SPE 184730-MS
Well Collision Avoidance Management and Principles

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On behalf of the SPE Wellbore Positioning Technical Section (WPTS) Collision Avoidance Sub-Committee also referred to as ISCWSA
Introduction – Well Collision Avoidance

- Not a new subject, but
- Current guidance
  - Disparate
  - Company specific
  - Occasionally contradictory
- Goal: Standardise
  - Rules
  - Process
  - Nomenclature
  - Improve efficiency
  - Reduce implementation errors
  - Input to API RP78 development

Nomenclature:

Reference Well:
  - The well being drilled

Offset Wells:
  - Adjacent wells
“The adoption of a particular minimum allowable separation rule, no matter how conservative, does not ensure an acceptably low probability of collision”
Offset Well Risk Classification

**HSE Risk Well**
Collision with it could result in an uncontrolled release of material:
- Hydrocarbons
- Chemical (e.g. H₂S)
- Nuclear (e.g. radioactive material)
- Biological
- Physical (e.g. geothermal)

or undermine facilities. (e.g. working mines, piles)

Does not have to be at surface:
- Sub-surface blowouts
- Sub-sea releases

**Non-HSE Risk Well**
Can be addressed solely in financial terms

- Temporal risks - damage after the collision
- Remediation (access and time)
Well Collision Frequency

<table>
<thead>
<tr>
<th>Date</th>
<th>No.*</th>
<th>Collision Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1980</td>
<td>3</td>
<td>1/2150</td>
</tr>
<tr>
<td>1980-1998</td>
<td>1</td>
<td>1/16330</td>
</tr>
</tbody>
</table>

*Offshore North Sea, GOM and Canada – uncontrolled flow to surface

Why the interest?

- Unreported incidents?
- No uncontrolled flow?
- Changes in industry practices?

- Land based drilling activity increased
- Drilling pads
- Closer well spacing
- Conductor sharing
- Additional slots
- Poorly surveyed old well stock
## Well Collision Example

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
<th>Cause</th>
<th>Avoiding Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>18*</td>
<td><strong>Offshore:</strong> Whilst drilling a fast ROP top hole section with a recognised collision risk, the well built angle faster than expected. The first few MWD surveys failed QA/QC due to suspected magnetic interference. The rig crew rejected them entirely and continued to drill blind. They drilled into an offset well causing a kick, throwing the drillstring out of the hole. When investigated, plotting the rejected MWD surveys showed the well heading straight towards the offset ...</td>
<td>Failure to plot, and manage anomalous readings.</td>
<td>Adhere to required practices, after each survey and project ahead.</td>
</tr>
</tbody>
</table>

* One of 19 HSE and Non-HSE incidents recorded over the last 15 years

**Human Factors**
- Risk habituation?
- Collisions are still relatively rare
- But less so than indicated
- Major influence is well density
- Industry trends ... added care
Leading Indicators

% of wells for which exemptions are required

Helps detect “weak signals”

Poedjono et. al. 2009
The Collision Avoidance Elements

- Minimum Allowable Separation Distance (MASD)
- Separation Factor (SF)
  - Dimensionless number
  - Critical condition SF = 1
  - Topic elaborated on in the 2nd paper

<table>
<thead>
<tr>
<th>Element</th>
<th>No. Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data structure integrity</td>
<td>4</td>
</tr>
<tr>
<td>Position uncertainty</td>
<td>-</td>
</tr>
<tr>
<td>Well reference point</td>
<td>1</td>
</tr>
<tr>
<td>Wellbore survey program</td>
<td>-</td>
</tr>
<tr>
<td>Collision avoidance management</td>
<td>9</td>
</tr>
<tr>
<td>Wellbore survey operations</td>
<td>1</td>
</tr>
<tr>
<td>Quality assurance</td>
<td>-</td>
</tr>
<tr>
<td>Effective communication</td>
<td>3</td>
</tr>
</tbody>
</table>
### Typical MASD Dispensations

- Effectiveness not predictable
- Energy still being put in
- Penetration always possible
- Penetration can be rapid

**Acceptable mitigations are those which reliably preserve the relative well separation and so reduce the probability of well to well contact.**

<table>
<thead>
<tr>
<th>Proposed Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple casing strings protecting the tubing</td>
</tr>
<tr>
<td>Jetting instead of drilling</td>
</tr>
<tr>
<td>Rotary drilling instead of motor drilling</td>
</tr>
<tr>
<td>Drilling with a mill-tooth bit instead of a PDC bit</td>
</tr>
<tr>
<td>Drilling with a dull or “shirt tail” bit</td>
</tr>
<tr>
<td>Drilling with low ROP</td>
</tr>
<tr>
<td>Monitoring the shakers for cement/steel</td>
</tr>
<tr>
<td>Monitoring offset wellhead vibration</td>
</tr>
<tr>
<td>Monitoring offset casing annular pressure</td>
</tr>
<tr>
<td>Low angle of incidence between wells</td>
</tr>
<tr>
<td>Soft formation</td>
</tr>
</tbody>
</table>
Graphical Representation of Well Separation – Travelling Cylinder

- Simplest, documented method
- Key device to show tolerances
- Support plan review and approval
- Monitor progress / project ahead
- Assess closure between wells
- Shared situational awareness

- Training essential for its use
- Scan down the OFFSET well
- Orthogonal and end-to-end cases?
- Short radius drilling?
Graphical Representation of Well Separation – 3D Ladder Plot

- Shows each well’s MASD
- Not direction specific
- Magnetic interference zone
Planning Phase Workflow

Complete set of wellbores

Offset Well Classification

Use of SSSVs

Operational improvements (F) can not alter the conditions or assumptions on which the scan is based

Start

Plan Engineered Well Path (A)

Select & Classify All Appropriate Offsets (B)

Wellbore Proximity Analysis (C)

SF Acceptable? (D)

Construct Tolerance Lines (E)

Consider Operations Improvements (F)

Control Well Plan Revision and Prepare to Execute Plan (G)

End

Manage Allowable Deviation

• Re-plan Well Path
• Revise Survey Program
• Resurvey Offset Well
• Resurvey Relative Wellhead Position
  And / Or
• Re-evaluate Offset Well Classification
• Consider Ranging
• Other Compliant Options

Yes

No

Change Possible? (J)

Unable to Create Allowable Well Path (K)

End

Yes

No

H
Execution Phase Workflow

Preconditions met
B, C, D, E, F, I Loop
Stop Drilling
Identify situations where the reference well is drilled significantly off-plan

Start

A
Confirm Preconditions
- Offset Status per Classification
- Approved Well Plan Revision
- Operational Conformance as per Plan

B
Acquire and QC Directional Survey
Measurement per Survey Program

C
Calculate Position
- Project to Bit
- Project Ahead According to AC Plan

D
Stop Drilling
At TD?

E
Wellbore Proximity Analysis

F
Acceptable to Drill Ahead?

G
Can Adjust?

H
Stop Drilling
Refer to Planning Phase

I
Drill Ahead to Next Survey Point

End

Yes

No

Yes

No

Yes

No
Conclusions

• Well collisions remain an operational risk onshore and offshore
• Rigorous application of the Elements will help avoid collisions
• Collisions: Data, Collision Avoidance Management, Communication
• Risk habituation has played a significant part in a number of these
• Remediation costs for non-HSE collisions generally higher than plan
• Analysis of collisions difficult (infrequent, reluctance to share data)
• Further work: barrier management / measure well to well separation
The efforts and contributions to this paper made by the officers of the SPE Wellbore Positioning Technical Section (WPTS), the members of the Collision Avoidance Sub-Committee and the generosity of the member’s respective companies for supporting their participation and attendance at meetings are gratefully acknowledged.