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Risk Associated with Drive-Off/Drift-Off when Drilling on DP

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1 BACKGROUND

During recent years drilling from vessels applying DP has become common practice. Drilling on DP, particularly in shallow waters has however, made it necessary to put more focus on the ability to perform safe disconnection of the drillstring and marine riser during a drilling operation.

Loss of position without safe disconnection could result in critical damage to the well barrier as well as to exposed subsea equipment. The ultimate consequence could be a well blowout and/or severe damage to subsea production systems like production templates resulting in risk to personnel, environmental damage, financial loss and harm to the reputation of the company.

This paper focuses on these aspects with emphasis on operations in shallow waters, i.e. water depths less than 350m. Examples have been taken from the 5th generation drilling rig “West Venture” owned and operated by Smedvig ASA and now operating on the Troll field in the North Sea.

2 RISK OF DRIVE-OFF/DRIFT-OFF

The risk of position loss due to drive-off or drift-off during drilling or well intervention operations can not be disregarded.

Statistics on loss of position for DP vessels in general indicate a frequency of position loss in the order of 1 to 1.5 incidents per vessel year operating on DP.

It is, however, by no means obvious that this figure is relevant when considering drilling on DP using DP class 3 vessels. Many of the loss of position incidents have occurred during relocation operations or with vessels operating in DP class 1 or 2.

However, even for a drilling vessel operating in DP class 3 the risk of position loss cannot be disregarded.

When evaluating loss of position in a drilling context the degree of position loss must be defined, i.e. the critical excursion in meters. This distance is of course dependent on the water depth at the actual location.

Based on the general statistics and by adjusting for:

- DP class
- Degree of excursion

a frequency of position loss of 0.3 per year was derived for the case in question. The split between drift-off and drive-off was found to be 2/3 to 1/3 respectively.

The risk of position loss was also modeled by fault tree methodology reflecting the specific features of the rig and operations in question, i.e. :

- Power generation and distribution system
- Position reference systems
- DP control system
- Thruster arrangement and control system
- Sensor systems, i.e. Gyros, MRV's, etc.
- Critical utility systems
- Environmental conditions
- Operator interaction.

This resulted in a calculated position loss frequency of approx. 0.1 per rig year.
The analysis of risk of position loss clearly concludes that this is a situation which has to be considered and that safe disconnection of the marine riser is mandatory for the foreseen loss of position incidents.

3 CONSEQUENCES OF DRIVE-OFF/DRIFT-OFF

The consequences of loss of position is in principle lost efficiency and increased cost if the marine riser is disconnected prior to critical excursion.

If the marine riser **is not** disconnected fast enough something will break.

The key question is what will break?

For the case in question a number of detailed analysis were performed in order to determine the consequences of a loss of position with no disconnection of the marine riser.

A number of scenarios were considered in this context:

- excessive top riser angle
- excessive lower riser angle
- excessive stroke-out of the riser telescopic joint
- possible contact between moonpool and riser or riser tension system
- excessive horizontal pull-forces on the BOP.

Based on these analyses it was found that the most critical factor was the excessive horizontal pull-forces on the BOP, i.e. the consequences would most likely be a toppled BOP.

The ultimate consequence in case of a position loss with no disconnection would hence be:

- an open hole - which could develop further into a blowout situation, depending on the well operation in progress. Note that the operations in question include well drilling and completion as well as well testing.

- extensive damage to subsea equipment - in particular this was a major concern for the case in question with drilling on a multiwell template

Such consequences are clearly unacceptable. The main focus should therefore be to ensure that safe, reliable and fast disconnection of the marine riser can be achieved for the critical scenarios.

4 FACTORS AFFECTING EMERGENCY QUICK DISCONNECT (EQD)

The following key factors affect the probability for a successful disconnect operation:

- Available time, i.e. time to reach critical excursion
- How to detect the position loss
- How to initiate EQD
- Time to execute EQD
- Reliability of EQD system.

Available time
The time available to perform EQD is basically dependent on:

- speed of the vessel
- critical distance.

The critical distance is a function of the water depth: the shallower the waters, the shorter the distance, and hence the shorter the time available.

The speed of the vessel in case of a loss of position is a far more complicated issue. In case of a drift-off, which generally constitutes 2/3 of the position loss cases, this is a matter of environmental conditions. This can be calculated based on statistics on environmental conditions and the hydrodynamic behavior of the vessel. The operating condition limitations need also to be considered in this context.

In case of a drive-off the situation is more complicated. The following key factors are of importance:

- cause of drive-off
- available thruster force
- environmental conditions
- recovery actions initiated by the DP operator.

By analyzing and modeling the different functions affecting the above factors, time/distance plots for various drive-off scenarios were modeled. These were subsequently verified and calibrated based on sea trials.

The recovery actions are heavily dependent on operating procedures as well as training and experience of the DP operators.

How to detect the position loss
This factor is dependent on the cause of the position loss as well as the position reference systems that are being applied. For the drift-off scenarios all position loss situations will be detected by the system. However, for the drive-off situations a fraction of the cases will/may not be detected by the system itself as a system failure may be the case of the drive-off.

The time from the onset of the incident to detection is also a critical parameter.

Operator training and experience as well as the DP system configuration are important factors in this respect.

How to initiate EQD
A key issue in this context is whether EQD should be initiated manually or automatically. In the case of manual initiation the key question is by whom.

Traditionally the driller based on information provided by the DP operator and the DP system has initiated EQD.

When operating in shallow waters, and when the time factor becomes critical, this needs to be looked into carefully.

For the case in question it was concluded that the only possible way was to initiate EQD automatically by the DP system. However, the DP operator and the driller also had the possibility to initiate EQD manually in addition to the automatic system. The main benefit from this was to gain time as well as to increase the reliability of the EQD disconnect system.

Time to execute EQD
The time to execute EQD, i.e. the time from initiating EQD to complete unlocking is obviously a key element in the total risk picture.

Traditionally this time is in the order of magnitude of 30-40 seconds. Detailed analysis of various unlocking systems has, however, showed that this time can be significantly reduced.

For the case in question an improved and slightly modified unlocking system has been developed in order to reduce this time.

Reliability of EQD
A comprehensive reliability model of the EQD system was established in order to analyze the system reliability as well as various principles for activation.

5 OPERATIONAL IMPROVEMENTS

Based on the systematic evaluations and analysis of the loss of position risk a number of operational improvements have been made.

Interaction by DP Operator
All DP vessels are manned with highly skilled personnel who are trained to handle abnormal situations in the DP system. However, what actions that should be taken if a drive-off occur, are difficult to decide before the actual situation occurs. Our conclusion after long discussions and simulations of what is possible to do in a relative short period of time is to stop the accelerating force by putting the thrusters to zero speed. By doing this the speed will gradually decrease and after a while end up in a "drift-off speed" corresponding to the weather acting.

Manual or Automatic Disconnect
Initiating the disconnect sequence must be done when the vessel reaches the predefined red zone. If this action is delayed, either by operators evaluating or hesitating to push the button it may be crucial for the situation. It is also important to arrange the Emergency Disconnect buttons in such a way that initiation is possible without moving away from the driller's position.

In shallow waters, automatic disconnect is another and for Smedvig the preferred solution. This means that when the vessel reaches the red zone limit, a signal from the DP system will trigger the emergency disconnect function in the BOP control system. In addition the usual status alarms will be activated and direct communication is established between the DP operator and the driller.

By doing this the driller can focus on his tasks on the drill-floor where he should concentrate on preparing for hang off at the same time as he is fully aware of the rig's position both by looking at the status lights and by communicating with the DP Operator.

Disconnect Time
The time needed from initiating the emergency disconnect sequence to the time where the LMRP actually is free, is of course also a very important factor. Today's BOP and BOP Control Systems have a disconnect time of approx 30-35 seconds. Optimization of this time may be possible by looking at parallel activities in the sequence.

Reliability of EQD
The reliability of the EQD system can be improved and has been improved by increasing the redundancy of the system.

6 SOFTWARE TOOL FOR ESTABLISHING THE RED ZERO

Especially for operations in shallow waters, the red zone should be established as far away from the "well-center" as possible. Based on experience, the zone is set at a point corresponding to approx. 4 degrees riser angle.

However, in order to better control all the effects discussed above, a simple computer program has been developed. The program will advise where the red zone should be set based on the following:

- Vessel characteristics
- Environmental conditions
- Footprint (Initial position and excursions)
- Drive-Off Scenarios
- Recovery
- Max. allowable riser angle

The tool was used for establishing said limits for the drilling rig West Venture. In addition to get a good feeling for a correct limit, it was also useful in analyzing the importance of the various effects. The sensitivity of each parameter was also visualized and helped in the understanding of the problem.

7 CONCLUSION

Based on the systematic analysis of the risk associated with loss of position a number of improvements have been identified and implemented. The improvements include operational as well as emergency procedures and technical aspects.

With this focus and improvements the operator is confident that the well operations can be performed in a safe way when operating on DP even in relatively shallow waters.