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Session I

Review of DP Applications, Consequences and Cost of Failures

Drilling Fundamentals-DP Operations-Drilling with Riser

By: Earl Robinson

BHP (Houston)

Session Planners

Paul King: *Transocean (Houston)*

Earl Robinson: *BHP (Houston)*

Drilling Fundamentals-DP operations-Drilling with Riser

During drilling operations conducted in a DP mode, the ultimate goal is to maintain control of the well with no damage to drilling equipment in the event of a station keeping failure.

Modern DP systems have greatly enhanced reliability of DP systems for drilling, but incidents still ocurr. When an incident does occur, it is required that the well be secured and the riser be disconnected before any damage occurs to either the wellhead or any of the drilling equipment including BOP stack, LMRP, slip joint, moonpool or riser tensioners.

During actual drilling or tripping of drill pipe and there is loss station keeping ability it is necessary to be able to

1. Hang off the drill pipe on pipe rams
2. Shear the drill pipe
3. Effect seal on the wellbore
4. Disconnect the LMRP
5. Clear the BOP with the LMRP
6. Dissipate any energy in the riser/riser tensioning system
7. Safely capture the riser

The timing of these operations is critical, particularly items 1-4.

Modeling analysis can be done to predict various excursion scenarios that could possibly occur. These models can predict excursions of the vessel for various combinations of environment (for drift off or power loss scenarios) and uncontrollable thrust excursions (or drive offs)

It is also possible to model the reaction of rig equipment during these excursions. The items that are critical during an excursion are:

1. The LMRP connector/Lower Flex joint angle
2. Moon Pool Clearance
3. Slip Joint Stroke
4. Tensioner Stroke Limits

It is critical to have the LMRP disconnected before either the LMRP connector reaches its limits for disconnect (~10°) or the Slip Joint strokes out or contacts the moonpool.. Other wise, there is a high risk of bending/damaging the wellhead or losing the riser, or both. Since once the disconnect sequence is initiated there will be a finite amount of time

pass before the disconnect actually will take place, it is necessary to initiate the disconnect well before limits of any of the equipment is reached.

On most drilling units in use today, systems are designed so that once the final disconnect sequence is initiated with all required subsea functions taking place in sequence automatically, the LMRP will lift off in 30-40 seconds. Therefore the sequence would be initiated at least 30-40 seconds prior to limits of any equipment being reached. In reality, it is best to begin this sequence earlier in the event of any malfunctions or miscalculations.

The point at which to initiate the disconnect must be clearly defined with no ambiguities, since the driller alone may have to make this decision quickly, with no help from ether a tool pusher or company drilling supervisor. If a certain pre-defined limit is reached, then the sequence has to be initiated with no questions asked. The question posed when is then the time to begin preparations to disconnect, and what is the best indicator to use (It is explicit that there will always be communication with the DPO and driller.)

Traditionally in DP operations, many people have used offset distance, measured in percent of water depth, to establish "watch circles" to indicate when to begin disconnect procedures. To overly simplify some of these procedures, preparation for disconnect would begin at a distance of 2.5% of water depth, and disconnect initiated at 5.5% of water depth. Generally, an offset of 2.5% constituted a "yellow alert" and an offset of 5.5% of water depth constituted a "red alert". It is assumed that there will be time to safely disconnect and clear the LMRP before any equipment will reach it's limits. With low mud weights, this is probably true except for the most extreme conditions.

With higher mud weights, however, lower flex joint angle will be much higher than for lower mud weights for the same given offset. Additionally, the lower flex joint angle, particularly at higher mud weights, reaches its limit of 10° before , or at the lower mud weights, at about the same time that the other 3 items reach their limits. On most modern DP rigs, equipped with multiplex control system, flex joint angle read out is available at the DP console on a real time basis, and can be tied into an alarm on the drill floor. For this reason, some rigs use the lower flex joint angle instead of offset as the primary indicator of the time disconnect. Offset is certainly a part of the equation, but is used for information rather than the definitive indicator.

Tying flex joint angle into alarms on the rig floor allows for an independent alarm over and above direct communications with the DPO. Typical of some rigs, in a de-graded status, a reading of flex joint of 3° would indicate to the driller to hang off drill pipe and prepare to disconnect, a "yellow alert" status. A reading of flex joint 5° would indicate that point which to disconnect, or "red alert". Except for the most extreme conditions, if a disconnect is affected at a lower flex joint of 5 degrees, if the LMRP lifts off in 30-40 seconds, all equipment should remain within it's operating limits. While communications with the DPO are crucial, the driller having a direct read out is a redundancy in the event communication with the DP room are lost for what ever reason.

It is of note that as rigs move into deeper water, slip joint stroke could well become the limiting factor rather than lower flex joint, especially at lower mud weights. Since offset increases for a given lower flex joint angle in deepwater, longer slip joints may be a requirement in ultra deep water .

No matter what criteria is selected for yellow and red alert, these procedures must be short, clear , and concise. There should be no ambiguities -it is unfair to the driller to require him to make too many judgment calls in the heat of the battle. Situations must be reviewed before operations start so that final procedures are to the point-at a certain limit the pipe is to be sheared and the LMRP disconnected-no questions asked. Procedures should be posted in the driller's house and there should be a clear procedure for the following:

- Normal Drilling Operations
- Well Control Situations
- Casing Across he BOP
- BHA Across the BHA.

Additionally, general procedures should have the toolpusher and co. rep on the floor any time that there is anything in the BOP that can't be sheared.

Modern DP MODU's generally are outfitted with a multiplex BOP control system. This is a requirement due to the speed of response required to disconnect. Additionally, sufficient hydraulic storage should be available on the BOP/LMRP to allow for the disconnect sequence to function with no re-charge from the surface.

Levels of Vulnerability-Drilling with Riser

Clearly, when ever the riser is connected, vulnerability is high for a severe incident. Following is and estimation of increasing levels of vulnerability with a brief discussion of each:

Bit above BOP Stack—This is the point of least vulnerability, and is the preferred position for any operation other than being on bottom drilling.

Drill pipe across Stack--- Whenever drill pipe is across the stack, the driller must always be cognizant that it could become necessary at any time to hang off the drill pipe, shear and disconnect. He must also be aware that as the rig drifts off location during a station keeping upset, he will have to leave enough room to allow the block to slack off to keep the tool joint at the hang off point. For this reason, slip time should be kept to a minimum, and when drill pipe is hanging from the elevators, as much pipe as possible should be left hanging. These practices have to be clearly communicated to any one who is on the rig. While experienced DP operations personnel understand these issues, with the wave a new builds/conversions under construction, experienced personnel are in short supply.

Shear rams must be tested on the rig to both shear and hold working pressure on any drill pipe that will be across the stack. Some drilling rig BOP's are equipped with dual shear rams to provide redundancy in the event of a disconnect. This is philosophical issue that has to be addressed by both contractor and operator.

BHA Across stack-BHA should be held to a minimum in the likely event that the BOP system is not capable of shearing the components. Heightened levels of alert should be implemented when the BHA is across the stack, with provisions and procedures for dropping the string in the event that a station keeping upset occurs while the BHA is across the stack

Well Kick—It is advisable to hang off during well control situations so that in the event of a station keeping incident, activity is kept at a minimum in the event a disconnect is necessary. Running a drill pipe float should be considered as an extra barrier in an attempt to keep pressure off the drill string for reconnect operations.

Casing across the BOP—This is possibly the most vulnerable situation during DP drilling operations. Only recently have BOP's had the ability to shear casing. In the past the procedure for handling a station keeping incident while casing was across he BOP called for a procedure where by the casing was dropped. This procedure, from a practical stand point, is clearly fraught with risk. The ability to drop casing in an expeditious manner is suspect, even with air operated tools. Further, the speed at which the casing would fall would seriously jeopardized the ability to close the BOP in time in very deep water. Newer BOP's with the ability to shear casing are much more advantageous. Even then , however, procedures have to be closely planned and communicated since shearing casing and securing the well for disconnect will most likely take longer than shearing and sealing on drill pipe. Some casing shear rams do not seal after shearing, therefore consideration must be given to placement of these rams in the event of having stuck casing across the stack and have to disconnect due to station keeping problems. Even if casing is sheared, if it is stuck across the blind shear rams, there is no way to secure the well for a disconnect.

Another consideration for deepwater DP operations are long, heavy casing strings. Some of these strings will require heavy, high strength landing stings. It is a requirement that what ever landing string joint is across the BOP stack is capable of being sheared. If the landing string cannot be sheared, it is generally possible to substitute a joint of lesser weight pipe on the bottom of the landing string that can be sheared.

Consequences and Costs -Drilling with Riser—It is obvious that the potential costs of a failure to disconnect could be catastrophic with far reaching implications. Potential results of a failure to disconnect include

- Damaged Wellhead
- Damaged BOP

- Loss of Riser
- Uncontrolled subsea blowouts

It is difficult to quantify the costs of these scenarios-at very best the costs would be astronomical, with the potential to have legislation suspend DP operations in the area of a disaster. This suspension could conceivably last years until all questions have been answered and procedures dictated from governing bodies. Costs could be upward of 100 million dollars.

Drilling with out Riser –In the event of a station keeping incident while drilling riserless, here are very few options, if any, to safely release from the well. Fortunately, generally at this stage of the well, investment in minimal and an resulting damage should be something that is not all that costly. At best, remedial action would be to just renter the well. At worst, a re spud and replacement of the drill string could be required, but overall costs would not begin to approach those of a failure to disconnect t with the BOP stack on bottom. Costs should be less than 10 million.