pigging - A maintenance tool for oil and gas pipelines and flowlines to ensure flow assurance.

Pipeline pigs are introduced into the line via a pig launcher and trapped and removed from the line by a pig receiver, both housed on the platform. Without interrupting the flow, a cylindrical or spherical pig is forced through the line by product flow, or it can be towed by another device or cable. The pig sweeps the line by scraping the sides of the pipeline and pushing debris ahead. As it travels along the pipeline, there are a number functions the pig can perform, from clearing the line to inspecting the interior. Pigging is performed during commissioning and start-up, as well as periodically as part of a maintenance regime.

Prevention of Emulsions

Much of the oil produced worldwide is accompanied by water in an emulsion that requires treating. To prevent increased transportation costs, water treatment and disposal costs, and deterioration of equipment, purchasers of crude oil limit the basic sediment and water (BS&W) content of the oil they purchase. When water forms a stable emulsion with crude oil it cannot be removed in conventional storage tanks. Emulsion-treating methods must be used. Free water is knocked out in the Production Separator initially. Almost all emulsion-treating systems use demulsifying chemicals, heat and coalescers to separate oil in water emulsions. Equipment used can include Treaters and Electrostatic Coalescers.

Oil and Gas Exporting

The processed Oil and Gas will be exported to shore, either by pipeline or by shuttle tanker, depending on the distances involved and also the facilities on shore. In the case that the shore infrastructure is insufficient for a pipeline to be used (i.e., no oil or gas terminal), then shuttle tankers are used which requires an offloading hose arrangement. Additionally, the platform will also require some sort of storage capability such as tanks in the structure or hull. Typically, FPSOs are favored for this kind of application.

Living Quarters

Most offshore production platforms contain living quarters for the crew working on the platform. Offshore operations on a platform are continuous day and night, which require support by crew sizes ranging from a few dozen for a production platform to over a hundred for large platforms with simultaneous operations of production and drilling. The living quarters on a platform provide not only accommodation for the offshore crew, but also canteen and medical facilities, recreation and exercise rooms, etc.

Drilling Package

On many large offshore platforms, a drilling package is installed over the well bay area as part of the platform installation to allow for concurrent operations of production from existing wells and drilling for new wells or workover in the existing wells. On smaller platforms however, a mobile drilling unit will be brought alongside the platform when a new well is required or an existing well needs to be worked over.

Well Testing

In some cases, the processing facilities on a production platform are also used for well testing purposes. Before an oil and gas well is put on production, an operation called well testing may be executed to establish the flow from the well for a period of time to demonstrate the existence of oil and gas fluids and the potential productivity of the producing reservoir. During well testing, the reservoir fluids of oil, gas and water as well as drilling fluids from the well will be flowed back to surface on a platform and these will be separated before the oil being exported into the pipeline, gas being flared, and other water and waste fluids being processed and disposed of.

Appendix

Project Construction Details, Example

1. Field Development

We take an example of development and installation of necessary items for the good operation of a platform , then in our case the project includes:
A fixed platform complex including a Production and Risers (SDBPR) and a Quarters and Utilities (SDB-QU) platform, then bridge linked to the SDB-PR; 10 subsea manifolds and 5 associated well clusters, tied back to the fixed platform; platform complex by twin 14” flowlines to each cluster; Subsea natural gas pipelines from the SDB-PR platform to the onshore Terminal. The first activity is the drilling which will continue after the starting of operation to raise the nominal platform production capacity. Globally the construction of the elements and utilities starting up are scheduled in 4 years and the commissioning and full production load is reached within 2 years after the commissioning of first production systems.

Fig: raising up of production and start up of unit time schedule

Equipment for drilling wells shall be anticipated such as semi-submersible systems or others. Well drilling is done during construction of modules. As indicated the modules are erected on shipyards or platform construction yards and transported to construction site or storage and assembling of the topside, subsea facilities, pipeline and jacket (or concrete supporting structure) construction sites. The routes for coming of the main systems shall be anticipated, including the winter seasons. Oil and NG extraction areas can be in a very challenging natural environment.

The drilling activities include the casing, cementing and surfacing of the well sections, with cleaning and testing. The casing provides a structural strength for the well protecting it from weak and unstable formations. It is cemented into place. A Blow Out Preventer is also installed to control the pressure in well prior to installation of the production facilities.

The Yard construction activities:

The projects construction activities are always requiring a number of minor upgrade works to be undertaken at the selected construction yards. The scope of the upgrades is depending on which elements of the offshore facilities and subsea equipment are undertaken at each yard. The scope of potential upgrades includes but are not limited to:

- Extensions of the yard to allow equipment storage and fabrication;
- Ground improvement work to increase the weight bearing capacity – e.g. piling work, backfilling and ground compaction …

Fig: Global project time schedule

In addition to yard upgrades, upgrades of vessels may be required. During commissioning and reactivation of wells, the vessels' firefighting vessels shall be tested.

Jackets and piles are then constructed with adequate legs, braced and necessary steel structures or concrete structures, which will support the topsides. Necessary components to avoid corrosion, painting, cathodic prevention are anticipated. The jacket sections will then be transferred to the assembly skid way, where they will be crane lifted into position and welded to other jacket sections to form the complete structure. Buoyancy tanks are placed for future handling. Very often it will be necessary to pre-ballast a number of compartments on the buoyancy tanks prior to jacket load-out, to ensure stability of the jacket during installation. The systems are filled with the same hydro test chemicals as used on the subsea pipelines and flowlines to protect the tanks from corrosion. Upon installation of the jacket the buoyancy tanks will be towed back to the shore for re-use or disposal. The foundation piles and the pin piles will be assembled at the construction yard.

Fig: Jacket erection main phases

The topsides are steel structures erected from steel girders, steel stanchions, and trusses and cross beams, which form and enclose decks and modules. Equipment, both electrical and mechanical will be installed into the topside modules. The topsides comprise a number of decks including an upper deck, weather deck, mezzanine deck, cellar deck and under deck. The main components of the topsides are:

Living quarters includes usually:

- Living Quarters
- Power generation and distribution system
- Direct Electrical Heating system
- MEG bulk storage (560m3) and distribution system
- Subsea hydraulic power system
- Subsea controls interface
- Chemical injection system including methanol
- Utilities, platform support systems and Infrastructure

Production:

- Flow line reception facilities including pig launchers and receivers
- Production and test manifolds
- HP, Test and LP Separation system
- Offline Seawater Wash Facility
- Flash Gas Compressors
- Condensate Export Pumps
- Flare system and boom
- Fuel gas and marine pipeline gas buyback systems
- Condensate and gas export systems
- MEG* import system

* *MEG : Mono-Ethylene Glycol system*

The topsides are together connected offshore by a bridge, also constructed from steel trusses and cross beams. It is planned to construct the bridge at the same yard as the SDB-PR topside.

Fig: Topsides erection main phases

The topside module elements including processing equipment and utilities will be tested onshore and where practicable, pre-commissioned. Then after assembling the complete topside systems are commissioned. Their final testing are expected once in place offshore. Following systems are concerned:

- Fuel gas system;
- Condensate export system;
- Flare system;
- Flash gas compression system;
- Chemical systems;
- Methanol system;
- MEG System.

Other systems shall be anticipated, among them, sea water system with necessary anti corrosion and biological growth inhibition, freshwater system, electric power generation emergency system…

When completed, the jackets and topsides are loaded onto the barge for transportation to the platform complex location. The jackets are each manoeuvred onto the barge and sea fastened by welding members from the jacket to the barge deck. The barge ballasted and trimmed to sea-tow condition. The transportation barge is assisted by support vessels during sail-away.

After barging, the jackets and top sides are installed The process followed to unload and position the jacket is shown in Figure below. Ballasting and use of the jacket buoyancy tanks will allow the jacket to be accurately positioned.

Once in position, the jacket are attached to the anchored crane and set down onto four pre-installed pin piles. Hydraulic gripper jacks will secure the jacket until permanent piling is completed.

The foundation piles are driven using an underwater hydraulic hammer and grouted to the jacket pile sleeves. Grout is supplied via flexible hoses from the Derrick Barge Crane Vessel to the grout manifold panel located on the side of the jacket; and pumped down into the annulus between the pile and pile sleeve.

The topsides can be designed for example for the “float-over” method of installation. For each topside the transportation barge is maneuvered between the two jacket towers such that the topside is positioned above the intended installation position on the jacket as illustrated in Figure below. The mating operation (i.e. the process of connecting the topside to the jacket) is executed by ballasting the barge such that the topside engages with shock absorbers in the jacket legs and the load is transferred. Sand jacks are then used to lower the topside until steel faces mate and are ready for welding, sand jacks during this process are discharged to the sea. The bridge will also be loaded onto the transportation barge and towed to the complex location offshore. The barge will be moored alongside the Derrick Barge Crane Vessel (DBA), which will lift the bridge and position it between the SDB-PR & SDB-QU platforms using rigging and guides.

Once in position the rigging will be removed and the temporary installation guides will be removed. The bridge will be welded in place to the platform at one end, with the other end fitted to allow natural movement during operation.

After the erection sea of the main items then the final tasks are planned. These hook up activities include:

- Installation of the SDB-QU firewater and seawater lift pumps and caissons;
- Installation of the hazardous open drains caisson pump;
- Tie-ins to all risers; and
- Connection of all umbilicals (including subsea cabling), which are layered during construction

Commissioning will start with living quarters and utility systems including the main power generators. The systems will then be started up over a testing period, allowing workers to inhabit the platform during commissioning and startup of the process facilities.

The current Base Case assumes that power during commissioning will be provided by the main platform generators, using diesel until fuel gas is available from onshore SCP facilities via the two SD2 32” marine export gas pipelines. To establish initial life support before the main platform generators are available it is planned to use one temporary diesel generator. It is anticipated that the temporary generator will be used for 6 months and the main platform generators will be run on intermittently diesel for 6-8 months during the commissioning period.

A number of vessels are used to support the SDB platform installation, hook up and commissioning (HUC) activities, including the DBA, anchoring handling vessels, the installation barge and support vessels. These vessels are used for Electric power, sanitary waste, galley waste, water, drainage water…
Pipelines are simultaneously installed to connect the platform complex to the shore, one of common method is the welding layering. The lay-barge lays pipe in an S-Lay configuration meaning that the pipeline lies on the seabed in the horizontal position, rises up through the water column and curves back to the vessel to assume a horizontal position such that pipe joints are added to the pipeline in a horizontal orientation. The tensioning system on the lay-barge maintains a controlled and constant deployment rate, while reducing bending stresses that could threaten the pipeline structure.

The pipe-laying operation is continuous with the barge moving progressively forward as sections of the pipe are welded, inspected, coated on board and then deployed to the seabed. The barge will be held in position by 10 anchors. As pipe-laying proceeds, the anchors are periodically moved by 2 anchor handling support vessels to pull the barge forward (with 1 more on standby). The distance of this will vary, but will typically be every 500m to 600m of pipeline length. Marine installation operations are occurring within an exclusion zone. During installation, exclusion buoys are placed around the lay-barge installation area to indicate that the area is an exclusion zone and to ensure that other vessels do not encroach upon the activity area. As pipe-laying progresses, the exclusion buoys are moved along the route.

The offshore sections of the pipelines are generally laid directly on the seabed and not trenched except in the shore approach area. Stability of the sections that is laid directly on the seabed and provided by the concrete coating along the majority of the lengths. Grout bags are used for any required freespan corrections and rock dumping may be used to provide additional support or additional cover if required. Systems are connected to shore with winching and jetty.

Appendix H

After the erection at sea of the main items then the final tasks are planned. Among them we have the connections of all umbilicals (including subsea cabling) which are layered during construction.
Commissioning will commence with living quarters and utility systems including the main power generators. The systems will then be started up over a testing period, allowing workers to inhabit the platform during commissioning and startup of the process facilities.

Pipelines and umbilicals are then pre-commissioned, cleaned and gauged, chemically treated, hydro tested. A link test is also performed.

Concerning the platform hook up tasks, are then starting the subsea infrastructures connections which are designed to transport production fluids to platform complex. These systems includes production trees, manifolds, production flow lines including in-line Direct Electrical Heating (DEH) cables and Subsea Safety Isolation Valves (SSIVs); and Subsea controls, chemical distribution (including MEG) and umbilicals. After their installation they are pre-commissioned, tested, cleaned, hydro tested, dewatered.

The platforms are equipped with a firewater distribution system, which will be supplied by diesel powered firewater pumps located on the SDB-QU platform. The firewater pumps are tested on a **weekly basis** for an hour with seawater circulated through the firewater system and discharged via the SDB-QU seawater discharge caisson.

A foam concentrate system will be provided to enhance the effectiveness of water spray protecting the separator module and the flowlines HP flare drum area, where there is potential for hydrocarbon pool fires.

2. Jacket Platform Construction Details

Overview of Platform

Platform Type	Fixed Production Platform
Design	Jacket and Topside
Location	Northern North Sea, Norwegian Sector
Platform Facilities	3 Phase Separation Water Injection Export Accommodation
Water Depth	150m
Well Heads	Subsea

The following is a CGI image of a typical fixed platform.

Construction Key Phases

For the purposes of this example, the key construction phases are simply as follows; (Note that many operations are undertaken simultaneously and the phase number is not necessarily indicative of the order of the task in the construction program.)

Phase	Description
A	Jacket Fabrication
B	Topside Fabrication
C	Module Fabrication Accommodation Module Separation Modules Power Generation Module Water Injection Module
D	Jacket Load-Out
E	Jacket Transportation
F	Jacket Installation
G	Module Installation
H	Topsides Loadout
I	Topside Transportation
J	Topside / Jacket Mating
K	Hook-Up of Flowlines etc.

Jacket Fabrication

The jacket for the Platform is built in a fabrication yard in Southern Europe. The jacket is constructed on its side due to the large size. The jacket is fabricated out of specially cut steel pipe, welded together one piece at a time. Special habitats will be constructed to allow for special coatings to be applied.

Topside Fabrication

The topside of the Platform is built in a shipyard in Korea. The Platform is built using a so called 'stick build' construction method. Construction will start by framing out and welding the cellar deck primary and secondary steel work.

Special habitats were constructed such that special coatings can be applied to the decks. Upon completion, the cellar deck is relocated onto the loadout support frame which will be required on completion to assist with the loadout of the topside onto the barge/transport vessel. Once located on the loadout support frame, major equipment such as Gas Turbines and Separators will be lifted into position.

Alongside the construction of the cellar deck, construction of the middle deck will commence alongside. Once the framing is complete, any required pipe racks that hang between the cellar deck and middle deck will be installed. Upon completion, crawler cranes are used to lift the middle deck onto the cellar deck. Tertiary steel such as pipe, cable tray and instruments supports will then be installed. Fabrication of the upper deck will be ongoing whilst pipework is installed on the cellar and middle decks. Electrical and instrumentation cabling will then be installed. At the peak, some 500 people are physically working on the construction of the platform. Their functions are as diverse as scaffolders to electricians and painters to welders.

Module Fabrication

Due to the enormous scale of offshore platforms, Engineers have decided to breakout the construction of certain facilities to expedite the fabrication. Here, the accommodation module, with little in the way of hook-up scope, is fabricated in a different yard to the main topside. In this example Engineers have also chosen to fabricate water injection modules, power generation modules, and Separation modules in different yards for installation both before and after installation of the topside. Expediting the fabrication is not the only reason Engineers have chosen to modularize parts of the platform. The Engineers at the time were limited by the method of loadout and installation of the topside. Heerema's Thialf semi-submersible crane vessel, currently the world's largest, has a maximum lift capacity of 14,200 tons, whereas the finished platforms weighed well in excess of 20,000tons.

Jacket Loadout

Once fabrication is complete, the jacket is skidded onto a barge located along side the shipyard. Winches were used to move the jacket onto the barge.

Jacket Transportation

Tug boats are used to tow the barge to its final location. If the distance from the fabrication yard to the final destination is well over 1000 miles.

Jacket Installation

Due to the size of the jacket, a crane installation is not viable and therefore the transportation barge was ballasted down at one end, allowing the jacket to simply slide off the back. Controlled ballasting of the jacket then allowed for up-righting and final set down. Once in position, piles were inserted through the pile sleeves located on the jacket and driven into the sea bed by subsea pile hammers.

Topside Loadout

As the topside was constructed on loadout support frames, specially designed skid beams are installed between the topside and the transportation barge. In a similar manner to the jacket, winches have been used to drag the topside along the skidway and onto the barge/vessel.

Topside Transportation

Due to the large distances involved in transportation of the topside it is transported on a heavy lift ship.

Topside Installation

Once on site, the topside is lifted into location using a heavy lift crane barge.

The platform is then hooked-up to the subsea infrastructure such as flowlines, power cables and communication cables.

Appendix

Claim Example

Using the fictional project described in the section above, a typical claim scenario is given below.

During the shipyard fabrication of the topside, a production module has been completed and delivered to the shipyard by barge. The module is being lifted from the delivery barge utilizing a floating crane. Once the load is picked-up the floating crane was maneuvered across the quay to waiting topside on the skidway. During the maneuver the module dropped into the quay in approximately 20m of water. The module was recovered.

Following the recovery and upon inspection, all four of the lifting padeyes had become detached from the module frame. Further investigation revealed that the padeyes had been welded to a sub structure of the module, rather than the main structural members.

Whilst the design drawings showed that a steel plate was to be welded to the module, the intention was that this be installed after the module was lifted and installed in its final location. On inspection, and as shown in the following image, full penetration welds of the pad eye had been completed, but only to the 8mm steel plate rather than to the main structural frame, as per the design.

The cost of replacing the module was US$15,000,000 for 100% Gross. US$250,000 deductible applies to shipyard fabrication losses.

The construction project was insured on WELCAR 2001 wording.

Key Claim Issues for Consideration

A. Who was responsible? What is their status in the project? What is the extent of their liability, if any?
B. Is there a 'defective or faulty workmanship' issue to be addressed? If so, what is the defective part and what are the costs associated to rectifying the defective part?
C. US$5,000,000 of the repair costs relate to increased costs of installing the replacement module in the at the final location offshore North Sea. The lead time to fabricate a replacement module was 3 months and would have delated sail away of the topside by 2 weeks. It is estimated that the Assured would have incurred an additional US$ 10,000,000 in hire charges for having the heavy lift vessel on standby for the 2 weeks. Is the additional cost of installing offshore reasonable and should it be included in the adjusted claim?

Appendix

References Bibliography and sources

- Offshore code of Practice VdS 3549 en 2014-01 (01)
- WILLIS TOWER WATSON Energy losses data base
- “Introduction to Offshore Structural Engineering” By:

  PerIvar Lokstad, Senior Structural Engineer, Ph. D (Marine Technology, Norwegian Institute of Technology, Norway), Technip Geo-production (M) Sdn Bhd, Malaysia

  Khairudin Ahmad, Senior Structural Engineer, M. Eng. (Structural Engineering, Cornell University, USA), Technip Geo-production (M) Sdn Bhd, Malaysia
- Shah Deniz 2 Project ; “Environmental & Socio-Economic Impact Assessment: November 2013 Final Issue
- Pictures of: “The Piltun-Astokhskoye-B (PA-B)”, the largest platform of the Sakhalin-2 project
- https://www.connaissancedesenergies.org
- “Fire and explosion modeling on off-shore oil and gas platforms”, Doctoral Thesis. Submitted in partial fulfillment of the requirements, for the award of Doctor of Philosophy of Loughborough University.
- By Jeni Louise Lewthwaite - April 2006 Loughborough University Institutional Repository
- Birch, A. D., Brown, D. R., Cook, D. K. and Hargrave, G. K., Flame Stability in Under expanded Natural Gas Jets. Combustion Science and Technology, Volume 58, pp 267-280,1998.
- Birch, A. D., Brown, D. R., Fairweather, M. and Hargrave, G., An Experimental Study of a Turbulent Gas Jet in a Cross-Flow. Combustion Science and Technology, Volume 66, pp 217-232, 1989.
- Lees, F. P., Loss Prevention in the Process Industries. Butterworth Heinemann, Reed Educational Publishing Ltd, Second Edition 1996
- “Swiss Re Underwriting Offshore Energy Risks” Swiss Re Centre for Global Dialogue Gheistrasse 37 8803 Ruschlikon Switzerland - 2016 by David Sharp & Rick Perdian
- “An Overview of Design, Analysis, Construction and Installation of Offshore Petroleum Platforms Suitable for Cyprus Oil/Gas Fields” by Kabir Sadeghi, GAU J. Soc. & Appl. Sci., 2(4), 1-16, 2007 Girne American University, Department of Industrial Engineering, Mersin 10, Turkey
- “Introduction to Energy Insurance” by Gard AS, Arendal 21 October 2010
- “Construction Planning of an Offshore Petroleum Platform” By O. A. Muyiwa & K. Sadeghi Girne American University, Faculty of Engineering & Architecture, Mersin 10, Turkey