LLOYD'S

ENERGY

DRILLING IN EXTREME ENVIRONMENTS:

Challenges and implications for the energy insurance industry

POST MACONDO

OEE POLICIES

HPHT

OPOL

PORE PRESSURE

About Lloyd's

Lloyd's is the world's leading specialist insurance market, conducting business in over 200 countries and territories worldwide – and is often the first to insure new, unusual or complex risks. We bring together an outstanding concentration of specialist underwriting expertise and talent backed by excellent financial ratings which cover the whole market.

This report was produced by the Class of Business and Exposure Management departments within the Lloyd's Performance Management Directorate. The Class of Business department is responsible for understanding and managing the market's performance at a class of business level and providing information and support to the market on all underwriting related matters. Lloyd's Exposure Management team is responsible for understanding and managing market aggregation risks and alerting the market to emerging risks.

About the authors

Andrew Rees graduated with a degree in geology and his first career move was to work as a mudlogging/pressure control engineer. This involved working on land and mobile offshore drilling units during the drilling of exploration wells and his role included responsibility for the early detection of drilling problems and kick situations.

After six years in the oil field, Andrew made the transition to the insurance world, working for two major energy brokers, ultimately as an account executive. Having gained invaluable insurance knowledge in this role over a six year period, Andrew joined Matthews Daniel in 1995 and has been a Director since 2002. He has been involved in the handling of many high profile claims, including the Lapindo Brantas Indonesian mud volcano and the Deepwater Horizon loss.

Andrew was the main contributory author for the "Overview of Drilling in Extreme Environments" section.

David Sharp has worked in the marine and energy insurance industry for 48 years. His background is principally in broking, latterly with Sedgwick (now Marsh) and AAA. His specialisation has been on oil company package insurance, including construction risks, control of well and pollution. He has led broking teams on complex insurance placements on offshore risks in areas as diverse as Australia, New Zealand, South Africa, Canada, Russia, Brazil, Indonesia, Malaysia and China, as well as being involved on many placements in the UK sector of the North Sea and the Gulf of Mexico.

David is the author of an industry publication entitled "Offshore and Upstream Energy Insurance", published by Witherby Seamanship in January 2009. He provides training courses for bodies such as the UK Chartered Insurance Institute and has contributed to their standard training manuals. He is a regular contributor at industry related conferences, having spoken in Singapore, Houston, Norway and the UK. David is now employed on an independent basis as a consultant and undertakes peer review work for a Lloyd's syndicate.

David was the main contributory author for the "Implications and Challenges for the Insurance Industry" section.

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Figures

foreword

The energy industry plays a vital role in the global economy and societies across the world. Lloyd's has a long history of working with and supporting the energy industry in playing this role. We provide cover to allow many oil and gas companies to take the risks they need to operate and grow their businesses. Currently, a significant proportion of global offshore energy premiums are written in Lloyd's[1].

Oil and gas companies are moving into new and increasingly harsh and remote environments to meet the world's growing demand for energy. However, exploring new frontiers carries risks and the Macondo incident in 2010 (often referred to as Deepwater Horizon) underlines the importance of understanding, mitigating and managing these risks as effectively as possible.

Many bespoke energy insurance products were developed when the energy industry was younger and had different needs. While these solutions responded to the industry's changing requirements, Macondo has highlighted the need to take a fresh look at the cover available. This report focuses on the products which currently exist and how insurance industry support for the energy industry will develop in the future. We need certainty about contracts for pollution and clean-up cover and both unanticipated and accumulating risk, to be able to provide the energy industry with the capacity and products it needs.

To explain the key issues involved in providing workable risk transfer solutions to oil and gas companies operating in extreme environments, this report has been produced in partnership with two industry experts. Andrew Rees uses his engineering expertise to explain the technical and operational challenges involved in drilling in extreme environments. David Sharp brings decades of experience as an energy broker to demonstrate how the market has fundamentally changed since Macondo and how the insurance industry needs to respond if we are to continue to work in partnership with the oil and gas industry.

We cannot eliminate all the risks involved in drilling in more extreme environments. We can, however, continue to evolve to meet the increasing demands of the energy industry as it reaches new frontiers.

Tom Bolt
Performance Management Director
Lloyd's

executive summary

1. As drilling moves into more extreme environments, the technical and operational challenges will increase

Both the costs and the risks of offshore drilling increase in deeper waters. The issues faced are significant and complex. To fully understand why deepwater introduces new complications and challenges, we need also to understand the technical difficulties involved in drilling in extreme environments.

2. The Macondo incident highlights the heightened risks of drilling in extreme environments

The Macondo incident was the first major oil spill in deepwater. The complexities involved in drilling this well and the difficulties in restoring control of the well and tackling the subsequent pollution and environmental damage highlighted the additional problems of managing risks in extreme environments. One of the toughest challenges will involve managing regulatory changes, especially if higher economic damage costs are imposed in the US.

3. The Arctic presents a unique set of risks for the energy industry

The potential wealth of natural resources in the Arctic and the loss of sea ice due to climate change is resulting in increased drilling activity in the region. As this activity moves further offshore and into remoter areas the operational, environmental and regulatory risks for oil and gas companies will grow significantly, with considerable implications for insurers.

4. There are uncertainties over available pollution cover in existing policies

In contrast to pollution cover under OEE policies, there is a perceived lack of clarity in relation to the scope of cover under standard forms of liability policy, particularly concerning clean-up expenses. However, the OEE policy is subject to a combined single limit and this may reduce the available cover under the policy for pollution costs, since the limit may be absorbed first by control of well and redrilling claims. Should a significant deepwater control of well incident occur, there may not be much (if any) limit available for seepage and pollution under the combined single limit for the OEE section. This leaves insureds seeking either more OEE cover, with the same lack of certainty over the combined single limit, or relying on their liability policy with its different triggers and exclusions. Pollution insurers need to fully understand the risks to develop appropriate products, aggregation management and pricing methodologies.

5. Higher limits may need more capacity in the insurance market

Many insureds, having reviewed their limits in the context of the Macondo incident, require higher limits for pollution and this will be exacerbated by impending legislation in the USA and elsewhere which may require insureds to purchase higher limits of pollution cover. There are initiatives within the insurance market to increase the supply of capacity for pollution insurance, but insureds will want to be satisfied that the coverage is appropriate and economic.

6. Insurers need to identify and monitor their accumulated exposure

Drilling in deepwater and remote environments increases the potential for significant aggregation in exposure. Well control and pollution losses may aggregate with physical damage, business interruption and removal of wreck claims, as well as any claims for death and injuries of personnel. This position is further complicated as each oil company in a joint venture will normally insure its interests under its own package policy. Insurers have developed sophisticated monitoring systems to track their aggregated exposures and will need to ensure these systems remain adequate in the future and can monitor the potential ‘clash’ of claims from several sections of a package policy, as well as from multiple insureds.

7. Insurance and energy industrIES should work in partnership

Insurance markets should work in partnership with the oil and gas industry to develop products that meet the needs of both parties, ensuring that companies have sufficient cover and insurers have enough capital to fully cover the risks involved and provide appropriate returns to capital providers. In turn, it is important that the energy industry adopt standards that ensure safety and reliability in the design and execution of drilling in extreme environments and restores confidence.

INTRODUCTION

Even in the wake of the global economic crisis, worldwide energy consumption continues to surge, fuelled by growth in emerging markets.

This ongoing demand for energy, together with diminishing supplies of traditional fossil fuels, especially in areas where they are easy to find and recover, is pushing oil and gas exploration out into new geographical and technological frontiers. This not only brings with it fresh new challenges and risks for oil and gas companies operating in these more extreme environments, but also for energy insurers who help the global energy industry manage the risks associated with offshore drilling.

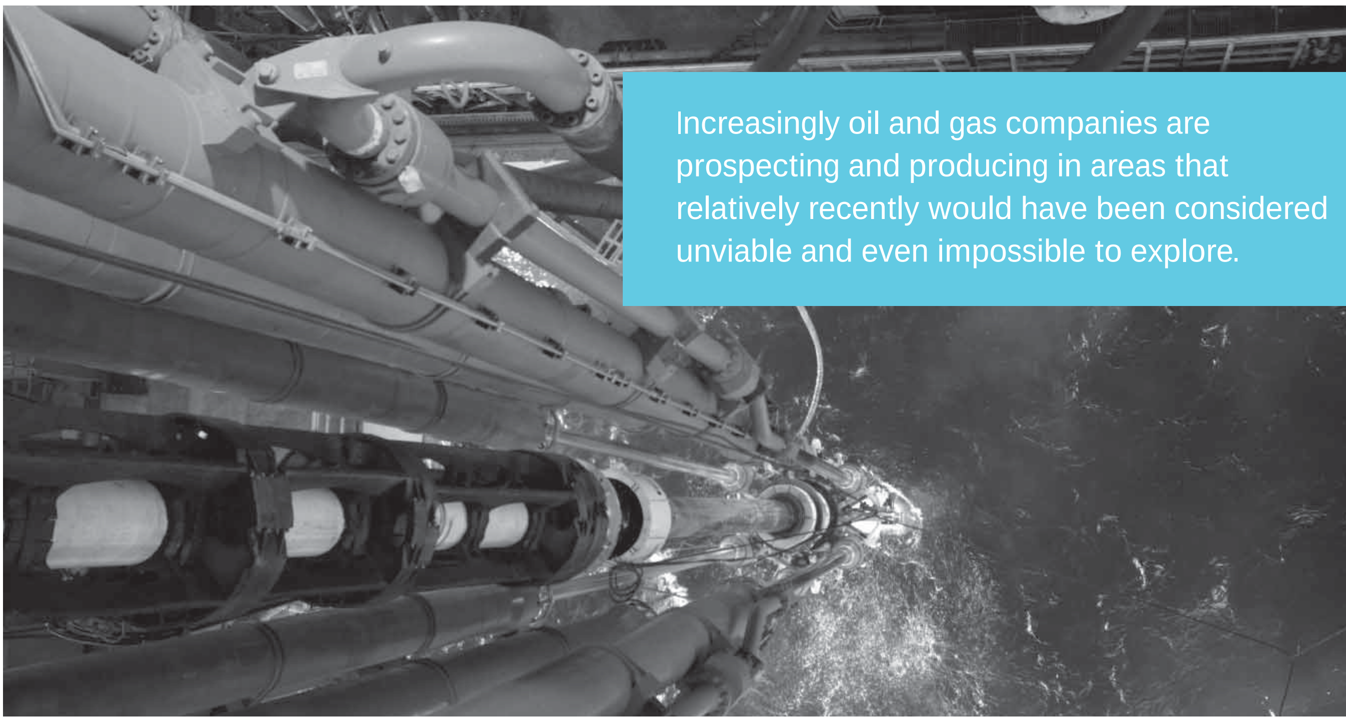
Increasingly, oil and gas companies are prospecting and producing in areas that relatively recently would have been considered uneconomic or even impossible to explore. This includes operating in ever deeper waters and moving into more remote and hostile environments. Over the past 30 years, offshore drilling has progressively been pushing back the frontiers of technology. Water and drilling depths have increased dramatically as the search for hydrocarbons has moved towards the outer edge of the world's continental shelves. This search has also advanced to some of the earth's most remote, extreme and often vulnerable environments, including the Arctic.

This report will examine the potential implications for the insurance industry in terms of drilling in extreme environments, particularly in the wake of the Macondo incident.

The first section of the report will provide an overview of deepwater drilling processes and techniques and in particular the technical and operational challenges facing oil and gas companies. It will examine some of the key issues they must consider, including well control and blowout prevention. It will also explore some of the wider environmental, regulatory and reputational implications operators in these extreme environments need to consider. The section includes a case study on some of the unique challenges facing energy companies operating in the Arctic.

The second section of the report examines in detail the insurance implications of drilling in extreme environments. It explores the challenges facing the market in the wake of Macondo and in particular how insurers need to address the issue of pollution liability coverage. It also discusses how rates, capacity and policy wordings have developed post-Macondo and the initiatives being undertaken to address ongoing challenges in the market. Finally it considers the implications of future regulations on both the energy industry and the insurance market.

The report concludes with Lloyd's views on the next steps for energy insurers in addressing the challenge of drilling in more extreme environments.



Increasingly oil and gas companies are prospecting and producing in areas that relatively recently would have been considered unviable and even impossible to explore.

Overview of drilling in extreme environments

> For decades the industry has known that significant conventional reserves exist in less accessible or environmentally fragile areas of the world. However, development of these areas is not without risk or cost.

With increasing demand for energy, but dwindling supplies of traditional fossil fuels, one response from the oil and gas industry has been to seek natural resources in increasingly remote and harsh environments.

The commonly held view that "all the easy oil is gone," which frequently accompanies announcements of new technology or new areas of oil and gas exploration, is almost certainly true, but what options are left for the energy industry to exploit remaining reserves of oil and gas?

In terms of fossil fuels, the uncomfortable reality is that relatively few alternatives exist. Options include:

- maximising recovery from existing reservoirs by enhanced oil recovery techniques, such as steam assisted drainage
- exploitation of non-conventional reservoir sources, such as shale gas or oil sand tar deposits
- development of the suspected vast reserves located in remote and extreme environments, such as deepwater and the Arctic.

Although this report does not specifically look at the role of renewable energy, these constraints on fossil fuel supplies, coupled with the European Parliament's recent ruling to reduce carbon emissions to at least 80% below 1990 levels by 2050, make renewables an inevitable and desirable part of our future energy mix. Unless Carbon Capture and Storage (CCS) can be successfully implemented, fossil fuels must be phased out in order to meet this target.

For decades, the industry has known that significant non-renewable conventional reserves exist in less accessible or environmentally fragile areas of the world. However, development of these areas is not without risk or cost. Any interference with fragile ecosystems, such as the rainforest or the Arctic, may have a negative impact on these environments and attract negative media attention, which can severely damage a company's reputation. Those operating in these extreme environments also need to consider the public's increasing environmental awareness: a growing number of compensation claims go beyond recovery and clean up costs and now include the impact of ecosystem losses to local economies. However, it is no surprise that drilling in extreme environments, despite the technical, environmental and logistical challenges involved, is actively being pursued. This section focuses on the issues involved in drilling for oil and gas in two environmentally extreme areas; deepwater and the Arctic. The first part examines the issues relating to deepwater, with particular focus on some of the technical and operational challenges, which will have implications for insurers. The second part explores the Arctic as a particularly unique and challenging environment for drilling.

A. Evolution of Deepwater Drilling

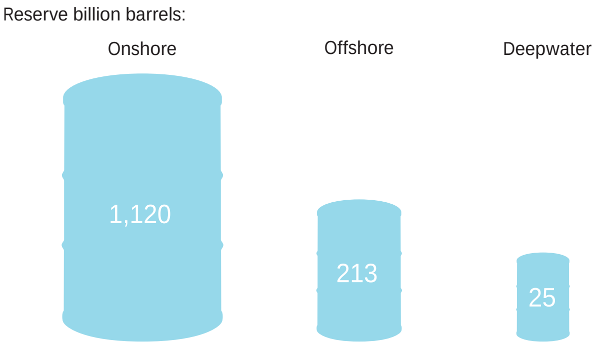
No existing example better highlights the inherent risks involved in drilling in deepwater than the Macondo blowout on 20 April 2010. This disaster raised awareness of what can go wrong and prompted a US moratorium on deepwater drilling on 30 May 2010. Following regulatory changes, this was lifted in October 2010 and new deepwater drilling permits are being issued. However, the risks remain and below we provide an overview of the challenges involved in deepwater drilling and identify the technology currently being employed to reduce risk and increase efficiency.

Deepwater drilling is conducted on the outer limits of continental shelves and the industry commonly regards any well drilled in excess of 1,000 feet as 'deep' and 5,000 feet as 'ultra-deep'[2]. The current locations of active or planned deepwater drilling operations are shown on the map below, with much of the activity occurring within the so-called 'deepwater golden triangle' encompassing the Gulf of Mexico, Brazil and West Africa.

According to the International Energy Agency (IEA), at the end of 2008 the world's total offshore crude oil reserve was 213 billion barrels (approximately 18% of the total oil reserves), of which deepwater oil reserves constituted 25 billion barrels (see Figure 2). The volume of new reserves being discovered in deepwater has seen an upward trend since the 1990s and has become increasingly significant in recent years. For example, from 2006 to 2009 annual deepwater discoveries rose from 42% to 54% of all discoveries, both onshore and offshore[3]. In 2008 alone, deepwater discoveries added 13.7 billion barrels of oil equivalent to existing global reserves[4].

The first deepwater well drilled in over 1,000 feet water depth was in 1975, with the 5,000 feet ultra-deep water threshold

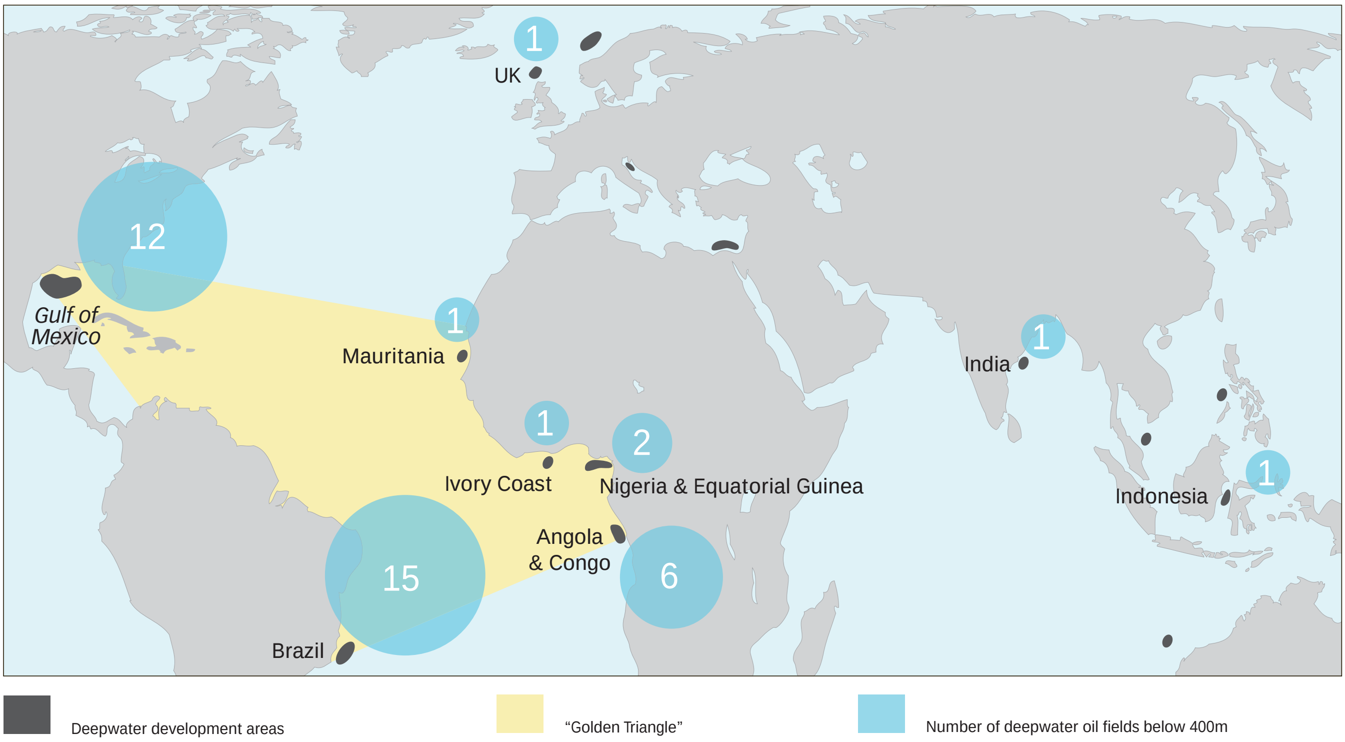
Figure 2: World offshore and onshore oil reserves[5]



Note: Figures are a representative sample of the world's major oilfields in billion of barrels.

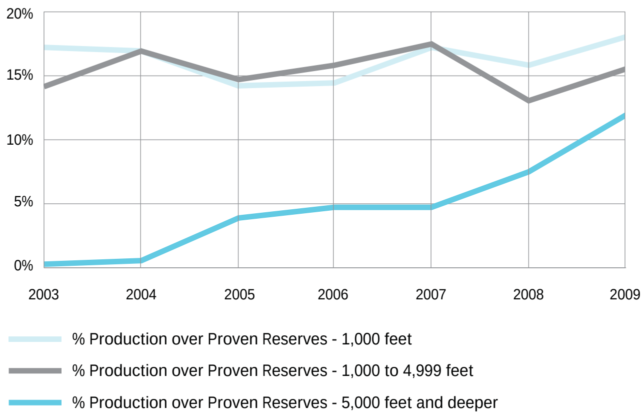
Source: World Energy Outlook 2010 © OECD/International Energy Agency 2010

Figure 1: Location of deepwater drilling oil fields



Source: Petroleum Economist

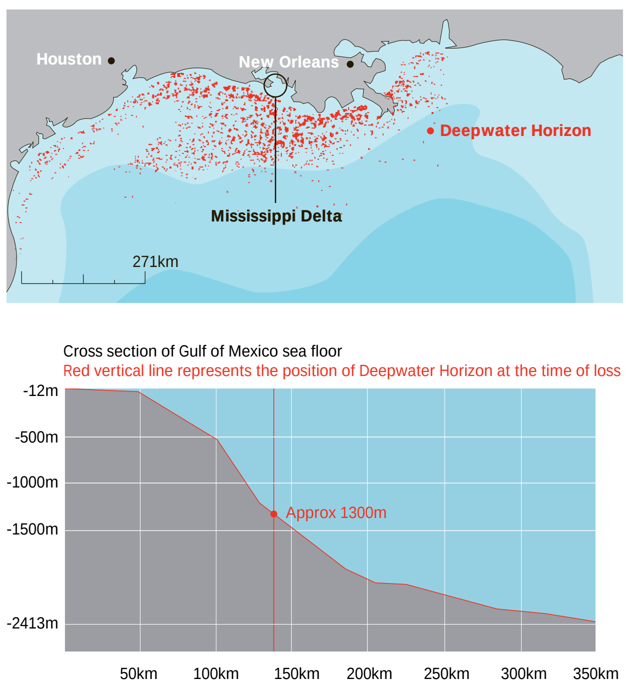
Figure 3: Percentage of proven reserves in production in the US Gulf of Mexico[6]



Source: US Energy Information Administration

being passed in 1986. Both these wells were in the Gulf of Mexico, but the current water depth record was set in early 2011 at 10,194 feet off the east coast of India. Production from deepwater fields started around 1995 in the Gulf of Mexico and accelerated from 2000 as increasing oil prices made expensive offshore projects viable. Although the cost and expertise required to drill deepwater wells has historically made them the preserve of the major oil companies, in recent years increased levels of funding and the availability of out-sourced expertise has allowed some mid-sized and smaller operators to drill in deeper waters. Growth in production of

Figure 4: Rigs and platforms in the US Gulf of Mexico (as at April 2009)[7]



Source: Eqecat EEF Generator

deepwater reserves is shown in Figure 3 with the current concentration of rigs and platforms in the Gulf of Mexico shown in Figure 4. However, this trend may slow down in the US post-Macondo, with increased financial responsibility likely to be imposed upon operators. The second section of the report examines this in more detail.

The cost of drilling in deeper water is not linear with depth; it increases exponentially[8]. The risk also increases significantly. The challenges faced are significant and complex: from the rig to the deepest section of the well. While some of the difficulties faced are identical to routine drilling operations, to understand why a deepwater environment introduces added complications and new challenges, it is important to recognise the technical challenges involved in drilling in extreme environments, especially deepwater.

B. Deepwater Drilling Challenges

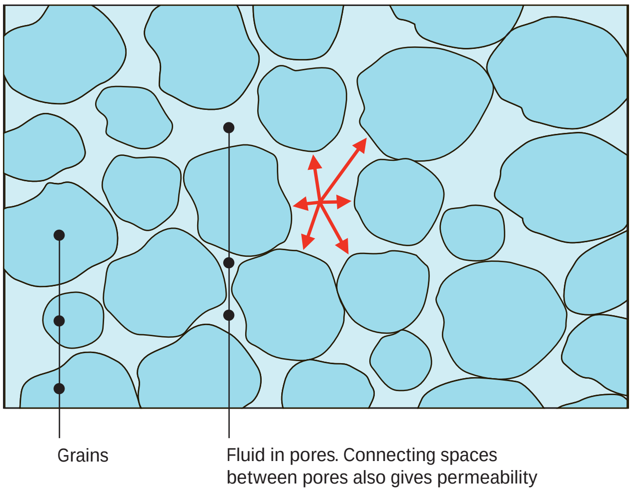
A well is normally drilled to obtain geological information and/or to produce or aid production from reservoir formations. In addition to the well having a planned total depth, it will also have a planned minimum bottom hole diameter. The tools which have to be run in the well to obtain geological information are not widely available with a diameter of less than six inches and production engineers will also require a minimum bottom hole size when installing completion equipment to ensure production efficiency.

The well depth and its lowermost diameter will have a major influence upon its design, especially so in deepwater. To understand the reasons for this, it is important to identify several key factors which influence the way any well is drilled and why these need extra careful consideration in deepwater. The interaction between some of these factors also has a direct bearing upon the design, complexity, cost and risk of the well.

Pore Pressure

Oil and gas reservoirs are located in sedimentary rocks. By their nature, sedimentary rocks are usually granular, with pore spaces between individual grains: the larger the grains, the larger the pores. The size of the pores and degree of interconnectivity determines the important rock characteristics of porosity and permeability (see Figure 5). If these properties are favourable and the pores are filled with hydrocarbons, a formation may be considered to be

Figure 5: Pore pressure[9]



Source: Andrew Rees

a viable reservoir. However, the overlying sedimentary rocks which must be drilled to reach the reservoir will also have varying degrees of porosity and permeability and may also contain pressurised pore fluids, such as water, gas or oil. The pressure is derived from the weight of the overlying rocks – the overburden. It is the most fundamental principal of drilling that pore pressures have to be managed as a well is deepened to prevent an uncontrolled influx into the well and the risk of blowout.

Drilling fluid (commonly referred to as 'mud' in the industry) is used for this purpose. The well is normally kept full of mud with a calculated weight to balance the pore pressure at any given depth. However, the rock sequence is never uniform and the diversity of rock types and historical tectonic activity results in pore pressure switches and over pressure/under pressure. For this reason, the mud weight frequently needs to be changed throughout the drilling process.

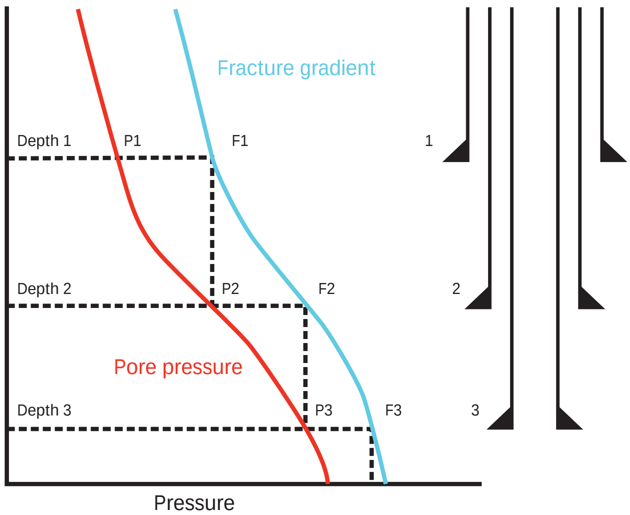
Fracture Gradient

A second important parameter is the point at which a rock will crack under the weight of the mud in the well. This threshold is known as the fracture gradient. In advance of a well being commenced, engineers will predict pore pressure and fracture gradients throughout the entire rock sequence to be drilled. This information, which will identify variations and switches in pore pressures, determines the depths that lengths of steel pipe, known as casing or liner strings, are installed and cemented in place to isolate drilled sections. Once isolated, mud weight can be raised or lowered, as necessary, to manage pore pressures as the well is deepened. Given that there are only a limited number of casing/liner diameter options and the requirement for a minimum hole size at total depth, drilling any deep well will clearly present a challenge. It is a classic risk/reward situation. Whilst cost savings of millions of dollars can be achieved by cutting out a single string, it may also increase the risk of wellbore instability or a well control situation developing.

Pore Pressure/Fracture Gradient Window

A deep well in deep water increases the difficulties. The small tolerance between pore pressure and fracture gradient is probably one of the most recognised deepwater challenges[10]. This 'window', through which a well can be safely drilled, is typically narrower than in an equivalent well depth drilled onshore or in shallow water. As the weight of the overburden, which affects the stress regime at any given depth, is the most important function in calculating fracture gradient[11], it follows that a seawater column, being lighter than an equivalent height rock column, results in a lower threshold at which a rock will crack. As the pore pressure is not affected to the same extent, the deeper the water, the more the window between the pore pressure and fracture gradient is reduced. This requires the installation of additional casing and liner strings to keep mud weight within the operational window.

Figure 6: Casing setting depth and wellbore design



- In this simplified example, which is used for illustrative purposes only, the shallowest casing, string 1, is set at depth 1, where the pore pressure is P1 and the fracture gradient is F1.
- Drilling continues to depth 2. At this depth, the pore pressure has increased to P2. The weight of the mud in the well will also have been raised to manage the increase in pore pressure. However, the weight of the mud in use is now almost equal to the fracture gradient at the seat of the last casing (F1).
- To safely drill ahead, casing string 2 is installed, with an increased fracture gradient at its seat of F2.
- Drilling and setting casing in this manner continues as the well is progressively deepened.

Source: Andrew Rees

Shallow Well Sections

Maintaining a balance between pore pressure and the fracture gradient is a particular problem in both the shallow and deepest sections of deepwater wells. Just below the seabed, the rocks are relatively young, unconsolidated and may contain high volumes of water due to low levels of compaction. Drilling shallow sections with a mud weight significantly above a normal seawater gradient runs the risk of fracturing formations and inducing fluid losses. For this reason, shallow sections are commonly drilled with seawater as a drilling fluid. Seabed well control equipment is not normally installed, primarily due to a lack of foundation because no surface casing has been installed in the well. It is therefore recognised by the industry that if an over-pressured shallow formation containing water or gas is encountered, the pore pressure will exceed the hydrostatic pressure of the seawater drilling fluid and a shallow water or gas blowout may occur. To avoid this, precautions normally taken include shallow hazard mapping to identify areas of risk and contingency measures to pump mud from the rig in the event that an unintended flow from the well begins.

Deep Well Sections

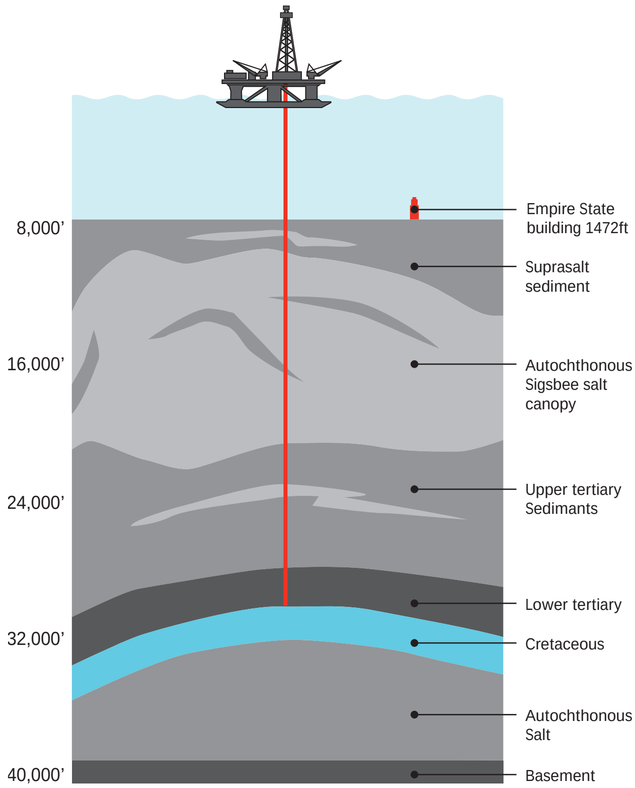
As the well is deepened, the operating window between pore pressure and fracture gradient reduces. This problem is compounded as the drilled hole diameter progressively gets smaller. The mud, which is circulated through the increasingly restricted space between the drillstring and the wellbore, adds additional pumped pressures, over and above static hydrostatic pressures. Careful wellbore design, mud composition and monitoring, and sympathetic drilling practices to avoid surging[i] or swabbing[ii] of the mud, is required to maintain well stability. Occasionally conditions mean that a well cannot be safely drilled to a planned depth. It is not generally known, for example, that the drilling of the Macondo well was stopped early due to the very narrow window between pore pressure and fracture gradient which prevented drilling ahead. The blowout actually occurred during work to temporarily abandon the well while awaiting planned future completion operations.

> It is not generally known that the drilling of the Macondo well was stopped early due to the very narrow window between pore pressure and fracture gradient which prevented drilling ahead.

i Surging: Increasing the effective hydrostatic pressure of the mud by lowering the drillstring too quickly

ii Swabbing: Reducing the effective hydrostatic pressure of the mud by raising the drillstring too quickly

Figure 7: Vertical drilling depths and geological formations encountered in a typical deepwater Gulf of Mexico well[12]



Source: © 2008 Society of Petroleum Engineers

Salt Drilling

Many of the target formations in deepwater wells are located below thick, massive salt deposits. These salts have properties that differentiate them from other sedimentary rocks, so careful planning is required to avoid drilling problems. Salt formations are very difficult to anticipate as the physical structure of salt inhibits seismic resolution[13]. The lack of available seismic data also complicates the mapping of the underlying, pre-salt geological formations. Identifying the base of the salt and establishing the underlying pore pressures are two of the more significant problems here.

Another important property of salt is its low density. Being lighter than the overlying formations, it can move within the geological sequence. Salt domes are formed when massive lobes of salt start to migrate to the surface through gravitational forces, forcibly pushing through younger, more dense formations. It is easy to understand why the stress regime changes in the formations immediately above and below a salt dome can create uncertainty when drilling. The mobility of salt can also result in creep, whereby the mobile salt will start to invade the drilled wellbore. Creep can result in short-term problems, such as sticking of the drillstring, which can normally be alleviated by increasing the weight of the mud. Longer term issues, such as the crushing of casing, which can result in well control problems, can be prevented by the use of thicker-walled casing in the wellbore design.

Tar Deposits

Tar deposits are often associated with the base of thick salt formations in deepwater wells. These viscous hydrocarbons are virtually impossible to detect on seismic images and can be sufficiently mobile to flow into the wellbore. Once an active tar horizon is encountered, it can be virtually impossible to stop it from flowing and causing problems. There are recorded instances of significant drilling delays caused by tar, with well sections needing to be side-tracked to avoid the problem. One Gulf of Mexico well, operated by Petrobras, suffered a delay of 127 days and additional costs of $55.8m after encountering a mobile tar zone[14]. Once encountered, the best practice is normally to quickly drill to the planned section total depth and run casing to isolate the tar.

High Pressure/High Temperature (HPHT)

As well depths have increased, so have downhole pressures and temperatures. Industry definitions of HPHT conditions vary, but wells with a bottom hole temperature in excess of 300°F and pressures above 10,000 pounds per square inch (psi) are generally considered to fall into this category[15]. Until the mid-1990s, the components used at the bottom of the drillstring were generally considered to be 'dumb iron': basic steel drilling tools and not likely to be compromised by high pressures and temperatures. Many of the current range of measurement whilst drilling (MWD) or logging whilst drilling (LWD) tools[iii] are rated for maximum downhole pressure use of 25,000 psi and their reliability reduces as temperatures rise above 300°F. With expected downhole pressures of over 35,000 psi and temperatures above 450°F in future planned deepwater wells, this is a clear example of technology struggling to keep pace with industry requirements.

With expected downhole pressures of over 35,000 psi and temperatures above 450°F in future planned deepwater wells, this is a clear example of technology struggling to keep pace with industry requirements.

Number of Casing/Liner Strings

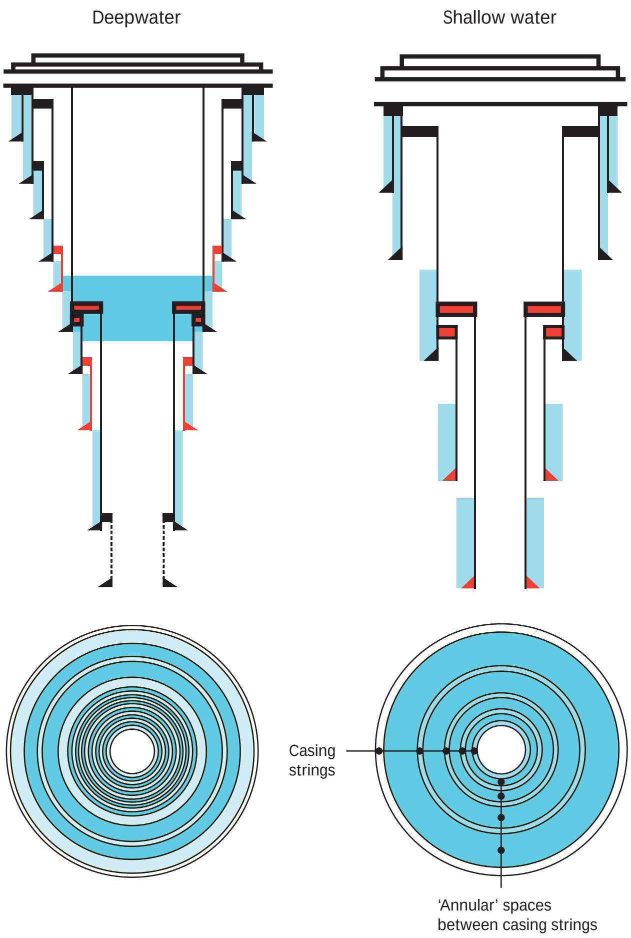
It is generally accepted that geological complexity is increased in a deepwater well. This, in combination with the narrow window between pore pressure and fracture gradient described above, requires many casing or liner strings (referred to generically as 'tubulars') to allow mud weight changes. In deepwater wells, it is common to use as many as ten tubular strings, including contingencies, compared with the five strings typically used on more conventional wells[16] (Figure 8).

As technology has advanced, the historically available 'off the shelf' range of casing and liner sizes have been increased to accommodate this requirement. Specialist

Stacked casings

iii Specialist monitoring equipment commonly found at the bottom of the drillstring to obtain real-time geological and directional data as the well is deepened.

Figure 8: Comparison between wellbore designs in deepwater and shallow water[19]



Source: © 2007 Society of Petroleum Engineers

strings can be run in-hole and then expanded in-situ, to isolate open hole well sections without a reduction in the wellbore diameter[17]. With an increase in the number of strings used, there are tight tolerances in the well and additional attention to quality assurance is required. To prevent wear and withstand a long production life, which can extend beyond 20 years, high specification tubulars are frequently used for critical well sections.

However, even with the highest grade tubulars in the well, some of the standard well design criteria cannot be met. During a well control situation, for example, the ability to force a hydrocarbon influx back into formation by pumping water under pressure to the last installed casing depth, is a typical load case used for standard casing design. A deepwater well design will not normally pass this test and the industry has made adjustments to deepwater load cases so that casing burst ratings are not exceeded[18].

Well Control Issues

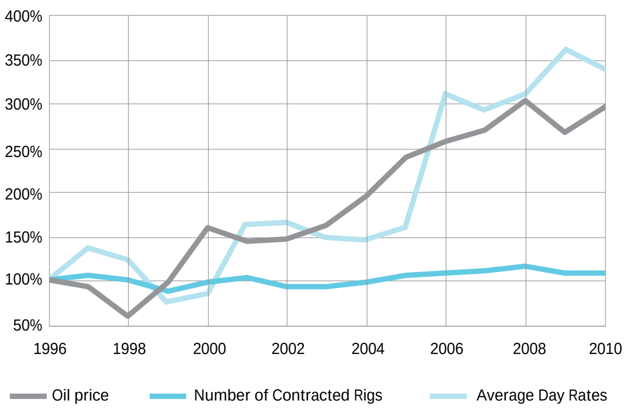
The problems faced in restoring control at Macondo have brought into focus the difficulties involved in stopping an uncontrolled flow in deepwater. Access to the wellhead on the seabed at 4,992 feet, which was considerably beyond any depth that divers can operate (typically 1,500 feet) led the head of the Incident Response Command to report that the remedial operation was "…closer to Apollo 13 than the Exxon Valdez[20]". The problems faced are compounded when additional factors are involved, including the limited supply of rigs and equipment capable of operating at such depths, and the formation of gas hydrates in the low temperature/high pressure environment.

Kick detection, the first sign of an influx of pore fluid into the wellbore, can be masked by the compressibility of the mud column (both by its own weight and circulation pressure while the mud pumps are on). Shutting off the pumps will relieve some of the compression and cause the mud to flow back at the rig. The additional frictional force imposed when pumping can also result in a temporary overbalanced situation, whereby the effective mud weight exceeds the pore pressure to the extent that mud is lost to porous formations. When the pumps are shut down, the lost mud is returned to the wellbore and a phenomenon known as 'ballooning' occurs. This can lead to flow backs of up to 50 barrels being recorded at the surface[21]. If either loss of compression or ballooning are incorrectly interpreted as a kick, time can be wasted circulating out a non-existent kick[22]. Furthermore, once a kick has been successfully identified and the well control equipment shut to stop the surface flow, the additional pressure required to circulate out the influx can be enough to break down the formation. This will complicate the well control operation and great care needs to be taken in planning and executing such an exercise.

Rig and Equipment Issues

Deepwater wells are almost always drilled using either a drillship or semi-submersible rig. However, conventional drilling rig mooring systems are not always practical in very deepwater, with the current maximum anchored depth being a semi-submersible in 8,951 feet in the Gulf of Mexico. For this reason, most of the ultra-deepwater mobile rigs are dynamically positioned and maintain position using thrusters. However, not all deepwater rigs are of the same standard, with the highest specification units in great demand and commanding day rates approaching circa $1m. During times of high oil prices and an increased

Figure 9: Indexed relationship between average day rate, contracted number of rigs and oil price (Oil price is based on Brent Crude)[23]



Source: Adapted from IUMI Global Marine Insurance report 2010

incentive to drill, the demand upon the finite supply of rigs drives day rates higher as illustrated in Figure 9.

There are currently 156 drilling units capable of drilling in depths of more than 5,000 feet, but the anticipated future demand for deepwater drilling is reflected by the further 71 units currently under construction. Most of these new rigs will be rated to drill in depths over 10,000 feet to keep pace with future industry requirements, with the highest specification units capable of operating in up to 12,000 feet of water. The increasing size of the most recent 'sixth generation' (built from 2005 onwards) vessels, which can weigh up to 30,000 tonnes, is driven by the additional equipment, storage and accommodation requirements for deepwater drilling operations. Figure 7 shows the number of current platforms or rigs relative to leases and approved applications highlighting both the shortage of available rigs and the impact of the deepwater moratorium (see Section ID).

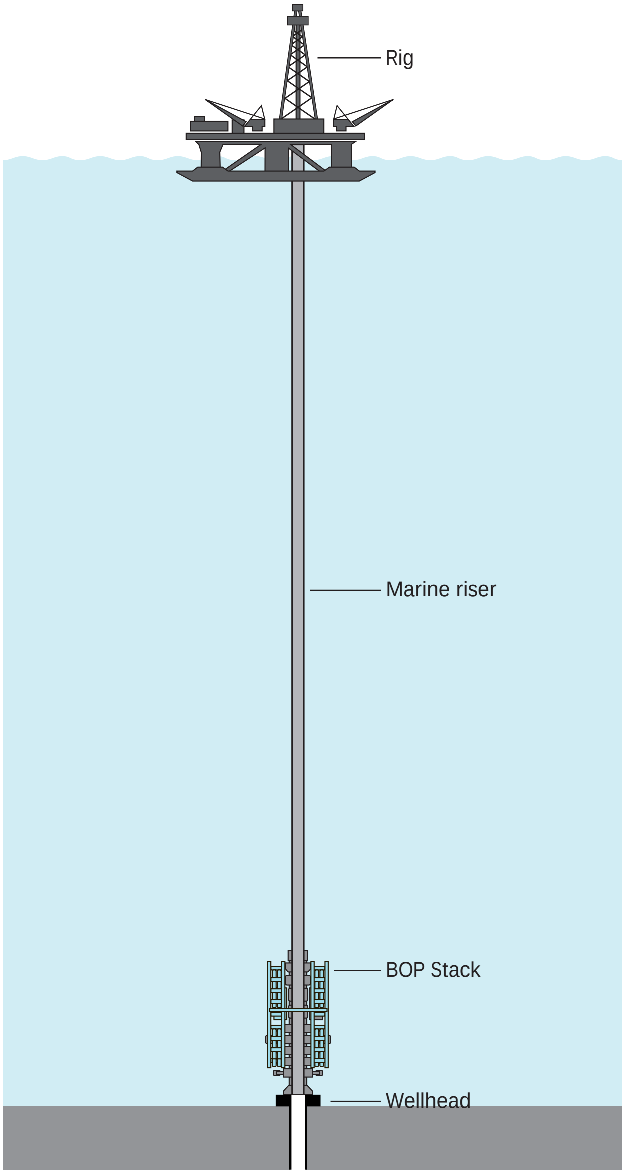
Figure 10: Offshore leases, applications and active platforms by water depth in the US (correct as of July 2011)[24]

Water depth (metres)	Active leases	Approved applications to drill	Active platforms
0 -200	1,965	33,819	3,172
201-400	130	1,110	20
401-800	300	835	10
801-1000	395	510	7
1000 and above	3,302	1,653	26

Within the energy industry, deepwater is considered over 1000ft. This is equivalent to around 305 metres. Ultradeep water is equivalent to around 1500 metres.

Source: BOEMRE

Figure 11: Simplified diagram showing the configuration of equipment between the rig at the surface and the wellhead on the seabed[25]



Source: Andrew Rees

Riser pipes

While in use, blowout preventers (BOPs) are always attached to the wellhead and normally located at the seabed on any well being drilled by a floating unit. A marine riser is used to connect the top of the BOP to the rig (see Figure 11). The riser, which is essentially an the extension of the well from the seabed to the rig through the water column, requires a minimum internal diameter (typically 19.5 inches) of not less than the largest casing string planned to be installed in the well after the BOP is in use.

It is essential that marine risers, which can be in excess of 10,000 feet in length[26], are kept in tension. Buoyancy modules are used on the riser to manage tensional stress through the string length and lighten its weight at the surface. As such, it is the weight of the casing and drillstring, which have no artificial buoyancy, which tests the capacity of the rig derrick and hoisting system on deepwater wells. Modern deepwater drilling units have hoisting systems capable of lifting weights of up to 2.5 million lbs[27].

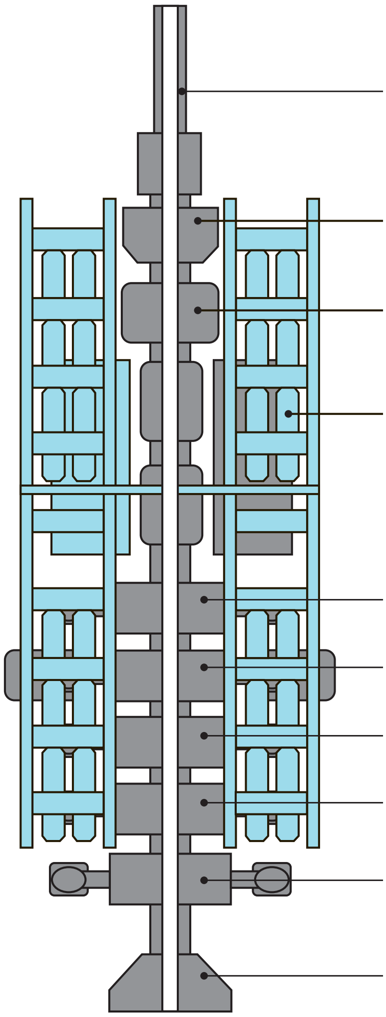
A quantity of 4,500 barrels of mud is required to fill a 10,000 foot deepwater rig riser. The capacity of the well below the seabed can double this volume and modern rigs are designed to accommodate up to 20,000 barrels in their mud tanks[28]. To keep this quantity of mud circulating, often through tolerances of less than one inch at a depth of more than 30,000 feet, the rig mud pumps must be suitably rated, with working pressures of 7,500 psi as a minimum[29]. Additional mud boost pumps and lines are often used to assist mud circulation up the marine riser, which may be laden with rock cuttings during periods of fast drilling.

Blowout Preventer (BOP) Issues and Limitations

A deepwater BOP is used to shut in the well on the seabed and its primary function is to stop a flow in the event that a well control situation develops. Figure 12 provides a schematic diagram of a BOP stack. It employs a variety of mechanical valves and devices to close either the full bore of the BOP or around any obstruction in the bore, such as the drillstring. In extreme circumstances, it may be necessary to cut through the drillstring using 'shear rams' to seal the bore of the BOP.

The ability of the BOP to perform this function and to contain high shut-in pressures are key requirements for deepwater BOPs. Although almost all deepwater BOPs in use today are rated to 15,000 psi, only one manufacturer is currently producing a 20,000 psi unit. The industry has identified a need for BOPs rated to 25,000 psi to

Figure 12: Schematic diagram of a BOP stack[30]



Source: Andrew Rees

drill future planned ultra-deepwater high pressure/high temperature wells[31].

A further example of technology struggling to keep pace with the demands of the industry is the questionable reliability of BOP shear rams to successfully cut through high grade steel drill pipe under maximum operating conditions. This is a known concern within the industry[32]. As a result, requirements have recently been added to existing regulations that specify the configuration of BOPs to ensure adequate capacity, redundancy and shearing capacity to prevent loss of well control[33].

C. Environmental Issues

There are many potential and well-documented, environmental impacts of oil and gas production in extreme environments, ranging from various forms of

Figure 13: High profile oil spills from offshore blowouts[35]

Date of Incident	Location	Incident and Spillage Details (Estimated figures)	Insured loss ($)
28.1.69 - 12.2.69	Santa Barbara, California	80,000 - 100,000 barrels	Not available
3.6.79 - 23.3.80	Ixtoc Well, Mexico	3.3 million barrels	22,000,000
22.4.77- 30.4.77	Ekofisk Norwegian Sector, North Sea	202,381 barrels	6,887,000
1980	Funiwa Niger Delta, Nigeria	200,000 barrels	53,554,000
2.10.80 - 10.10.80	Arabian Gulf	100,000 barrels	1,300,000
21.8.09 - 3.11.09	Timor Sea, Australia/ Indonesia	28,800 barrels of condensate oil	425,000,000
20.4.10 - 15.7.10	Gulf of Mexico	4.9 million barrels, plus 11 fatalities and 17 injuries	2,560,000,000

Adapted from Willis Energy Loss Database and American Petroleum Institute Analysis of US Oil Spillage 2009

pollution through to possible damage to local ecosystems, particularly oceans and wildlife, and disruption to indigenous populations. The case study below examines some of the unique issues facing the Arctic as the frontier of oil and gas exploration arrives in this region. As this report's main focus is drilling, and deepwater drilling in particular, the primary environmental concern for the energy industry and insurers is almost certainly pollution and its implications for environmental liability. In terms of pollution from routine operations, including waste drilling muds and "produced water", this is an issue that oil and gas companies have been dealing with for decades. Understandably, following Macondo, most concerns around pollution currently focus on oil spills from blowouts: an issue with potentially major implications for the energy industry and insurers.

Before the Macondo blowout, an estimated 14,000 deepwater wells had been drilled worldwide without any major oil spill incidents[34]. Although the industry knew of the potential risks, planning for a major deepwater pollution event and its subsequent environmental impact was based upon other types of offshore spills, deepwater field tests and modelling of the likely flow dynamics.

The effect of large surface oil spills at or near the shoreline are relatively well understood following tanker groundings such as the Exxon Valdez in Alaska in 1989 and the Torrey Canyon off the Isles of Scilly in the UK in 1967. The largest offshore oil spill before Macondo occurred in the Bay of Campeche, Mexico in 1979 as a consequence of a well blowout in about 160 feet of water at the Ixtoc field. This resulted in a reported spillage of approximately 3.5 million barrels of oil and clean up costs of around $100m. There have been several spills since then, mainly as a result of well blowout, but none of consequence in deepwater. Recently, in August 2009, a well being drilled by the West Atlas drilling rig on the Montara field in the Timor Sea suffered a blowout resulting in a slick of oil and condensate that ultimately covered an area of around 2,500 square miles of ocean. However, the incident occurred a long way from land and resulted in a relatively small clean-up cost. The environmental effects of this spill are still being monitored and the Government of Indonesia has recently claimed that the spill reached their waters and caused some pollution.

Conventional pollution response methods vary depending upon the nature and size of the spill, but will often initially involve containment, usually by the use of floating booms, to gather and concentrate the pollutant before removal using absorbents, skimmers or by burning. Dispersants are also widely used which contain surfactants that break down the oil into smaller droplets, so it is more likely to dissolve into the water column.

Although an estimated 180 million gallons of crude oil naturally seep into the world's oceans every year, the question of how oil reacts if it is forcefully released in deepwater remained unanswered. Some observers suggest that oil might get caught as small droplets in subsurface cross currents or stratified layers in the ocean and either never rise to surface or emerge miles from the blowout location.

Following the spill of an estimated 4.9 million barrels from the Macondo well in 2010 oil did rise to the surface. Estimates of what happened to the spilled oil suggests that 23% of the oil naturally evaporated or dissolved, 29% was naturally or chemically dispersed and 25% was directly recovered from the wellhead, burned or skimmed[36]. The balance of 23% is considered to be 'residual', which includes oil that is on or just below the surface as light sheen, weather tar balls and oil that has been washed ashore. The residual and dispersed oil is eventually likely to degrade naturally.

Post Macondo studies have confirmed the presence of a deepwater plume of highly dispersed oil droplets and dissolved gases at between 3,200 and 4,200 feet deep extending for many miles, primarily to the southwest of the wellhead[37]. The long term effect of these substances on the deepwater environment remains uncertain, with depletion of the oxygen supply and levels of toxicity to exposed organisms being two areas of concern. Although studies have shown that a deepwater plume would have formed naturally (as around 15% of the oil escaping the wellhead would have been physically dispersed by the fluid turbulence), the use of 18,379 barrels of dispersant injected into the oil and gas stream may have doubled its size. Injecting dispersant reduced the amount of oil rising to surface and the risk of highly visible damage to shorelines and surface wildlife, but at the cost of more oil remaining within the water column and the risk of longer term impact on deepwater ecosystems. Further studies and monitoring may show whether the approach used at Macondo was correct and this will clearly influence future remedial operations in the event of a similar deepwater blowout.

Efforts to control the well and contain and clean-up the pollution were extremely challenging, attracted widespread negative public and media attention and damaged BP's reputation, at least temporarily. Arguably the two industries most at risk from the Macondo oil spill, tourism and fishing, have caused the most reputational damage. BP has set up a $20bn compensation fund for individuals and businesses affected by the spill, including compensation for lost wages or profits and personal injuries. Claims ranged from tourist trade losses, including reduced hotel, restaurant and fishing charter boat bookings, to claims lodged by real estate agents and developers for depressed demand. It is clear that the long term impact of Macondo extends far beyond the difficulties involved in well control and pollution clean-up and should be carefully considered by both the oil and insurance industries when considering the risks of deepwater drilling.

D. Regulatory changes

Regulation is an increasingly important issue for oil and gas companies operating in extreme environments. There were a number of regulatory changes in the US and UK following the Macondo blowout which will have implications for energy insurers. These are examined in chapter two, but almost all involve reducing the risks of blowouts and pollution and increasing operators' liabilities for operators in terms of pollution and clean-up costs.

The US Minerals Management Service (MMS) has been disbanded and replaced by the new Bureau of Ocean Energy, Management, Regulation and Enforcement (BOEMRE). The roles of regulating, promoting safety and collecting revenue, all previously performed by the MMS, have now been separately allocated to BOEMRE and two other Government bodies. Changes to US offshore regulation were introduced in October 2010, with a new requirement to develop a Safety and Environmental Management System (SEMS). These systems analyse the human factors that are difficult to regulate with the prescriptive regulations which the US system has historically adopted[38].

While some tightened prescriptive rules remain, the SEMS moves US regulation towards safety case practices adopted by UK regulators in the wake of the Piper Alpha disaster in 1988.

In the UK, Macondo prompted a review of industry standards and regulatory practices, which decided, in the words of Malcolm Webb, Chief Executive of UK Oil and Gas, that the UK continental shelf regime is "..robust and fit for purpose..". However, a number of lessons have been learned and are being implemented, including developing a containment cap as a shared resource available for emergency use similar to that used to control the Macondo well (Figure 14). The cap, which is rated to

Figure 14: OSPRAG Capping Device[40]

Source: Oil Spill Prevention and Response Advisory Group (OSPRAG)

15,000psi and been built by Cameron[39], was successfully tested in a simulated emergency deployment exercise off the West coast of Scotland in July 2011.

The US deepwater drilling moratorium was lifted in October 2010, but it is not known if the Macondo event will deliver a similar step change in safety performance in the US oil and gas industry to that of the UK industry after the Piper Alpha disaster twenty years ago.

At a European level, the European Commission has just completed a public consultation on oil and gas offshore safety. The aim was to consider, following Macondo, whether current regulatory frameworks and practices are adequate in terms of accident prevention, emergency preparedness and response. The results will be used to establish a framework and adequate measures at a broader EU level. A draft resolution was adopted by the European Parliament in July 2011 and this is discussed in more detail in the following section. Lloyd's contributed to this public consultation and a summary of this contribution is provided below.

Lloyd's Response to the European Commission's Consultation on Oil and Gas Offshore Safety

Lloyd's has submitted a response to the European Commission's consultation on Oil and Gas Offshore Safety. Following the Macondo incident the Commission is considering whether to introduce mandatory financial security (including insurance) for oil exploration and extraction and whether to extend the Environmental Liability Directive (ELD) to cover environmental damage to marine waters. In March 2011 the Commission instigated a consultation on Oil and Gas Offshore Safety.

Lloyd's submission argues that:

- Extending the ELD would make it difficult to provide insurance for the costs of remedying environmental damage to marine waters
- The EU should focus on obtaining international agreement on a liability regime specifically designed to deal with the offshore oil and gas industry
- Current legal arrangements regarding compensation for "traditional" damage caused by accidents on offshore installations depend on national liability regimes and appear sufficient. Claims are likely to be complex and allocation of responsibility can be difficult, often involving consideration of non-European legal systems, such as the US. Consequently, it is difficult to see how the EU could improve the situation
- Insurance cannot provide a complete solution to problems of remedying and compensating for environmental damage.
- The Offshore Pollution Liability Agreement (OPOL) is a proportionate and reasonable approach to the determination of liability and of financial responsibility in the event of an offshore pollution incident
- Imposing an obligation on the offshore energy industry to purchase insurance at levels that insurers cannot provide or on a basis that insurers deem imprudent would create a substantial problem for the offshore industry.

E. Case Study: Drilling in the Arctic

Oil and gas exploration and production has been taking place within the Arctic Circle for several decades, but until fairly recently has been largely restricted to onshore or near-shore operations. The first onshore exploration drilling on the North Slope in Alaska started in the 1940s and the northern reaches of West Siberia were first drilled in the Soviet era. Near-shore drilling (i.e. within 10 miles of the shoreline) first began in Beaufort Bay in 1981 using artificially constructed gravel islands and has since moved further offshore. The Barents Sea has an offshore exploration history spanning more than 30 years.

While development of these areas continues, the remorseless drive to replace oil and gas reserves is pushing the industry into new parts of the Arctic, often into more extreme and fragile environments with ecosystems already under stress from the impacts of climate change. Such areas include Baffin Bay to the South of Greenland and locations further offshore in the Barents, Beaufort and Chukchi seas. What are the potential rewards and the challenges faced in drilling in such extreme and environmentally sensitive areas?

The potential rewards are significant. The Arctic continental shelf remains one of the last areas on earth with

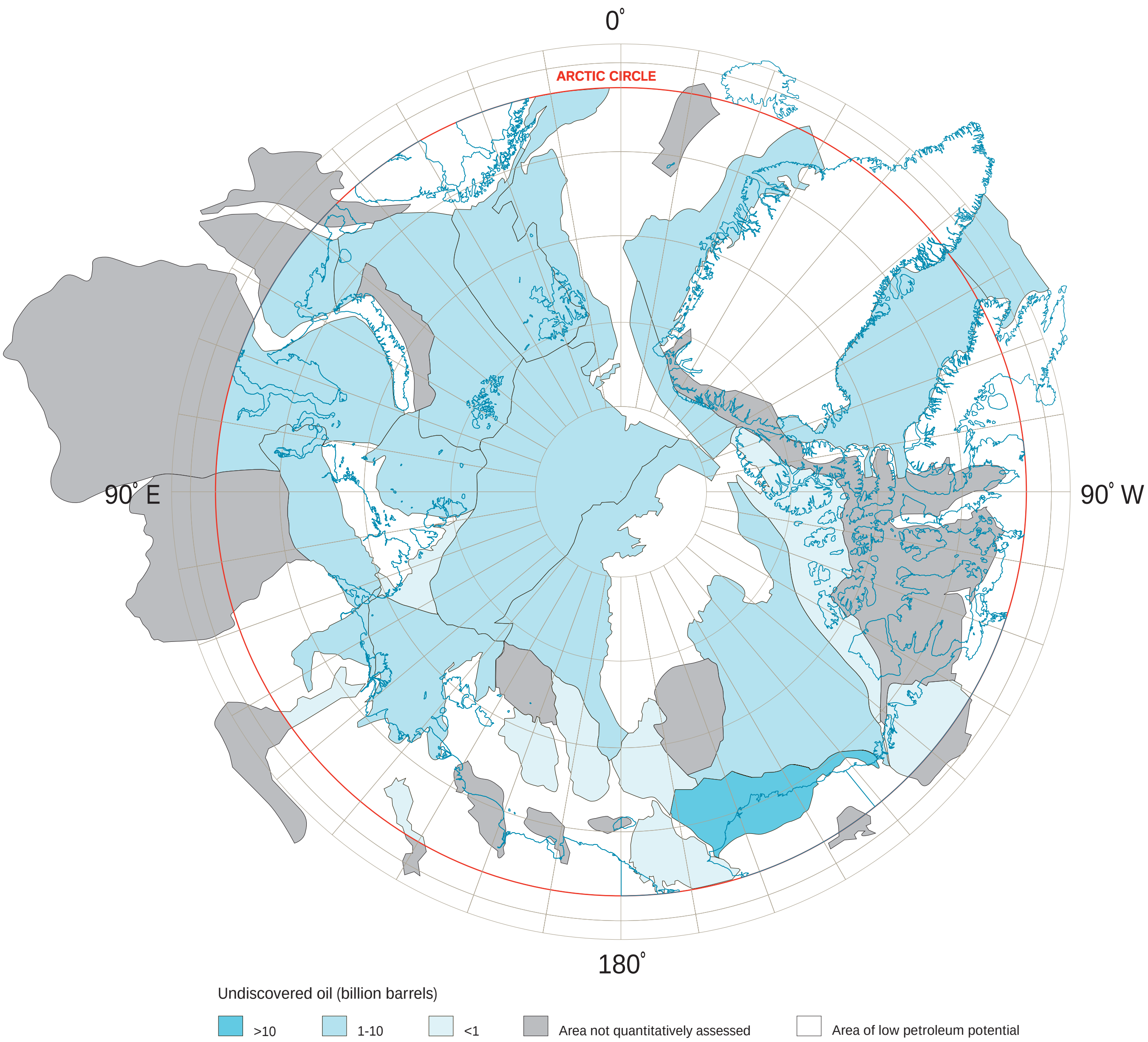
Figure 15: Map of the Arctic[41]

Source: CIA The World Factbook

unexplored potential for massive hydrocarbon reserves[43]. A 2008 United States Geological Survey estimated that areas north of the Arctic Circle had 90bn barrels of undiscovered, technically recoverable oil and 44bn barrels of natural gas liquids. This represents 13% of the expected undiscovered oil in the world with most of this located under less than 500 metres (1,640 feet) of water. However, these estimates come with a caveat - major geological uncertainty. Large stretches of ocean are still frozen for most of the year and there are restrictions on seismic acquisition and exploration drilling in many areas.

The potential wealth of natural resources of the Arctic has created heightened geopolitical tensions involving the five surrounding countries: Russia, US, Canada, Norway and Greenland. The UN Convention on the Law of the Sea allows a country sole rights over all natural resources within a 200 nautical mile zone from its coast line, but this can be increased if it can be proved that its continental shelf extends beyond this distance. This has led to disputes over the Lomonosov Ridge which is a subsea ridge of continental crust, with Russia, Canada and Greenland all claiming that it is an extension of their continental shelf.

Figure 16: Undiscovered oil in the Arctic region[42]



Source: Map courtesy of the U.S. Geological Survey

Figure 17: Summer ice cover and disputed territories[44]

Source: Boundary information sourced from the International Boundaries Research Unit, Durham University (www.durham.ac.uk/ibru/resources/arctic)

While the potential rewards may be significant they are not easily obtained. There are logistical challenges working in such remote locations, especially with poorly developed infrastructure. These are complicated by the extreme weather and its associated hazards whilst drilling. In addition, there are sensitive environmental issues to be managed, with a heightened risk of reputational damage in the event of a major pollution incident.

Extreme Weather

Both onshore and offshore drilling operations face the problem of extreme weather and its effect upon personnel, equipment and operating practices. The Arctic is characterised by extreme cold, varying forms and amounts of sea ice, seasonal darkness, high winds, extended periods of heavy fog and week-long storms that approach hurricane strength. With temperatures as low as -50°C, material properties change, uninhibited or unprotected fluids freeze and humans work at reduced efficiency. Wind chill can further reduce temperatures and its effect on humans is recognised by commonly adopted procedures for outside work[45]. However, both offshore and onshore Arctic drilling units are extensively protected from the harsh weather and routine tasks are rarely performed outside of the protected envelope[46].

Although the drilling derrick will normally be certified to operate to temperatures down to -40°C[47], it is enclosed by insulated wind walls to protect equipment and personnel. If Arctic units are not purpose built, they will typically be reinforced to withstand the increased stress caused by wind loading on the enclosures. Other preventative measures include sealing cracks to prevent water ingress, ice formation and potential wedging damage. Hot air blowers and other forms of heating will be used on the rig floor and other critical locations around the rig. Arctic diesel, with a low gelling point of -45°C, is commonly used in the winter, together with synthetic hydraulic oil suitable for use to -40°C for operating well control equipment[48].

Although extreme cold and short daylight hours affect both onshore and offshore drilling operations, both areas also face some unique challenges.

Onshore Arctic Drilling

Permafrost, which is defined as soil at or below the freezing point of water, varies in depth across the Arctic and can extend to depths below 300m in some areas[49]. Wellbore instability when drilling through this layer is common, as the heat of circulating mud can melt the frozen water matrix, allowing boulders and loose gravel to fall into the

A drilling rig in Arctic Russia.

wellbore. A more serious problem is drilling rig instability if the thaw radius around the well is not monitored and controlled. Preventative measures include keeping the mud cool and a minimal delay in isolating the permafrost section using centralised and well cemented casing. The risk of permafrost thaw, which is likely to be exacerbated by climate change[50] and drilling rig instability grows if there is heat transfer from hot oil flowing up production wells at the same location.

Offshore Arctic Drilling

In addition to the frequent high winds and waves experienced in open water, Arctic offshore drilling operations are also exposed to iceberg risk and sea ice in the colder seasons. For this reason, mobile rigs which are able to quickly disconnect from the well at short notice are used for drilling operations. This feature, together with recent improvements in the detection and monitoring of icebergs using radar satellite technology, has helped to minimise iceberg collision risks.

Mobile units able to withstand thick sea ice, however, require appropriate specification and design for year-round drilling operations. Historically, drilling units specially designed for Arctic waters often have a cylindrical body with a conical shape structure at the level of the ice-water line for breaking ice.

Climate change has caused the melting of sea ice cover for longer periods and increased the areas of open water. Units with improved seakeeping ability are thus required for some remote, deeper Arctic waters, including the Barents Sea (offshore Norway and Russia); Orphan Basin (offshore Newfoundland); and fields offshore Greenland and Iceland (see Figure 15).

The water depths in these areas range from 300m to 3,000m and several of the fields are in exploratory drilling or development planning stages. Purpose-built semi-submersibles and drillships are now being used to drill in these areas. While these are designed for ice features with

Figure 18: Sakhalin-2 Project: Molikpaq platform offshore Sakhalin[51]

Source: Sakhalin Energy

steel plate thicknesses of up to 4 inches and properties designed to withstand lower temperatures, they can also be disconnected to safeguard against large ice features and icebergs. They are dynamically positioned and capable of quickly connecting and disconnecting the marine riser[52].

Environmental Issues

The risk of environmental damage to the unique, diverse and fragile Arctic ecosystem is an area of concern for many. The Arctic largely remains a pristine, unspoilt environment due to its remote location, low population density and historical absence of industrial activity. Consequently the Arctic makes a substantial contribution to global biodiversity, with the region supporting globally significant populations of birds, mammals and fish. These ecosystems are already under stress from the impacts of climate change and this stress would be significantly increased in the event of a major oil spill. Any response to an oil spill following an offshore blowout in the Arctic is also likely to be complicated by several factors including:

- Gaps in knowledge relating to appropriate oil spill response with conventional methods of containment, dispersal and clean-up remaining unproven in Arctic waters. The method of response and effectiveness is expected to be significantly different between open water conditions in summer and ice cover in winter
- The remote location and vast distances from the infrastructure and support services required to cope with a major pollution event
- The seasonal nature of the ice pack in some areas, which can limit accessibility and the available time for relief well drilling
- The difficulties of operating in sub-zero temperatures
- The rate of natural evaporation and biodegradation of spilled oil is slower than in temperate regions due to lower Arctic temperatures
- The growing value placed on the environment by society which has raised the possibility of more frequent and higher litigation costs.

However, in certain circumstances, the presence of ice can help the oil spill response, as pack ice may prevent the oil from spreading. This natural containment, combined with reduced wave action and slower weathering in the presence of significant ice cover, can extend the potential for response operations, such as burning and dispersant[53] application. Yet, these operations themselves will have detrimental environmental impacts which will need to be managed.

Although individual Arctic countries will have their own regulatory controls, they all face similar weather challenges and infrastructure difficulties. In short, the damage caused by an oil spill in one part of the Arctic may not be limited to the waters of the country where it occurs. In recognition of this, international cooperation and standards for Arctic oil and gas activities are very important and the Arctic Council is actively involved in this area.

In the meantime, Arctic drilling continues but with heightened governmental and public awareness of the potential consequences of a major oil spill following a blowout. Examples of measures taken to manage this risk includes a requirement in Greenland for the presence of two drilling units in their waters so that a relief well can be started immediately. There is also an ongoing review of Canadian regulations in the Beaufort Sea, where there are moves to ensure that in the event of a blowout, a relief well can be drilled in the same season as the original well. Although such measures and other identified risks make the Arctic a costly and technically challenging area of operations, business and society may conclude that this is largely outweighed by the unexplored potential of much of its continental shelf.

These ecosystems are already under stress from the impacts of climate change and this stress would be significantly increased in the event of a major oil spill. Any response to an oil spill following an offshore blowout in the Arctic is likely to be complicated by several factors.

implications AND CHALLENGES FOR THE INSURANCE INDUSTRY

Prior to the Macondo loss, the overall claims record was not seriously affected by drilling in extreme environments.

A. The Offshore Energy Insurance Market: Position pre Macondo

In examining the implications and challenges for the insurance industry of drilling in extreme environments, it is important to review the position of the energy insurance market before the Macondo loss. During the previous decade, insurance market capacity had grown substantially to meet the increasing expense to the oil industry of operating in remote and hostile environments, including deepwater and the Arctic.

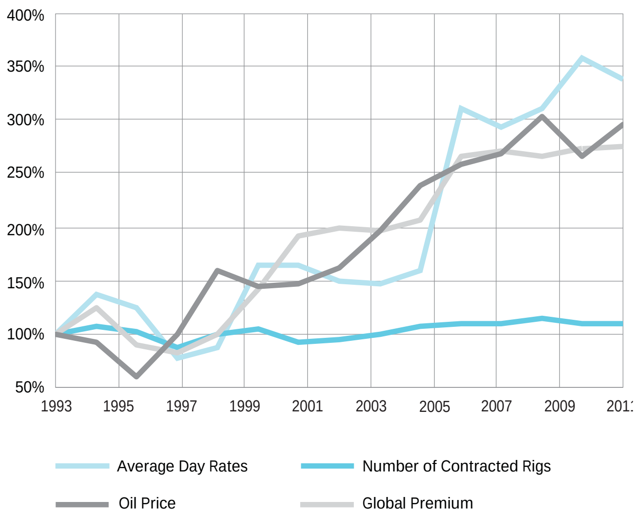
Capacity and Rates Pre-Macondo

The energy insurance industry has largely shown it can provide the capacity to cover the huge capital expenditure associated with drilling in more extreme environments. It has been helped by capital provided by the oil companies themselves through their captive insurance companies. However, such capacity is limited by the capitalisation of the captive and the fact that they do not traditionally insure third party risk. Insurance industry commentators estimate that the commercial insurance market is theoretically able to put capacity of between $3.5bn and $4bn towards these offshore energy risks. However, capacity varies in relation to the type of risk and its pricing. In general terms, maximum capacity of this size would be available for the operational risk on fixed and floating platforms once they are installed and in production. Less capacity would be available for risks priced at a level the market believed inadequate, or for specialised operations, such as exploratory drilling and construction, which are seen as more hazardous.

The largest risks in the insurance market at the moment, in terms of limit required, involve Floating Production, Storage and Offloading (FPSOs) vessels. These units are particularly suited to deepwater developments and oil fields in remote locations, because oil can be exported from the production location by shuttle tankers, rather than through expensive pipeline systems. The value of the hull and infrastructure of the largest of these vessels may exceed $2bn. The asset value frequently rises to above $3bn when the cost of the risers and mooring systems are taken into account and to more than $5bn when the sub-sea systems linking the FPSO to the wells are added. These vessels can also contain up to two million barrels of oil adding in some cases up to a further $100m to the insurance.

A strengthening oil price has contributed to the desire to explore for hydrocarbons in deeper water and remote environments. The costs and risks involved are reflected in high oil prices and in the insurance premiums generated. In the exploratory drilling phase the mobile drilling rigs being used in these environments require less capacity. Current insured values for the latest generation of semi-submersibles are around $700m. However, at present, there is a supply shortage of such units and this has led to an increase in day rates for their usage. Figure 19 shows a correlation between oil price, day rates and global offshore energy premiums.

Figure 19: Indexed relationship between global offshore energy premium, average day rate, contracted number of rigs and oil price (Oil price is based on Brent Crude)[54]



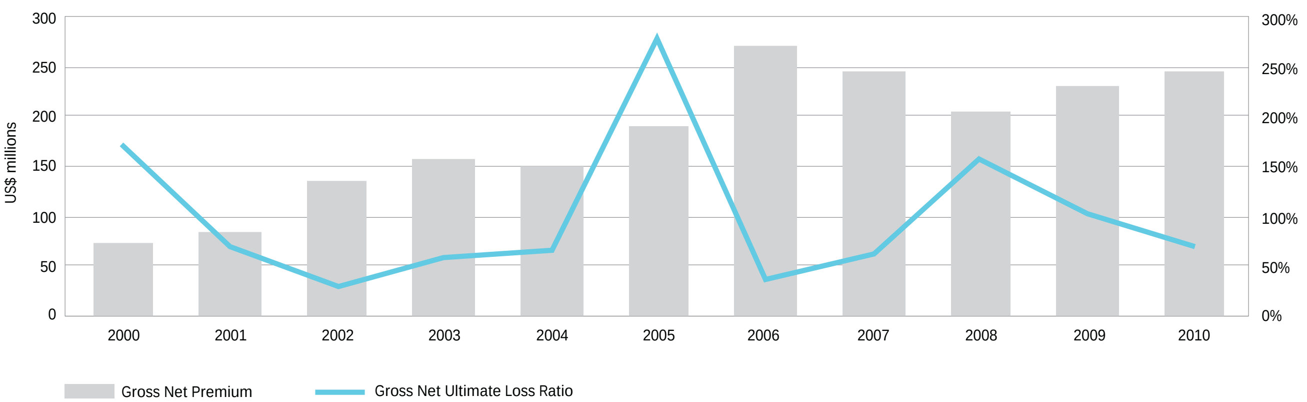
Source: Adapted from IUMI Global Marine Insurance report 2010

As suggested in the first section, repair or replacement costs for damaged infrastructure or to control wells for re-drilling or restoration are significantly higher in very deepwater than in shallow or medium water depths. The advanced technology required is expensive and a comparative scarcity of infrastructure and human resource will push costs even higher. In remote environments the expense of mobilising and demobilising equipment and specialised repair vessels will also add significantly to the overall cost. Insurers have responded to these challenges by surcharging premium rates in anticipation of such increased repair costs and also by imposing minimum deductibles. However, the scope and extent of cover for these risks has remained broadly intact to date, even when taking into account the enhanced repair costs associated with such developments.

Loss Experience

Prior to the Macondo loss, the overall claims record of the energy industry was not seriously affected by drilling in deepwater. There had been a number of construction related claims for developments in deep water and remote environments, but none so large they tested the market. Claims continue to occur in all types of offshore environment. Much attention was focused on the substantial claims arising from hurricanes occurring in the Gulf of Mexico, principally in 2004/5 and 2008. Control of well claims for making wells safe, in particular, resulted in a spike in loss ratios for these years (Figure 20). In response to this region's enhanced risk profile, insurers imposed windstorm sub-limits and aggregate limits and changed their underwriting approach for wind related control of well cover. However, by the beginning of 2010 the market had come to terms with these losses and appeared in

Figure 20: Control of Well Lloyd's Premium vs. Performance[55]



Source: Lloyd's

Is Macondo likely to happen again: probabilities and behaviour

The absence of similar losses to Macondo in deepwater does not necessarily preclude further losses in the future. A paper by the Deepwater Horizon Study Group (DHSG) based at Berkeley University examined wellbore instability rates for deepwater wells and found that the number of days spent addressing wellbore instability was almost double for more complex wells, such as Macondo, than less complex wells in shallower water. Furthermore, the paper argues that the use of blowout preventers has increasingly become a routine part of operations and that time spent using BOPs has been increasing (see section IB for an explanation of BOPs[56]) .

It is worth examining what the probability of another Macondo might be. Some industry commentators argue that 50,000 wells have been drilled since 1947 with only one occurrence of a Macondo style event. However, others counter that these numbers may be masking reality, as the absence of more incidents does not necessarily mean that the risk is a 1/50,000 event. The study completed by the DHSG found that of the 5,000 wells drilled since 1993 only 43 were as complex as the Macondo well. Is the probability of another Macondo type event therefore 1 in 43, or even higher, given that the rate of wellbore instability in these 43 wells is unusually high?

Behavioural science tells us that people can misjudge risk due to an inability to conceive possible negative events, as desired scenarios or outcomes are easier to imagine (also known as scenario bias). Furthermore, a failure resulting from a very unlikely chain of events is considered to have a negligible probability of occurrence[57]. The DHSG study suggests that a scenario involving total blow out, total loss of rig and complete loss of well control for 87 days, as happened with Macondo, was not even considered possible.

There is also a risk that both the energy and insurance industries do not learn from their experience of Macondo due to hindsight bias, by which people conclude that their ability to handle a past event was higher than it really was. When discussing the Macondo incident, Professor Nancy Leveson from MIT who acted as a consultant for the US Presidential Oil Commission also warned that the more time that passes without any incidents, the more easily organisations lower their estimates of the probability of an accident occurring[58]. The absence of events in recent history and a good safety record should not be taken as evidence that the risk is low.

Further analysis into whether or not the Macondo incident was a one-off is therefore required to allow the energy and insurance industry to more accurately form estimates of the likely frequency of similar Macondo style events.

reasonably good shape. Indeed, despite the trend towards drilling in deeper water and remoter environments, a continuing good claims experience and increasing capacity suggested that a softening market might even emerge.

Policy Wordings

Before Macondo the London Joint Rig Committee, which is a committee of London based insurers underwriting offshore energy risks, had undertaken a series of major wording reviews with the aim of providing model wording available for use by the market. A new production or “operating” form was produced and work had started on a revised form of WELCAR (the policy form designed for construction risks), which is expected to be complete by the end of 2011. It was also suggested that a new policy form for well control risks would be produced, although to date no such initiative has been started. The reasons for these policy wording reviews was to support developments in the market in relation to the scope of cover, ensure clarity of contract, and to take into account the continuing claims experience, rather than to significantly change the policy. It was the emergence of new forms of production infrastructure, such as FPSOs, that led to policy wording changes, rather than the development of deepwater drilling. At this time pollution, in terms of coverage, pricing and independent review of procedures, was not considered.

Pollution Risks before Macondo

Pollution arising from offshore blowouts and pipeline ruptures has occurred in the past. However, as mentioned in the first section, these incidents have generally had a lower profile than those involving seagoing tankers. There have also been no significant blow-outs or pollution spills in the Arctic region.

Before Macondo, the last offshore pollution event to create significant media interest occurred in January 1969. This involved a blowout at the Dos Cuadras field, offshore California, resulting in the spillage of 80,000 to 100,000 barrels of oil which damaged large areas of the Californian coast around Santa Barbara.

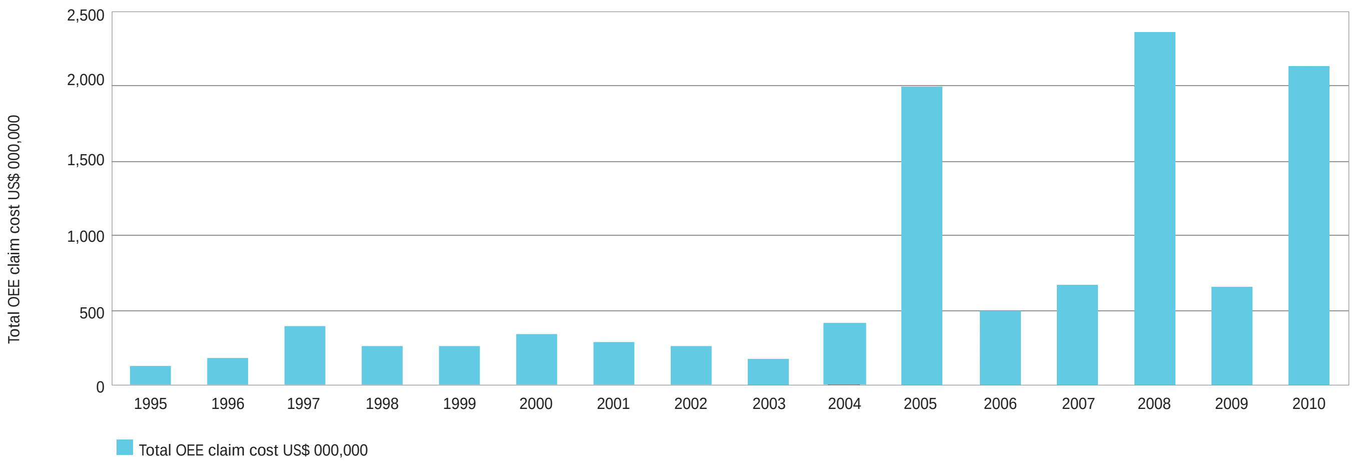
Because of the significant time lapse between the two incidents, energy insurers had not spent a great deal of time focusing on the scope of cover and pricing of capacity for pollution arising from offshore wells. This risk is covered in a specific policy form, known as Operator's Extra Expense (OEE) cover, which also covers costs to control blowouts and re-drill wells. The part of this cover that has previously received most attention was well control cost which, together with the cost of making wells safe, formed many of the claims paid out by the insurance market from the hurricane events mentioned earlier (Figure 21). All of this changed as a result of the Macondo loss. To understand these post-Macondo changes it is important to know how the market has traditionally provided cover for pollution, well control and related exposures and how the capacity for the risk had been priced.

Financial Responsibility for Pollution Risk

The way risks have traditionally been divided between oil companies and drilling contractors may be changed by Macondo. To date, the cost of well control and any subsequent pollution has been borne by the oil companies, irrespective of cause. Generally the only exceptions to this rule are losses resulting from gross negligence or wilful misconduct by the drilling contractor or units drilled by a contractor under a turnkey drilling contract. In return, the drilling contractors have accepted responsibility for pollution from fuel and bunkers on board the drilling unit. These arrangements have been backed up by mutual indemnities. This system applies almost universally as it is the oil company that is responsible to the licensing authority for well control and pollution from drilling activities on a licence block. To sub-contract this responsibility to the various drilling contractors employed on the licence block would require the oil company to monitor the financial responsibility provisions of each contractor. Pushing this responsibility down the chain would also still inevitably pass the cost of insurance back to the oil company, whose enhanced risk profile and greater funds make it better placed to absorb this risk. Additionally, the oil company can seek protection on a global basis from the insurance market and achieve economies of scale. The OEE policy has therefore evolved in response to the oil company rather than the drilling contractor.

The lesser risk of pollution from on-board fuel tanks and stores is normally insured by the drilling contractor under commercial market liability policies or in non-poolable programmes of a Protection and Indemnity Club and is not covered in this report.

Figure 21: Annual offshore OEE claims cost[59]



Source: Willis Energy Loss Database

B. Overview of cover

Development of OEE Policies

The Santa Barbara loss described above led to US insurers inserting pollution exclusions in liability policies and, as a result, significantly reduced insurance capacity for pollution risks. This gap was filled by London insurers, particularly the Lloyd's market. In the early 1970s the existing OEE policy, which at that stage covered only well control and re-drilling expenses, was extended to cover pollution liabilities and clean-up costs. By 1978 a London Composite OEE Policy emerged to cover well control, re-drilling of the well, and seepage and pollution from the well and property damage on associated equipment.

Overall claims experience under this OEE policy between the mid 1970s and mid 1980s was unfavourable. Insurers found that the language of the policy was interpreted by US courts in a manner not intended when the cover was offered. The intent had been to cover blowouts, but in some cases the policy has subsequently been interpreted to cover kicks. As a result, the policy form was changed and in 1986 a new wording emerged known as the EED (Energy Exploration and Development) 8/86 form. This has become the standard template for well control cover and associated risks for both offshore and onshore drilling. Although the insurance market did attempt to introduce an alternative wording, known as LSW 614A, in 1994 (to tighten up some of the remaining concerns with EED 8/86), it was largely rejected by the oil industry.

Third party liability risk, other than pollution arising directly from the well, was not covered by this policy form. Pollution liability from offshore production facilities, arising from leaks, ruptures and explosions (other than blowout) is included within an oil company's corporate liability policy. There are a number of such policy forms in use. Offshore liabilities are still largely underwritten under an "occurrence" based policy form, which covers incidents arising during the policy term irrespective of when the claim may ultimately be made (as opposed to a "claims made" basis of cover that responds to claims advised during the policy term). While there are variations in the coverage form, the principle features of liability cover for offshore operations are broadly similar (please see "Corporate Liability" below).

Cover under OEE Policies

The OEE policy, as represented by the EED 8/86 wording, is a composite policy form designed to "stand alone".

The semi-submersible drilling rig, Deepwater Horizon and a supply vessel

This means that it is not designed for inclusion in an oil company's package placement, although invariably it is. It includes General Conditions and Particular Insuring Conditions for each main section of cover. These main sections are control of well, re-drilling and restoration of wells, and seepage and pollution from the well.

1. Control of well

Most claims to date have occurred under control of well and re-drilling cover - the coverage being triggered by a well becoming out of control as defined under the policy. This definition is important. It relates to a flow of well fluids emanating from the well bore above the surface of the ground or water bottom that cannot be promptly controlled by certain defined actions that are clearly stated in the policy. These, for example, will include the activation of blowout prevention equipment or circulating out excess pressure in the well. However, even where the well may not strictly be considered out of control, there is cover where the appropriate regulatory authority states that it is. There is similarly a detailed definition of when the well is brought under control, as it is at this point that insurers' liability for well control costs cease. Provided the conditions as defined in the policies are met, insurers will pay the costs of equipment and manpower used to bring the well under control, inclusive of costs incurred at the instigation of the regulatory authority. At worst these costs will include expenditures for hiring mobile drilling rigs to drill relief wells (to intersect the well that has suffered the blowout and release pressure in the well).

2. Re-drilling

When a well is brought under control it may need to be re-drilled or restored to its pre-blowout condition. This is where the second section of cover applies. Insurers will be liable for the costs incurred in re-drilling to the depth at which control was lost, but their liability will be capped on the basis of a formula linking the policy indemnity to a percentage of the original cost of drilling the well (plus an agreed amount representing inflation). The insurance market will often allow insureds to delete this limitation on payment of an additional premium. Recoveries under the re-drilling section of the policy are based on the insured using the most prudent and economical method to re-drill the well, with a time limit for the start of re-drilling or restoration.

3. Seepage and pollution

The third section of cover relating to pollution has brought the lowest number of claims and, until Macondo, there were very few offshore incidents of any significance.

Coverage under the form is triggered by pollution from wells resulting from blowouts and not pollution from other facilities or causes. However, it has been possible to extend cover to include pollution from the production facility itself, provided the original cause of loss is a blowout. This section of the policy offers the most "user friendly" pollution coverage provided by commercial market insurers, certainly when compared to coverage contained within liability policies. Its insuring agreement is in three main parts:

- Firstly it covers legal liability, or liability incurred under a lease block contract, for damages in respect of third party property damage and injury
- Secondly, and perhaps more importantly, it covers costs incurred by the insured to clean up, or attempt to clean up, seeping, polluting and contaminating substances. This second part does not require legal liability. The insured has autonomy to act quickly to try to prevent pollution reaching the shore. Therefore, the OEE policy provides much more effective cover for clean up expenses than under liability policies (which is discussed in more detail below)
- Finally, the policy covers legal defence costs.

These coverage provisions are based on a pollution incident which is sudden and accidental and for which notice provisions are incorporated into the policy.

OPOL

Insureds operating in the North Sea, who are parties to the voluntary Offshore Pollution Liability Agreement (OPOL), can buy an endorsement to OEE policies, which will meet the obligations incurred under OPOL. This gives cover on a strict liability basis for compensation to third parties, including local authorities for pollution damage and for clean-up expenses incurred voluntarily or under a lease block obligation. OPOL requires operators signing up to the agreement to have financial responsibility for claims up to certain limits. Before Macondo, this limit was $120m per incident and $240m in the annual aggregate. Many insureds choose to demonstrate financial responsibility by means of insurance.

Conditions and Limits

The EED 8/86 policy contains various important warranties and conditions in the policy. Primarily the insured must install a standard make of blowout preventer on the wellhead and ensure it is installed and tested according to industry practice. This applies to both drilling and well intervention operations, such as reconditioning or deepening of the well. There are various due diligence provisions that must also be observed. For example, there is a warranty that the insured will endeavour to comply with all regulations on fitting storm chokes and other equipment to minimise damage or pollution and that, in the event of a blowout, the insured will try its utmost to stop the flow of well fluids.

All three sections of cover are insured within the umbrella of a combined single limit, applying to each accident or occurrence. There is no dedicated limit for pollution liability or clean up. For example, the limit purchased for compliance with OPOL financial responsibility provisions is included in the combined single limit. To strictly comply with the OPOL financial responsibility provisions, oil companies had to obtain agreement from insurers that OPOL requirements had priority in allocation of the limit. In response to the Macondo incident, some insureds are choosing to purchase a dedicated limit for the pollution risk. Typically the industry has purchased higher combined single limits for offshore wells than onshore wells with limits for the former being in the range of $100m to $300m.

In addition to these main provisions of cover, most oil companies will buy a suite of additional coverage options. These will include:

- Underground blowout - covering costs to contain blowouts within the well bore
- "Making wells safe"– covering expenditures to prevent wells from becoming out of control when the surface infrastructure is damaged by certain named perils, such as hurricanes
- Extended re-drilling – covering costs to re-drill or restore wells that have been lost as a consequence of damage to production infrastructure caused by certain named perils.

OEE policies have responded to a vast number of claims resulting from blowouts in virtually every location where drilling takes place. Both buyers and sellers understand the product and have confidence in it. There appears to be less understanding of cover provided under corporate liability policies.

Corporate Liability

Most oil companies engaged in exploration and development drilling will have a corporate liability policy or series of policies arranged in layers covering the entire range of their activities. Smaller oil companies may rely upon a specific section of their "package" policies covering third party liabilities. This is a layer of coverage which sits in excess of dedicated primary liability policies, such as employer's liability and vehicle liability. However, for offshore well pollution risk there is no dedicated underlying policy unless the form has been specifically structured to sit in excess of the OEE policy. Larger oil companies will have layers of liability cover with specific markets and the scope of coverage will generally be unique to the market concerned.

> Problems have arisen in the interpretation of the coverage scope for pollution liability and clean-up cost.

The policy forms most common in the London market are the LSW 244 and JL 2003/06 wordings and are generic liability forms used for energy business with customised exclusions. Both forms exclude pollution from wells and this exclusion must be deleted, if this policy is to sit in excess of the OEE policy cover. However, the cover available is not the wider cover available through the EED 8/86 policy form, but rather the policy has its own insuring conditions and exclusions. Problems have therefore occasionally arisen in the interpretation of the coverage scope for pollution liability and clean-up cost, whether resulting from wells or production facilities. Specifically, the retaining of policy exclusions far more appropriate to land based activities has caused problems. This issue is addressed in the following sections.

C. Impact of Macondo

Claims Following Macondo

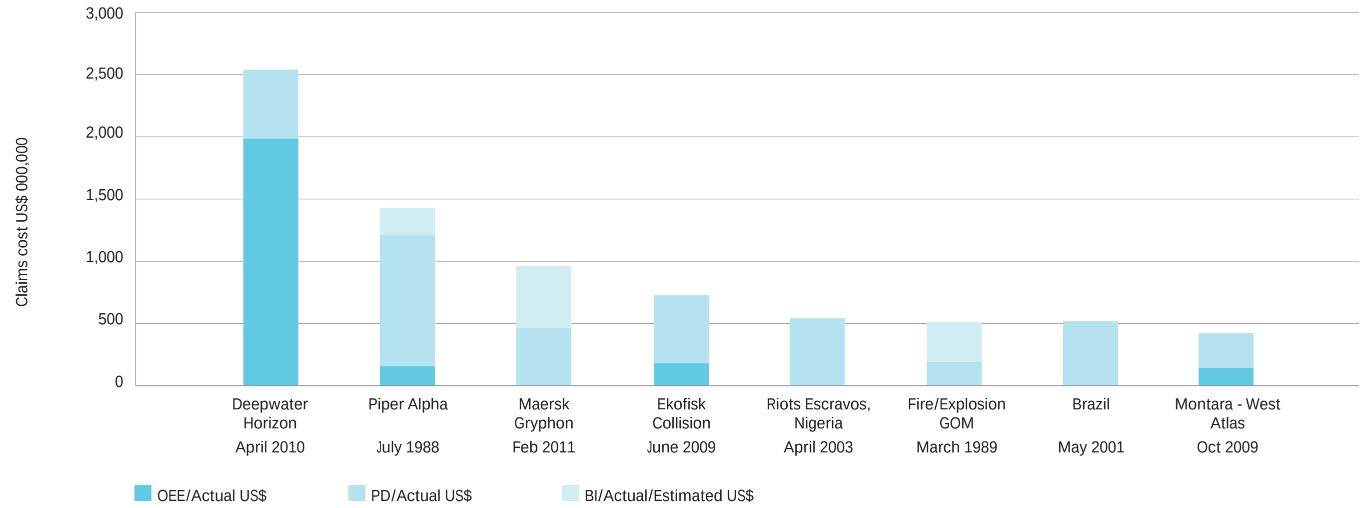
The Macondo incident has not, as yet, resulted in a catastrophic claim to the insurance market. Within one week of the incident the insurance market paid $560m as a total loss settlement on the semi-submersible drilling rig "Deepwater Horizon", of which $270m was paid by the Lloyd's market[60]. There was no loss of hire insurance placed on the unit. The amounts insured under the OEE cover for control of well costs and pollution from the well were comparatively low in relation to the subsequent loss, as the operator, BP, had self-insured this risk and its partners had purchased low limits as was normal practice at this time. It is understood that the drilling contractor, Transocean, has a corporate excess liability insurance programme, thought to carry a limit of $950m in excess of primary retentions and underlying policies. It is understood that BP and its partners have sought a right of recovery under this insurance as an additional insured party. However, insurers under this programme have filed a defence that BP and its partners are not covered on an unrestricted basis. Policy recoveries under the liability programme may take some time to complete and will depend upon liabilities established between the parties and US courts on issues including gross negligence, limitation rights and other matters. As there was no Protection and Indemnity entry placed on the drilling rig, Transocean will rely on its corporate liability programme to pay any claims. There will also be death and personal injury claims. To date it is understood that some of these claims have been settled, but for undisclosed sums.

BP has incurred a substantial sum in clean-up costs and will have continuing liability for residual clean-up and environmental monitoring. The company has also agreed with the Deepwater Horizon Oil Spill Trust to cover third party compensation costs to the value of $20bn. The extent to which BP's partners, Anardako Petroleum and Mitsui Oil Exploration Co Ltd., will share these costs will depend on the terms of the Joint Venture Agreement between the partners and court findings on gross negligence or wilful misconduct. It is now known that BP came to a settlement with Mitsui in May 2011[61] and has also come to agreements with some of its sub-contractors including Weatherford[62].

While digesting the potential claims costs of the insurances that were actually in place for Macondo, the immediate reaction of the insurance market to capacity and pricing concentrated on the OEE issue. Insurers needed to consider whether the premiums charged for control of well and pollution cover provided under the EED 8/86 policy

Aerial view of the pollution resulting from the Macondo incident

Figure 22: Individual offshore energy losses[63]



Source: Willis Energy Loss Database

were adequate and, particularly, if sufficient surcharge had been included in the rating for deepwater wells and the attendant pollution risk. Figure 22 demonstrates the breakdown of loss type for a series of offshore energy losses, including Deepwater Horizon.

Impact on rating

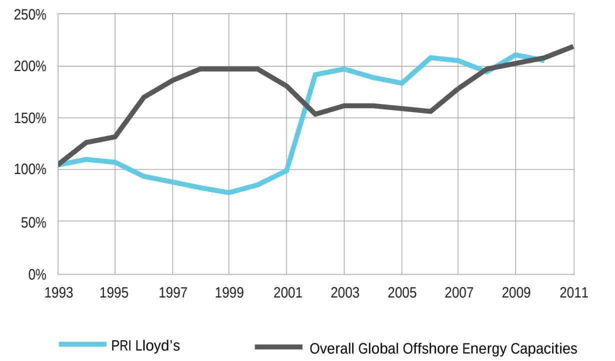
Historically, premiums were calculated according to the depth of the well and the region where drilling was taking place. Modifications were then made depending upon the limit, deductible and extent of cover required. For wells with an enhanced risk profile, such as deepwater wells, a surcharge was built into the rating matrix. Anecdotal evidence suggests that this formula driven approach for rating the wells has recently been discarded by a large section of the market when rating offshore deepwater drilling wells in favour of simply applying a rate per cent on the capital expenditure of the well (known as the Approved for Expenditure Cost, or AFE). This pricing approach had been used before Macondo, but since the incident it has become more deeply entrenched within the energy insurance market.

Buyers focus on the adequacy of the limit purchased, particularly as the standard policy form provides a combined single limit over all covers. A “rule of thumb” developed within the industry that a limit of at least three times the AFE cost of the well was required. Many insureds, having reviewed their limits in the context of the Macondo incident, have decided that a higher limit is more appropriate (up to six times the AFE cost). This leads to the question of whether there is market capacity to support this. This capacity issue will become even more serious if insureds also decide that they need a dedicated limit for pollution.

Impact on capacity

Before Macondo few questioned the adequacy of global capacity to cover the highest limits purchased for OEE cover - up to $500m (capacity and premium rates are shown in Figure 23). Some insureds purchased limits on an “interest” basis, meaning that the limit reflected their ownership interest in the licence block. Macondo has not had a dramatic impact on the available capacity, though the norm is now to offer coverage limits on a 100% basis regardless of an oil company’s ownership interest in a block. However, for wells that are in production,

Figure 23: Offshore insurance capacities and premium rate index (100% = year 1993)



Source: Adapted from Willis Energy Market Review and Lloyd’s Premium Rate Index report it is necessary to include other insurable interests in assessing capacity requirements. This is because a blowout leading to the total loss of a production facility will result in claims for first party property damage and business interruption, as well as well control and possibly removal of wreck and pollution. The accumulation of such losses arising from a single incident would impact available capacity.

It is estimated that before Macondo there was approximately $1bn of capacity for liability insurance in respect of offshore drilling[64], including pollution related liabilities. However, immediately following the blowout, capacity for liability insurance contracted. This occurred as a result of greater awareness within the market of the possible accumulation of liability from different parties involved in the drilling operation, namely the oil company, drilling contactor and suppliers of specialised equipment. However, by 2011, a number of insureds have been able to purchase an excess level of liability cover at a catastrophe level, sitting in excess of existing OEE policies, liability insurances and Protection and Indemnity Entries.

Pricing of Pollution

The pricing of capacity for pollution related liability has also been scrutinised following Macondo. Previously under OEE policies a relatively small surcharge was typically included in the rating matrix for pollution cover, but this explicit practice is not replicated in AFE-based rating. Under liability policies there was generally no discernible rate applied for pollution: a premium is charged for the layer of cover rather than apportioned over different insurable liabilities. This practice has clearly raised concerns following Macondo. The market was faced with three key issues:

- Ensuring that the premium charged is appropriate for the level of risk
- Ensuring that the cover available is broad enough to satisfy doubts over its appropriateness and
- Ensuring that correct and accurate aggregation methodologies are utilised.

The potential effect on the profitability of the class is hard to gauge at the moment.

D. Current pollution products

Exclusions

Both of the corporate liability policy forms referred to previously have, in the first instance, a full pollution exclusion. There is a “buy-back” of cover for property damage and injury to third parties from seepage, pollution and contamination provided the event occurred during the policy term and was discovered and reported within the

Semi-submersible oil rig platform at sea.

specified time limits. However, there is no specific cover for the clean-up cost, so the insured would have to demonstrate that the clean-up action was taken to avoid property damage. This would be difficult with an exclusion that denies coverage where the liability arises solely as a result of obligations imposed by local regulations or statute. In most regions of the world drilling will be subject to lease block or statutory obligations on the operator for pollution clean-up.

A further third party property damage exclusion does not provide cover for costs incurred to abate or investigate the threat of seepage, pollution and contamination of the property of a third party. Because of these two exclusions, it appears that there is little, if any, cover for the clean-up cost. To be able to provide effective cover, a specific insuring agreement in the form of an endorsement overriding these provisions would be necessary. It is unlikely that many insureds have such an endorsement.

These limitations in cover for pollution risk in liability policies, intended or not, have been highlighted since Macondo. Apart from the availability of capacity, this is arguably the issue that has caused most concern amongst insurance buyers.

Pollution cover within the OEE policy would appear to be a more appropriate product. It offers cover for compensation to third parties for property damage and injury, as well as clean up expenses incurred on either a first or third party basis.

OPOL Endorsements

Endorsements covering OPOL related liabilities have also been reviewed in the wake of Macondo, given that OPOL has increased its financial responsibility limits to $250m per incident and $500m in the annual aggregate. This increase has focused insurers' attention on the scope and extent of cover provided under this agreement. Liabilities under OPOL are not limited to discharges of oil from wells, but include pollution from fixed and floating facilities and mobile drilling rigs. It also creates strict liability on participants for compensation and clean-up with very limited exceptions. The scope of liabilities under OPOL is unlike pollution insurance wordings in the market for several reasons. For example:

- OPOL does not require a pollution event to be on a sudden and accidental basis with strict reporting requirements and
- OPOL also guarantees the payment of sums to claimants in the unlikely event that a party to OPOL fails to meet its obligations.

The market had to address these issues to ensure that coverage provided under OEE policies was not more than intended.

E. New Pollution Initiatives

The market has begun to draft a new pollution insurance form to provide buyers with an even more clear and meaningful product which will not, at the same time, expose insurers to a lack of cover under reinsurance policies. This work, under the auspices of the Joint Liability Committee, is well advanced. The aim is to offer an alternative to the pollution cover from OEE policies by creating a separate "tower" of cover for offshore pollution, whether from wells or offshore fixed and floating facilities.

In terms of OPOL, the traditional cover provided by the market merely extended the pollution cover under the OEE policy to meet the insured's liabilities under OPOL. Following a market review, the Joint Rig Committee produced a new OPOL endorsement wording that clarifies the extent of cover being provided. When adopted in policies, this clarifies that insurers are not responding to the OPOL guarantee.

In addition, there have been moves to provide additional capacity from certain sectors of the market. This stems from a widespread belief that limits imposed under US legislation will increase substantially.

It is worth noting that this requirement for additional capacity is only likely to grow in the future as societal attitudes to environmental damage change with growing pressure and calls for the definition of environmental harm to be widened resulting in higher potential costs of damage.

F. Improving Risk Management

Energy Industry Response

The energy industry acknowledges that it must review all procedures, including contingency plans, for deepwater drilling or drilling in remote environments and make improvements where required. Before Macondo, the

SUMMARY OF THE FINDINGS OF THE US NATIONAL COMMISSION ON THE DEEPWATER HORIZON OIL SPILL AND OFFSHORE DRILLING

1. The Macondo loss was not inevitable.
2. The technical failures at Macondo can all be traced back to management errors by the companies involved in the incident including lack of guidance, supervision and training.
3. The offshore oil industry often focuses on increasing efficiency to save rig time and associated costs. However, management processes to ensure that these efficiency measures did not compromise risk management were inadequate prior to the Macondo loss.
4. The former Minerals Management Service (MMS) had a built-in financial incentive to promote offshore drilling that contradicted its responsibility to ensure safe drilling and environmental protection.
5. The MMS was unable to maintain up-to-date technical drilling safety requirements to keep up with the industry's rapidly evolving deepwater technology.
6. In addition to improved regulatory oversight, the oil and gas industry will need to take its own steps to improve safety, including self-policing mechanisms.
7. Scientific understanding of environmental conditions in sensitive environments, such as deep Gulf waters and the Arctic, is inadequate.

Source: Summarised from the National Commission on the Deepwater Horizon Oil Spill and Offshore Drilling

industry had a good record in terms of exploration and production in these extreme environments. However, the initial report from the US National Commission on the Macondo incident showed fundamental flaws in practice in several areas, which the industry will need to address[65].

Industry regulation will undoubtedly play an important role in improving risk management. As mentioned in the first section, the regulating body in the Gulf of Mexico is the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE)[66] which has already been split so that regulatory enforcement is distinct from treasury and licensing. A new OPA (Oil Pollution Act) to replace OPA 1990 is likely and will almost certainly require higher standards of safety and potentially impose higher limits, including increased limits of financial responsibility (See section IID). Such initiatives will impact on the safety plans that the oil industry will need to develop.

Insurance Industry Response

Traditionally, offshore energy insurers have not employed in-house engineering expertise. They have concentrated on traditional underwriting disciplines and relied on external professionals to monitor and review technical engineering matters. This meant that offshore insurers have generally required their insureds to employ independent surveyors to review oil company procedures for activities, such as load-out, transit and emplacement of structures and sub-sea engineering. In deepwater developments, insurers have also sought independent advice on matters, such as flow assurance.

Insurers are increasingly requiring a review of drilling methodology on exploration wells, particularly where the drilling is into a formation not previously drilled. An independent party will then carry out a desk-top review of drilling procedures, focusing upon issues, such as the expected pressures in the well, the casing and mud circulation programmes and the appropriate adequacy of equipment and manpower. Such independent reviews are more likely to be conducted where drilling in extreme environments. Insurers may wish to make this type of review compulsory for deepwater wells.

However, it is more likely that the underwriting of such ventures will be subject to the traditional application of premium rating and deductibles and warranties or conditions precedent to liability.

G. Aggregations

Most exploration and production licenses are let on a shared basis to a number of oil companies who work under a Joint Venture Agreement. Most joint venture partners therefore insure their own shares under their own package insurances. If cover is arranged on a "for interest" basis, insurers will find it more difficult to assess their total exposure and therefore it is almost certain that limits will need to be provided on a 100% basis.

Another issue is that well control costs and pollution claims may aggregate with physical damage loss and possibly removal of wreck on production units operating in deepwater and remote environments. There may also be liability claims if personnel are injured or killed in the incident. Since Hurricanes Katrina and Rita in 2005, insurers have developed sophisticated monitoring systems to track their accumulated exposure. However, they will need to ensure these systems can adequately monitor the 'clash' of claims from several sections of a package policy and from multiple insureds, especially as most insureds may be purchasing higher limits.

H. Insurance Regulatory Changes

US

Immediately following the Macondo well blowout, the US administration started to develop legislation to reduce the risk of blowout and pollution, increase limits of liability and financial responsibility, and impose harsher penalties on parties found responsible for pollution. The applicable legislative act at the time of the loss was the US Oil Pollution Act (OPA), passed in 1990 as a direct result of the Exxon Valdez oil spill incident in Alaskan waters. This determined a limit of $75m for economic damage, but did not stipulate any limit for clean-up cost. The limit is not applicable in certain circumstances, for example, as a consequence of gross negligence or wilful misconduct of the responsible party or where there is non-compliance with federal safety regulations.

The Act also established a limit for financial responsibility of $150m, in respect of a worst case oil spill with a discharge volume of greater than 105,000 barrels from an offshore facility located seaward of the boundary of a state. Currently there are two bills pending in Congress to raise this $150m limit to $300m. OPA 1990 also mandated strict, joint and several liability with very few exemptions.

Much of the focus within Congress has been upon raising the $75m limit for economic damages. A bill passed in the House of Representatives initially proposed a $10bn limit. However, this limit was subsequently removed and the bill in its entirety has not been ratified by the Senate. Currently there are two bills pending that would remove the limit for spills from offshore facilities. H.R. 1393, the Oil Spill Prevention Act of 2011[67], was introduced in April 2011 and was referred to the Sub Committee on Energy and Mineral Resources. Senate Bill 214, the "Big Oil Bailout Prevention Unlimited Liability Act of 2011"[68], also proposes to remove this limit and has been referred to a Senate Subcommittee on Environment and Public Works.

Concern has been expressed in US energy industry that there will not be sufficient insurance capacity if the limit is raised to $10bn or higher, or if liability is unlimited. This would effectively limit offshore drilling in the deeper waters of the Gulf of Mexico to a handful of very large oil companies, who have the capital base to absorb such potential liability.

In addition to these bills, there is further legislation pending to increase safety standards for offshore drilling. However, the likelihood of these bills being ratified by both houses is currently not clear. The current pending bills generally seek to increase the requirements for comprehensive safety plans, blowout prevention measures, and pollution response plans. One of the more recent of these is the H.R. 1890, termed the "Save America from Environmentally Reckless Drilling Act"[69]. It was introduced in May 2011 and has been referred to a subcommittee on Energy and Mineral Resources.

One act passed through Congress amended OPA to authorise advance payments from the Oil Spill Liability Fund to the federal on-scene spill response co-ordinator. This Fund was originally established in 1986 and was financed by oil and shipping interests by means of a contribution of five cents per barrel on imported and domestic oil. OPA 1990 provided an authority to borrow up to $1bn in aggregate from the Fund for any one pollution incident.

Europe

There has also been intense regulatory activity in Europe. As mentioned in the first section, the Industry, Research and Energy Committee of the European Parliament adopted a draft resolution in July 2011 which recommends that site specific impact assessments and plans for environmental and safety procedures should be a precondition for all offshore oil and gas operations. Requirements include site-specific contingency plans that need to be submitted to and approved by the national authorities before drilling begins. Following the adoption of this draft resolution, the European Commission is expected to unveil new draft legislation later in the year.

The preferred underlying principle for European legislators is that the "polluter pays" so primary responsibility for disaster response lies with the industry. This premise was created by the European Union Environmental Liability Directive and currently applies to onshore operations. Previously national governments have generally shared the financial burden of catastrophic offshore spills by imposing liability limits in relevant legislation. Today, however, national governments expect the industry to fully accept the liabilities, costs and reputational consequences of catastrophic spills. Nevertheless, the feeling is that the public sector must oversee the safety and co-ordination of any disaster response.

Greenland was the first significant territory to issue a full round of new upstream exploration licenses for all water depths post Macondo. In authorising drilling in these remote environments, the Greenland government has ensured that licence holders assume unlimited strict liability on a joint and several basis.

Insurance Industry Initiatives

It is inevitable that these regulatory changes and initiatives will require a solution to meet higher limits of liability than is currently available from commercial insurance markets.

Various mechanisms have been suggested, including the creation of a pre-loss funded mutual fund and governments requiring additional corporate bonds and guarantees above insurance limits. However, such initiatives are unlikely to provide an equitable "fit" for every company: smaller and medium sized companies are almost certainly going to be disadvantaged because they will not have the financial strength of larger oil companies.

Anticipating the imposition of higher limits, several market initiatives to provide additional capacity are being developed within the Lloyd's market. Munich Re has also proposed a facility which aims to provide up to $10bn of cover.

Resolving all these issues in a way acceptable to all energy companies and the insurance industry will be extremely challenging. Yet, the insurance industry has invariably responded to industry demand for new products, capacity and initiatives. Rather than working individually to create new products, the insurance market, in partnership with the energy industry, should be able to develop products at risk-based prices that will enable energy companies to continue to provide the fossil fuels society demands.

Drilling platform.

CONCLUSIONS

Macondo has highlighted a number of important issues for both the energy and insurance industries as oil and gas exploration and production moves into more extreme environments. There is also recognition of the technical complexities involved in operating in such locations, as well as the potential environmental impacts and liability.

While the insurance industry is already tackling some of these issues, others still need to be addressed:

- The insurance industry must fully understand the risks involved in this type of operation so that realistic levels of capital and reserves are held
- Capital providers and insurers need to have confidence that the energy industry is addressing the safety and reliability standards of equipment working in such extreme and possibly untested environments
- The insurance and energy industries should be mindful of growing potential environmental damages particularly as societal attitudes to environmental harm change
- The insurance industry needs to monitor potential accumulated exposures to ensure an accurate understanding of aggregated totals and any potential 'clash' of claims from different sections of a package policy and from multiple insureds
- There is an opportunity to clarify perceived uncertainties over available pollution cover in existing policies: pollution insurers need to fully understand the risks in order to develop appropriate products, aggregation management and pricing methodologies
- There is uncertainty around changes to the proposed regulatory environment in the US and how much capacity will be available to support the likely higher limits of liability for pollution.

Although Macondo was a significant event, offshore spills of greater than one million barrels have occured before. In the context of the trend towards drilling in more extreme environments and the associated increase in technical complexity, the potential frequency of such incidents must not be underestimated: the greater the depth, the greater the potential well instability. The combination of problems encountered with Macondo - failure of the blow-out preventer, explosion, total loss of rig and the prolonged efforts and expense to bring the well under control – had not previously been envisioned. The failure to anticipate such a scenario is partly a behavioural risk which should be addressed.

The fall-out from Macondo also changes the environment in which the oil and gas industry, and their insurers, operate. Both are under increased scrutiny from regulators, governments and indeed the general public. However, if regulators impose an obligation on the offshore energy industry to purchase insurance at levels that insurers cannot provide or on a basis that insurers deem imprudent, it is likely to create substantial problems for both the energy industry and insurers.

The fact that the frequency of losses for complex deepwater wells so far has been relatively low may simply reflect the small number of such wells to date and it does not necessarily mean that the risk of operating in these environments is low. As this report shows, the range of risks and, in particular, the instability of deepwater wells present very real challenges which both insurers and insureds need to face up to and prepare for. It is important that the energy industry adopts standards that ensure safety and reliability in the design and execution of drilling in extreme environments and restores confidence.

To address these issues as the operational, regulatory and environmental challenges evolve, the insurance industry will need to work closely with energy companies to develop appropriate and economic products that meet the needs of both parties.

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