Offshore Drilling Challenges and Opportunities

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Outline

- Offshore Defined
- Drilling Vessels
- Drilling Challenges
- Permitting
- New Technology Opportunities
- The Future
- Questions
**Offshore Defined**

**Government Controlled Offshore Lands**
United States - Exclusive Economic Zone
*(3 Billion Acres – 4.1 Million Sq. Miles)*

**Gulf of Mexico Seafloor Bathometry**
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Shelf, Deepwater and Ultra Deepwater
Deepwater Gulf of Mexico Bathymetry

Green Canyon
Salt Province
Abyssal Plain
30 Miles
48 km
Walker Ridge

Deepwater Gulf of Mexico
Technically Challenging Environment

Much of the prospective Gulf of Mexico deepwater area is covered by layers of massive salt.
Salt Canopy

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Drilling Challenges

In the middle of last century the industry started exploring below the world’s oceans. Since then, new technology has consistently pushed the industry into deeper water depths and total drilled depths. Records continue to be broken with current 6th Generation drill ships able to drill to 12,000 ft water depth and to 40,000 ft total depth.

Platform Rig

Drilling Challenges

Industry Deep Water Gulf of Mexico Drilling Records
It wasn’t until the early 1980’s that explorers started looking for oil below salt. With the advancement of seismic imaging and drilling technology the industry has been successfully pushing these limits deeper.

Most of the Wilcox reserves in DW GOM are covered by a salt canopy, in some cases up to 20,000 ft thick.

Technology is Pushing the Envelope on Water Depths

In 7,000’ of water and five miles below the seabed, technology is pushing the envelope on water depths...
An explosion and fire occurred on the Deepwater Horizon on April 20, 2010 in the US Gulf of Mexico, about 52 miles southeast of Venice, LA. The Horizon was engaged in drilling activity on behalf of BP at Mississippi Canyon Block 252. Eleven people were lost. The Deepwater Horizon sank on April 22, 2010 in nearly 5,000 ft of water.

Subsea BOP

- LMRP – Lower Marine Riser Package
- Control POD
- Annular
- Ram Bodies

60 feet tall 620,000 lbs
Ram BOPs

Blind Shear Ram
shears smaller tubulars and then seals wellbore (or seals wellbore with no pipe)

Casing Shear Ram
shears large tubulars – does not seal

Pipe Ram
seals annulus around various drill pipe sizes

BOP Emergency Systems

1. Emergency Disconnect
2. Deadman
3. Autoshear
4. Remotely Operated Vehicle (ROV)

Primary Methods to Secure the Well:
• Emergency Disconnect System (EDS)
• Autoshear/Deadman Backup
• ROV Tertiary Intervention

New Regulations – Worst Case Discharge (WCD) Casing Design

Pre-Macondo

Post-Macondo

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GOM Deepwater Well Complexity
A Bird’s Eye View

Gulf of Mexico Deepwater
Casing Program: 36” - 7 3/4”

Conventional Deepwater
Casing Program: 30” - 7”

WCD Casing Design - Challenges

- Dynamic Drilling Casing Loads
  - Thermal Annular Pressure Build-Up from WCD
  - Deep Collapse from WCD
  - Thermal induced upward forces on hanger from WCD
  - Approach load limits of hostile pipe
- Extreme Cement Hydraulics
  - Tight annulus for circulation
  - Centralization near impossible
  - Approach limit of software
- Casing Points
  - WCD flow - causing deep collapse and formation breaching
- Hole size

Well Containment

Marine Well Containment Company
- 10 Members (Chevron, ExxonMobil, Shell, ConocoPhillips, etc.)
- Rapid response system available to capture and contain oil in the event of a potential underwater well blowout
- The system will be flexible and able to begin mobilization within 24 hours and can be used on a wide range of well designs and equipment, oil and natural gas flow rates and weather conditions.
- The interim system (15,000 psig capping stack) is engineered to be used in deepwater depths up to 10,000' and have initial capacity to contain 60,000 barrels & 120 MMCFG per day with potential for expansion.

Helix Well Containment Group
- 22 Members
- Operate in up to 8,000 feet of water
- 10,000 & 15,000 psig capping stacks
- Intervention equipment to cap and contain a well
- Capture and process 15,000 BOPD & 95 MMCFG
Well Construction Impacts

- Extended time required for internal well planning
  - Was ~21-27 weeks
  - Now ~27-36 weeks = New Norm

- Extended time required to receive permit approvals
  - Was ~14-21 days
  - Now ~30-45 days or more = New Norm

Optimistic Permitting Timeline Estimates

Permitting Challenges

- Exploration Plans
- Development Operations
  - Coordination Documents
    - Deepwater Operating Plans
    - Conservation Information Documents
- Development and Production Plans
- Application for Permit to Drill
- Application for Permit to Modify
Permitting Challenges
- Notices to Lessees
- New Rules
- New Legislation
- Higher Level of Scrutiny
  - Oil Pollution Act
  - National Environmental Policy Act
  - Coastal Zone Management Act
  - Endangered Species Act
  - Marine Mammal Protection Act

New Technology Opportunities
- Identify technologies that can be developed and applied which will have a reasonable opportunity to:
  - reduce the ranges of key uncertainties
  - enhance safe operations and environmental protection
  - increase rig efficiency
  - lower non-productive rig time
- The goal of implementing new technologies is to ensure the successful execution of offshore well operation

Technology Enhancement Objectives
**New Deep Water Drillships**

- Most advanced drilling capabilities
- Dynamically positioned, with double-hull
- Two drilling systems in a single derrick
- Stronger and more efficient top drive so wells can be drilled deeper
- Other unique features will target drilling wells up to 40,000 feet of total depth
- Variable deck load of over 20,000 metric tons; capable of drilling in water depths of up to 12,000 feet

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**Effective Drilling and Completions Optimizing Performance**

**Drilling and Completions Technology Today**

- Integrated technology solution
  - Seismic imaging
  - Reservoir modeling
  - Rock mechanics
  - Drilling operations
  - Real-time monitoring

(Live video camera and feed from rig)

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**Drilling and Completion Technology Enhancement (near term)**

- Risers (esp. High Pressure and High Temperature)
- Managed pressure drilling
- Dual gradient drilling
- Sonic Bit Monitoring
- High strength light weight cements
- Single trip multi-zone frac packs completions
Dual Gradient Drilling

- Dual Gradient Drilling (DGD) is a step-change deepwater drilling technology that should enhance safety and environmental performance, as well as drilling performance.
- Awareness of these potential benefits led to the technology’s development in the late 1990’s by a consortium of industry operators, drilling contractors and service companies.

Definitions

Managed Pressure Drilling (MPD) is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly. It is the intention of MPD to avoid continuous influx of formation fluids to the surface. Any influx incidental to the operation will be safely contained using an appropriate process.

Dual Gradient Drilling (DGD) is one of the 4 variations of MPD. It is the creation of multiple pressure gradients within select sections of the annulus to manage the annular pressure profile. Methods include use of pumps, fluids of varying densities, or combination of these.

SubSea MudLift Drilling is the method of DGD developed by the SubSea MudLift Drilling Joint Industry Project from 1996 until 2001. The project resulted in Industry’s first successful DGD well. The core technology is the MudLift Pump (MLP). Now made by GE Oil and Gas, this pump has been renamed the MaxLift 1800 Pump (still MLP).

Dual Gradient Drilling - Comparison

With DGD, we literally replace the mud in the drilling riser with a seawater-density fluid and use a denser mud below the mudline.
DGD - Production Benefits

Fewer strings of casing can lead to larger casing at TD. Higher rate, designer completions, for example, horizontal or multi-lateral wells, may then become possible.

This can lead to higher rate wells and higher recovery factors in deepwater reservoirs.

Conventional (Single Gradient) vs. Dual-Gradient Drilling

- Formation Pressures (FP) and Formation Stresses (FS) are functions of the weight of the water and sediments above them.
- In deepwater, the lower density seawater can dominate FP and FS.
- Conventional drilling uses a single density fluid to manage FP and FS.
- Dual Gradient Drilling uses two fluids: seawater density above the seabed, and a higher density fluid below the seabed.
- This is more in harmony with natural pressure profiles.

SubSea MudLift Drilling

A sea-water driven positive displacement pump is located above the BOP/LMRP. It withdraws the mud from the well and pumps it back to the surface through a line attached to the drilling riser.

The riser is filled with a seawater-density fluid.

A Subsea Rotating Device (SRD) sits above the MaxLift Pump which can be used to rapidly change the pressure profile in the well.
The Heart of the System: MaxLift 1800 Pump (MLP)

- Positive Displacement Pump installed above BOP
- Pumps drilling mud from seafloor up mud return line to rig for processing
- Driven hydraulically by conventional mud pumps converted for seawater installed on the rig and available for maintenance
- Powered by seawater which is returned to Triplex Pump
- Two interchangeable mirror image Triplex Modules
- Pump can be broken into ~ 50 MT lifts for initial lift onto rig

Dual Gradient Advantages

- Dual Gradient Drilling is a step-change deepwater drilling technology that has been under development for over 15 years.
- DGD has the ability to enhance drilling safety, efficiency and environmental performance.
- DGD can lead to improved deepwater production and reservoir recovery.

Well Construction Sonic Bit Monitoring (Accusound & Inficomm)

- Advance preparation for operational changes that mitigate non-productive time (NPT) encountered above, within and below the salt canopy
- Capture and transmit high frequency acoustic signatures from the drill bit to the surface in real-time
  - Sonic signature measures bit/bearing wear, actual weight on bit, and formation changes developed by Accusound
  - Transmission to surface using a new electromagnetic pulse (EMP) technology commercially developed by Inficomm
Sonic Bit Monitoring

Well Construction
High Strength, Light Weight Cements

- Geo-polymer and graphite reinforced light weight cements with very high strengths and very low permeability
- New cements could:
  - minimize the effects of lost circulation zones
  - drilling mud contamination
  - problems associated with placement techniques
Advances in technology have allowed industry to drill and produce offshore resources safely.

Many technical challenges remain to be solved, but the industry is focused on finding solutions.

“The Offshore Drilling New Normal”

- Rebuilding government confidence
- Assurance future incidents will be minimized
- Greater worker and environmental safety
- Enhanced well containment and spill response