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Drilling Operations with Deep Water and Ultradeep Water Rigs

Lazăr Avram*, Lucian Negruț**

*Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti 39, Ploieşti, Romania
e-mail: lavram@upg-ploiesti.ro

**SAIPEM 10000 D.S., Saipem, Italia
e-mail: luciannegrut@yahoo.com

Abstract

The present paper presents an overview of deepwater drilling activity taking into consideration specific aspects related to management of drilling platforms in a safe manner.

General aspects

Deepwater is defined as water depths from 400 m to 1500 m with greater then 1500 m water depth classified as ultra deepwater (1600 m after *Mineral Management Service*). Most operators have thus recognized that deepwater drilling is as complicated as high pressure and high temperature or under balanced drilling and most drilling engineers are part of a team to deal with the issues associated with deepwater drilling from project pre-well planning right through to post well reviews [1-5].

The established objective for an exploration well is to collect a maximum amount of information during its life with a minimum cost on a safer manner. In addition to the geological, drilling and testing information for a deepwater exploratory well, the environmental information is playing an important role.

The environmental factors for deepwater: water depth; seabed condition (visibility, slope, hardness, and shallow gas); weather (wind and waves); currents and ecosystem generates a strong impact in well design program [1, 4]. Once ignored or unseen, they might lead to the major consequences in terms of operation delay and higher cost.

Water depth is a key factor on deepwater activity, with strongest impact in well design. Special technologies are required for deep waters, and the type of equipment planned to be used is depending on water depth. There are two positioning system units to be used: mooring rigs and dynamic position rigs and selection is made on the water depth criteria. Water depth may reduce operability of other equipment such as ROV's (*Remote Operated Vehicles*), critical for riser less operations.

Once the location is established, the seabed configuration is always inspected with ROV's, presence of slope formations may limit the escape directions. Specifically for deepwater, the seabed is usually a soft formation and this associated with shall waters and shallow gas may generate sever problems while drilling.

Volatile weather conditions in deepwater sector have made drilling particularly severe activity. The conditions also make extraction an expensive process, costs for developing new methods and technologies far exceeded other areas of activities.

Drilling operations with deep water and ultradeep water rigs

Well planning operation commence with rig selection. The rig must be capable to operate on specific area and environmental criteria are the main issues on selection of a deepwater rig.
The two types of drilling vessels are used today on deepwater drilling locations, the dynamic positioned rig or vessels moored. A mooring line failure under extreme weather conditions might move the platform far away from wellhead and request an emergency riser disconnection from the BOP. By use of drilling platforms dynamically positioned is reduced the risk of loosing position under harsh environmental conditions and DP systems are preferred for deepwater drilling operations (i.e. drill ship or semi-submersible drilling platform). However, the final decision of positioning system still remains with operator, but drilling vessel availability on the market must be considered as well.

Dual drilling activity rigs with a better riser system and BOP, casing and drill pipe handling, Extended Well Test (EWT) equipment and production, Floating Production and Storage Offshore (FPSO) capability generates significant advances in deepwater field development.

Dual activity concept: the well construction time is reduced substantial on dual activity due to the fact that operations can be performed simultaneously in parallel and not sequentially as done with a single rig. Advanced inspection and pre-testing capabilities, flexibility to perform a wide range of jobs will reduce nonproductive time. In performing simultaneous operation, upon arrival on location, one rig may be utilized to drill by jetting method and to set conductor casing, after that to drill the hole for surface casing, to run and cement surface casing. Meantime, the second rig can run the BOP stack and risers.

For short moving in the filed, a dynamic positioning platform is capable to save several days of rig operation time by moving with the riser and BOP stack suspended.

While performing normal drilling operations through the riser string, several operations can be carried out as offline operations by secondary rig:

- Prepare, make up and rack on derrick the drill pipe stands and BHA's, casing stands, casing hangers, running tolls and cementing stands;
- Function test motors, MWD equipment and electric line logging equipment;
- Prepare, test and rack on derrick the DST equipment;
- Make up, test and rack back completion equipment;
- Make up, test and run subsea trees to the mudline.

Before a rig to be selected it is important that the operating limits for the rig are fully understood: maximum operating limits and survival limits; LMRP disconnection procedure; subsea operating limits; mooring; deck loads; ROV launch and recovery limits.

Once maximum operating limits are known in conjunction with the historic weather data, an estimate of the expected downtime can be made. This will indicate if we can operate during bad weather. Survival limits will give an indication when emergency situations will occur. Survival limits should never be exceeded as this has obvious safety implications.

If the rig is a certain distance away from the well or during severe weather, the rig/riser will have to be disconnected from the well. Operating limits for when to disconnect and when we can no longer disconnect must be known to ensure safe operations.
The pressure regimes in deepwater are mostly normally pressured. Lower fracture gradients due to the deeper water need to be taken into account and associated with deepwater well control. In certain areas cementing of conductor and surface casing strings has been problematic due to fracture gradients. Lower temperatures at seabed (normally around 1 or 2 deg C), have an influence not only on mud viscosity but also on the formation of Hydrates during a well control situation. Cement recipes needs to be adjusted for the seabed temperature in the surface casing and the conductor.
Subsurface hazards such as shallow gas and potential aquifer water flows must be considered during the well design.
Once all of the above issues have been addressed the casing design can start. Top down designs is applied for the exploration wells and the bottom up design for the production wells. Most exploration and appraisal wells are vertical wells. If the well is to be kept as a producer, it may need to be converted into a horizontal well to be cost effective so this must be considered during the casing design.
For development of deepwater fields wells will need to be designed for maximum production. The required production tubing size will then determine the minimum casing sizes required. Maximising production and minimising cost might mean drilling wells from a single drilling centre possibly drilling horizontal, extended reach or multilateral wells.
Mud systems used in the top hole sections are all based on water based muds with returns back to the seabed. Once the riser is connected and returns are taken back to surface, any suitable mud systems for the formations can be used.
Most deepwater rigs are equipped with three or four mud pumps to manage the required hole cleaning. Two pumps to drill the well and one pump used to assist with riser cleaning.

Most deepwater wellhead systems are 18 ¾ in with some of the older rigs still equipped with a 16 ¾ in connector. Riser booster lines will also be required to provide extra velocity in the long marine riser. For deepwater development well the X-mass trees and production flow lines need to be considered.
Directional drilling for horizontal wells in deepwater areas must also consider the uncontrolled surface formations in deepwater. Well can be kicked off while still drilling riser less but this may prove challenging [4].
Location of the drilling centre for a field development must be optimised to minimise drilling costs and minimise footage to be drilled. It is important that for the field development down hole locations to be selected to optimize production and minimise drilling footage.
Deepwater well evaluation is the main objective for exploration and appraisal wells. All standard coring and logging technologies can be applied.
Emergency disconnect operations must always be considered when wire line operations are in progress.
Completion technology for deepwater production wells must be considered with great care. The aim is to minimize the well repairs and well intervention and completions should be designed to last the life of the field. Well interventions in deepwater will mean moving a rig back over the well and re-connecting BOP's. A repair programme that can be completed in 1 or 2 days on a platform may take as much as 14 days in a deepwater well. Coiled tubing technology in deepwater is limited especially if long horizontal sections are drilled in the reservoir.
Procedures for well control, emergency disconnect, BOP and riser running must all be ready in place before operations commence.

Well testing in deepwater can be safely executed as long as the possibilities of an emergency disconnect are always taken into account. Flaring of oil or gas may not be allowed and storage of hydrocarbons on an extended well test may present other problems.

As opposed to moored vessels, dynamic positioning is a fundamentally unstable operation because critical failure in the control or power systems can lead to the loss of the vessel's position.
The quantitative risk analysis (QRA) is a simple method used to estimate and address loss of position's risks. The aim of QRA methods is to quantify the risk levels and to find out if they are acceptable.
The contribution of the investigation and analysis are developed in order to:
- identify the various scenarios under which loss of position could occur;
- develop procedures/methods for each of the scenario and to allow proper disconnection of the riser in a timely and safe manner;
- allow Lower Marine Riser Package (LMRP) disconnection of the and/or equipment used during completion or well testing.

While operating, the loss of position is considered as being a major risk. The failure of the disconnection system, when activated, results in an escalation of the risk which can end up in damage of equipment and or Emergency situations. The damages caused by a failure to disconnect can be the following: loss of the drilling riser; BOP damage; other drilling equipment damage (tensioners, etc.); well damage (well head, fish in hole, etc.) and pollution or uncontrolled blow out (well flowing, mud spillage).
The loss of position, the offset and the riser angle are monitored in real time with two alarm levels which are installed in the system. These alarms can be set on riser angle or on the offset reached.

The **watch circles method**: is referring to an imaginary circle on the sea surface, the centre of which is the rig desired position. The rig's desired position will normally be the position which gives the minimum possible flex joint angle at the LMRP level. This is to minimise the risk of damage to the entire Well head/BOP/Riser assembly. The radiuses of the imaginary circles are expressed as a percentage of water depth.

“Yellow alarm” is allowed as soon as a dynamic positioning system failure leads to the loss of control of the vessel station keeping capability, even with the vessel remaining within the watch circle and/or also when the drilling platform reaches the working limit on the riser angle or calculated offset. The lower flex joint is designed to handle normal drilling operations up to a designated parameter (generally 2°). At this point, the Driller will immediately and without hesitation start the procedure "ready for disconnect", which is intended to optimise the "emergency disconnect" process in case the red alarm level is reached.

“Red alarm” is allowed as soon as the drill ship reaches the working limit on riser angle or a calculated offset and still gives the time to disconnect before the limit of equipment’s is reached (generally 4°). When any of the above conditions occur, the Driller will immediately and without hesitation activate the sequence "emergency disconnect".
When the BOP is connected to the well head, the disconnection operation is activated only by one button (Emergency Disconnect) located on the BOP panel, and all the functions on the BOP are performed in sequences in a time frame not exceeding 55 seconds (API requirement).
If the majority of the disconnection can be performed using the “Emergency disconnect” function, some of them cannot be supported and these operation need to be evaluated with purpose to be use as a guide to assist the on-site supervisors in decisional process (see cases related on tables 1 & 2).
The critical situations related to the normal drilling operations with a dynamic positioning rig need to be identified: tripping time of BHA (drilling string) in front of the BOP; tripping time of casing strings in front of the BOP; tripping time of BHA (DST string) in front of the BOP; time required for a kick control situation.

Table 1. Drilling 17 ½” to 8 ½” sections

Drilling 17 ½” to 8 ½”sections		
Yellow alarm	**Red alarm**	**Probable Incident**
- Stop drilling - Space out, stop drilling pumps - Close "middle pipe rams" - Hang off string on pipe rams, - Compensate required string weight.	**Case # 1: String hung off on MPR** - Activate "emergency disconnect" **Case # 2: Yellow alarm sequence not realised** - Space out if possible -Activate "emergency disconnect"	**If disconnection was made:** - Drill pipe hung off on rams and sheared - Or drill pipe sheared and dropped down hole. **If disconnection was not realised:** - Riser parted and dropped on sea bed - Damage on well head - Damage on surface equipment - Drill string twist off - Well flowing on sea bed - Difficult well recovery.

These situations combined with the other cases specific for completion phase need to be evaluated: tripping time of screens assembly in front of the BOP; time required for gravel pack or stimulation operations; tripping time of completion string in front of the BOP; completion operations with landing string for tubing hanger mode through the BOP; flowing well inside the marine riser.

The special operations such as: electrical logging; kick control; formation testing (DST) and running of completion strings and Xmas trees the Risk identification has to be performed.

Emergency disconnection during yellow or red alarm situations could have serious consequences and those will generate difficult well recovery operations.

Table 2. Kick control

Kick control		
Yellow alarm	**Red alarm**	**Probable Incident**
Case # 1: String already landed on rams" - Keep running the control until red alarm is announced.	- Stop pumping simultaneously - Close all kill and choke line valves on BOP stack - Activate "emergency disconnect"	- Drill pipe sheared - Influx migration up to BOP - Over pressure at casing shoe in case of gas migration - High probability of formation breaks down at casing shoe or in open hole.
Case # 2: Annular preventer closed and string in movement - Should time allows keep running the control - If not, space out - Close "middle pipe rams" - Hang off string on "rams" - Open "annular preventer" - Close choke manifold	- Close choke manifold - Stop pumping simultaneously - Close "kill/choke line" valves on BOP stack - Activate "emergency disconnect"	**If emergency disconnection occur at end of control** - Kill and / or choke line full of fluid influx (gas or liquid) **If drill string full of original mud** - Pressure between "pipe rams" and "SBR". **Difficult well recovery will be anticipated.**

Conclusions

The sixth generation mobile offshore drilling units, expected to be very soon on market (by the end of 2008) will contain radical changes in both appearance and structure from conventional rigs.

Judging by the research & construction projects currently ongoing, to meet the needs of the operators and the drilling contractors, we can expect some or all of the following:

- Large deck space
- Vertical riser storage system
- Powerful thrusters system
- Dual activity RamRig
- More compact

Because of the rise in day rates, a common goal expressed by those looking into new designs is to hire a rig that can get the job done quickly and safely.

Rig market

Effective rig utilization today is at nearly 100% and industry experts continue to predict rig shortage for the foreseeable future. Rig rates have reached record levels over the past years. Drilling contractors were awarded long contracts with high rates [6].

The day rates have at least doubled, but, once day rates are increasing, the costs for Contractors are increasing as well, especially labor costs. As a result of new built rigs, many of the new rig owners are realizing that they have to put those rigs to work soon and they need competent crews. They don't have the resources to hire and train crews, so they're basically sourcing them from existing drilling contractors.

Higher oil prices have given a boost to drilling activity worldwide, they've been key to marking mature fields profitable again

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Operaţii de foraj executate cu instalaţii offshore în ape adânci şi foarte adânci

Rezumat

În lucrare sunt prezentate aspecte specifice privind activitatea de foraj în ape adânci şi foarte adânci legate de managementul platformelor de foraj, aspecte analizate prin prisma elementului siguranţă.