ANTICOLLISION for MULTI-WELL PADS

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Surveying in the “Post-Hole” world

- Wellbore collision risks in post hole world are smaller, as well surface spacing is large.
- Some HSE Risk, but only in the gross error cases.
- Economic reasons to survey, i.e. understanding EUR and ensuring lease line compliance
- Government Regulation Requires Surveying
- Finding those “errant” wells.... i.e. the one every now and then that goes off at 45 degrees inc....
Transition to Pad Drilling

- 4 wells /section
  - 160 acre spacing

- 20 wells /section
  - 32 acre spacing

- 25 wells /section
  - 25 acre spacing
ANATOMY OF A MULTI-WELL PAD

Things are more complex on a pad

- Multi-well pads introduce substantially closer wellbores
- Smaller errors can lead to wellbore collisions.
Multi-well environments create a new drilling hazard – wellbore collision

- HSE-Critical Case
  - Drilling surface hole near an online well
  - Danger of high pressure breach to new well
  - Danger of offset well integrity degradation
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  - Mitigating measures in place for offset well (subsurface shut-in below intersect point)
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- **Delayed Risk Case**
  - Economic-only cases have the potential to become HSE cases, particularly in the event of near collisions (i.e. casing integrity decrease)
  - Damaged casing may fail when subjected to pressure later (e.g. during fracking)
QUANTIFYING ANTICOLLISION RISK

How can we measure the risk of penetrating an offset wellbore?

\[ P_d = P_c \times P_p \]

- \( P_d \) = Probability of wellbore integrity compromise
- \( P_c \) = Probability of wellpaths colliding (anticollision calculations)
- \( P_p \) = Probability of penetration of other wellbore in the event of contact

- \( P_c \) is a measureable risk using current industry-standard practices
  - ISCWSA has established error model framework for estimating wellbore position errors
  - Ultimately, position errors from multiple wells can combine to estimate \( P_c \)

- \( P_p \) cannot be measured or estimated with any current techniques, and therefore should not be used in anticollision considerations

Source: iscwsa.net
MYTHS AROUND $P_p$

“But what if I.....”

- ...use multiple casing strings to protect the tubing?
- ...use jetting instead of drilling?
- ...use rotary drilling instead of motor drilling?
- ...drill with a mill-tooth bit instead of a PDC?
- ...drill with a dull bit?
- ...drill with a shirt tail bit?
- ...drill with low ROP?
- ...monitor shakers for cement or steel?
- ...monitor offset wellhead vibration?
- ...monitor offset casing annular pressure?
- ...maintain low angle of incidence between wells?
- ...am drilling in a soft formation?

All of these are commonly assumed to reduce $P_p$, but their effectiveness is not predictable, and thus they cannot reliably ensure penetration will not occur.

Source: iscwsa.net
MANAGING $P_c$

Managing anticollision risk requires a comprehensive approach.

- Drilling Program Anticollision Policy
- Validated Survey Program, with Contingency Plans
- Well Execution to plan/policy
- Reactive Collision Avoidance Measures
What is an AC Policy?
- Definition of policy for management of wellbore collision risk.
- Generally include rules about how close a reference well can be drilled to an offset well.
- Specify corrective actions triggered at various separation levels between wells

Who's policy should we use?
- Both Operator and DD company policies exist.
- Operator policies focus on HSE and usually economic risks
- DD company policies typically focus only on HSE risk

Who defines HSE Risk?

A governing document (or documents) is used to manage drilling risk ($P_c$).
The SPE-WPTS (ISCWSA) has developed an industry-standard wellbore positioning error modeling framework.

- ISCWSA formed in 1995 by operators and service companies involved in critical anticollision wellbore construction
- Multiple SPE papers define a framework for modelling MWD and gyro survey uncertainty (67616, 90408, etc.)
- Uses mathematical probability models to convert survey instrument uncertainty to wellbore position uncertainty
- NOTE: IPM’s are vendor-specific, and not validated by the ISCWSA!!
Common Anticollision Rules

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  - Simply distance between wells
  - Does not account for position uncertainty
  - May be useful at very shallow depths
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  - $S/(U_R + U_O)$
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- **Probability of Intersection Rule:**
  - \( P_C = f(S, U_R, H_C) \)
  - \( U_R = \) Combined 1\( \sigma \) uncertainty
  - Not always valid...unfortunately.

Source: iscwsa.net
Design of a validated survey program is critical

- Anticollision calculations are based on Instrument Performance Models specified at planning stage.
- Selection of instrument performance models requires collaboration with survey providers to ensure that service to be run matches plan.
- Requires close collaboration with survey providers to ensure there is a good understanding of survey tools/errors.
- Magnetic Interference – typically within 50 ft, magnetic readings may be corrupted due to offset well magnetic interference.
SURVEY/AC PLAN EXECUTION

During drilling, the AC policy and survey program must be followed in realtime

- Monitoring of policy-based anticollision criteria in realtime
- Proper execution of survey program – deviations will require re-run of anticollision plan
- Use a travelling cylinder
Dealing with unexpected close approaches...

- **Reactive Response Objectives**
  - Primary – detection assessment and avoidance of an offset well
  - Secondary - typically to intentionally increase separation between wellbores

- Preferable to not find yourself in a reactive situation, but being prepared to react is significantly better than reacting blindly.
Magnetic and Gyro Surveying

- **Magnetic Surveys**
  - Sensors are generally similar across vendors
  - Major error source is Earth field model
  - Physical properties measured:
    - Magnetic Field (dynamic, complex model)
    - Gravity (simple, accurate model)

- **Gyro Surveys (North-Seeking/Continuous)**
  - Significant variation in sensors across vendors
  - Numerous dynamic sensor properties increase complexity of tool model
  - Physical properties measured:
    - Earth Rotation (simple, accurate model)
    - Gravity (simple, accurate model)
    - Tool Movement

- **Conventional/Free Gyros**
  - 1970’s Tech, subject to unmodeled drift errors... Don’t recommend using these.
PRACTICAL NOTE

Gross Errors – Not a part of the model.

- Instrument calibration and realtime QC checks are aimed at capturing tool malfunction and sensor performance errors.
- Human errors cannot be completely eliminated through software or equipment control, and cannot be modeled.
- Rigorous data management provides additional checks for detection of gross error.
- When practical, survey redundancy is the best method for gross error detection.
Magnetic Interference? Realtime solution: gyroMWD

- When multiple wellbores are within 50 feet of each other, magnetic MWD readings can be corrupted due to magnetic interference.
- These readings do not provide a reliable azimuth.
- In these cases, gyro surveys are the only reliable method for monitoring wellbore trajectory.
- Historically, gyro surveys were collected using wireline singleshots
- gyroMWD technology now enables collection of gyro surveys in realtime without the need to
IN SUMMARY

- Due to the nature of tight, unconventional resource plays, the number of wells required to maximize recovery factor of OOIP will decrease and increase respectively.

- Environmental and cost constraints will continue to necessitate use of multi-well pads, meaning that land markets will experience similar demand for collision avoidance procedures as have been in use offshore.

- A Scientific approach to anticollision ensures that HSE and economic wellbore positioning objectives are met.

- Operator, directional driller, and survey companies must work together to ensure that anticollision policies are in place and survey programs are valid and followed during drilling.

- Proper selection of wellbore survey technology is critical in ensuring validity of anticollision plans.
Thank You

For more information:
http://www.scientificdrilling.com
http://www.iscwsa.net

The Ultimate Partner In Wellbore Placement