Operations and Procedures

Refining the DP Watch Circle

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October 17-18, 2006
Refining the DP Watch Circle

Watch circles were used on the first DP Oil Drilling Rig, the Sedco 445, in about 1970, to clearly define when to safely disconnect during a loss of location.

- In 1970, riser connectors and EDS timing established watch circles
- DP rigs still use “watch circles”
- As rigs moved into deeper water, more factors had to be considered
- Even deeper water will require even more sophistication.
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Origin of Watch Circles

In order to drill offshore the well bore must be extended from the sea floor to the drilling rig. The system used to accomplish this consists of:

1. Wellhead
2. Blowout Preventer (BOP)
3. Marine Riser
4. Upper and lower flexible joints
5. Telescopic or slip joint
6. Riser tensioners
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Origin of Watch Circles

- Riser Tensioner
- Upper Flex Joint
- Slip Joint
- Marine Riser
- Lower Marine Riser Package (LMRP)
- Lower Flex Joint
- Blowout Preventer (BOP)

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In 1974, the Sedco 445 set a world record for successfully drilling in 600 meters of water.

In 600 meters of water, the limiting factor for rig offset was simple, the maximum angle at which the rig could disconnect from the BOP.

This limit was about 5° (8.7% of water depth) (Scale of ship & BOP adjusted for clarity)
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Watch circles in 1970 allowed a reasonable of rig motion while still keeping risk to a minimum

(Typical of 1970, 600 meters of water - drawn to scale)
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1970 to 1995

- Water depth records increased from 600 meters in 1974 to 2,000 meters by 1983
- YELLOW and RED were larger than the normal operating envelope, yet well inside the POD.
- Simple watch circles provided adequate time to disconnect without unnecessarily restricting drilling operations.
- From 1983 to 1995 the water depth record increased 300 meters
- Watch circles in 1995 similar to 1970.
- Beyond 2,000 meters other limits became important
  - Riser tensioner pulldown
  - slip joint extension
  - Moon pool contact
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Figure 3 – Wide Moonpool Allows Large Upper Angle

Figure 4 – Narrow Moonpool Limits Upper Angle
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1995 to 2006

• By 1995 the offshore drilling industry was recovering
  - Seismic technology greatly increased find ratio in deep water
  - World economic recovery
  - Tax Incentives to drill offshore
• Many attractive targets beyond 2,300 meters required
  - Longer, stronger, heavier riser
  - Taller and heavier BOPs, more functions, slower EDS
  - Taller drill floors
  - New drilling technologies
  - More crew and specialists
• Drilling in deeper water required larger rigs
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1995 to 2006

- Larger rigs changed the risk formula.
- Watch circles of 1970 were inadequate.
- Factors to be considered included:
  - Riser connector
  - Riser tensioner / slip joint stroke range
  - Multiple EDS sequences
  - Flex Joint stiffness
  - Upper flex joint angle
  - Well head / casing / soil strength
  - Rig velocity
  - Drift off analysis
  - Special operations or equipment
- Sophisticated tools required for complex analysis
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DP Vessel Drift-off and Watch Circle Program
Discoverer Spirit (3825)

Distance from Well Center to Disconnect: 4.4% WD 62 n
Distance from DP Set Point to Disconnect: 4.4% WD 61 n
EDS Sequence Duration: 4 min 15 sec (2.4 min)
Reaction Time: 2 min 45 sec (1.4 min)
Red Watch Circle Radii (centered on well): 1.6% WD 22 m 73 ft
Yellow Watch Circle Radii: 0.9% WD 12 m 40 ft

RIzer System & EDS Parameters:

Riser Point of Disconnect Offset Limits

<table>
<thead>
<tr>
<th>Component</th>
<th>Manual Value</th>
<th>Offset from Well Center or Watch Limit Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Flex Joint</td>
<td>6 deg</td>
<td>6.7% WD 33.6 n 306 ft</td>
</tr>
<tr>
<td>Upper Flex Joint</td>
<td>6 deg</td>
<td>6.0% WD 112.0 n 367 ft</td>
</tr>
<tr>
<td>Stroke-out (msec)</td>
<td>0.0 integer</td>
<td>0.0% WD 0.0 n 0.0 ft</td>
</tr>
<tr>
<td>Well Head Bending Moment</td>
<td>5100 lbf-ft</td>
<td>4.4% WD 616 m 262 ft</td>
</tr>
<tr>
<td>Structural Cage Bending Moment</td>
<td>5363 lbf-ft</td>
<td>1.6% WD 105.6 n 346 ft</td>
</tr>
</tbody>
</table>

Emergency Disconnect Sequence

1. Disconnect: 50 sec
2. Spin: 0 sec
3. Spin: 0 sec
4. Spin: 0 sec
5. Spin: 0 sec

Rig Heading & Environmental Conditions

Rig Heading Set Point: 3 deg TN
Rig Position Set Point Relative to Well: 0.0 m N (centerline of well)

Environmental Conditions: Date of Last Update: 29-Sep-06
Time of Last Update: 9:50

Wind (10m, 1 min avg) 17.0 m/s 32.6 km/h from 15 deg TN
Current 1.02 m/s 2.00 km/h from 045 deg TN
Seas Sig. Wave Height (ft) 0.0 ft 0.0 ft from 0 deg TN
Swell Sig. Wave Height (ft) 0.0 ft 0.0 ft from 0 deg TN

Watch Circle and Reaction Time

Outputs simple watch circles

Sophisticated Analysis

Similar to 1970
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Well Specific Operating Guidelines

Define the response for any situation.

- Critical equipment faults or failures
- Operating near capability
- Special operations
- Normal operations infrequently performed
- Vessel motion
- Sea floor obstructions
- Hurricanes
- Loop current
- SIMOPS
- CLOSEOPS
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- Sedco 445 in 600 meters of water
- Deepwater rig in 600 meters of water
- Deepwater rig in 1,400 meters of water
- Deepwater rig in 3,000 meters of water
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The Future

• New rigs will likely be more complex and larger
• SIMOPS will become more common
• CLOSEOPS will become more common
• Drilling innovations will require that we move closer to the operating envelope
• The challenge for the DP industry is to make sure we can support the advance of drilling technology while maintaining acceptable watch circles.
• Following are some ideas how we may progress
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The Future

• Faster emergency disconnect
• BOP stack angle
• Riser tension management
• Riser angle management
• Velocity measurement
• Velocity management
• Dynamic watch circle
• Whatever we do, keep it simple
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Conclusion

The watch circle is a powerful, yet simple tool to manage risk.

Over the past 3+ decades, we have been able to retain this tool, though the analysis to derive the watch circles has changed significantly.

It seems likely that we can continue to define our limits as watch circles as we move into deeper water in our search for more oil.
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Thank you

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MTS DP Conference Houston
17-18 October 2006