PERFORATING VERTICAL SMART WELL COMPLETIONS USING TUBING-CONVEYED PERFORATING GUN ASSEMBLIES: CASE HISTORY

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AGENDA/INTRODUCTION

BACKGROUND INFORMATION

FIELD APPLICATION

- Challenge #1  Cable Detection
  - Magnetic Based Locating Tool
  - Conventional Ultrasonic Acoustic-Based Locating Tool

- Challenge #2  Orientating Perforations
  - Electric Line Deployment
  - TCP Deployment

- Results

ACKNOWLEDGEMENTS
BACKGROUND INFORMATION

SMART WELL COMPLETIONS

- External casing fiber optic cable
- Distributed pressure/temperature /acoustic sensing across entire well length
- Allows real-time monitoring of well production or injection characteristics
- Any damage during installation or throughout well life renders the technology unusable
Fig. 14—A 4 5/8-in. θ to 180° gun system positioned at 90° relative direction to the FO cable before perforating to minimize the potential risk of inadvertently damaging the cable.
FIELD APPLICATION

- Shallow, Vertical Well
- Fiber Optic Cable outside 7in casing
- Requirement to perforate underbalanced without killing well over large interval
- Well must have completion in place prior to perforating
- Utilize the highest performance charges possible in 7in casing (not through tubing charges)
FIELD APPLICATION

CHALLENGE #1
- Locating the FO cable’s azimuthal direction on the outside of the casing in a near vertical (<5°) well with large casing (7-in. OD).

CHALLENGE #2
- Orientating the perforations in a near vertical (<5°) well

CHALLENGE #3
- How could the above 2 operations be referenced to each other
FIELD APPLICATION

CHALLENGE #1 – CABLE DETECTION

Magnetic Based Locating Tool

- Allows real-time detection and orientation of perforating gun away from external metal mass
- SIT tests demonstrated the optic fiber clamp could be easily and reliably identified
FIELD APPLICATION

CHALLENGE #1 – CABLE DETECTION

Conventional Ultrasonic Acoustic-Based Locating Tool

- Existing, readily available technology
- Required for cement or Pipe inspection on most wells anyway
- SIT confirmed detection of clamp

Fig. 12—Example showing possible location of clamp and reference points
FIELD APPLICATION

CHALLENGE #2 – ORIENTING PERFORATIONS

Electric Line Deployment

- Downhole rotation of guns away from metal mass e.g. dual completion or smart completion
- Not possible to use in this circumstance with guns on completion
FIELD APPLICATION

CHALLENGE #2 – ORIENTING PERFORATIONS

TCP Deployment

- Existing technology – Wireline Gyro with stinger and UBHO sub in TCP/completion string
- Simply rotate completion and check gun phasing compared to cable, set packer shoot guns
## RESULTS

<table>
<thead>
<tr>
<th>Operational Step</th>
<th>Results</th>
</tr>
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<tbody>
<tr>
<td>Measure direction of clamp / cable from UltraSonic Log</td>
<td>Clamp is at 258.5°</td>
</tr>
<tr>
<td>Run Gyro tool to engage in UBHO sub</td>
<td>Keyway is at 294.2°</td>
</tr>
<tr>
<td>Calculate the corresponding direction of the perforation phasing</td>
<td>Gun phasing is at 114.2 and 294.2°</td>
</tr>
<tr>
<td>Re-Run Gyro to confirm direction of Keyway</td>
<td>Results repeatable within 1°</td>
</tr>
<tr>
<td>Rotate completion string at surface by 60° clockwise to ensure gun string is at approx. 90° phasing to clamp</td>
<td>Keyway is at 359.8°, so Gun phasing is at 179.8 and 359.8°</td>
</tr>
<tr>
<td>Re-Run Gyro to confirm direction of Keyway</td>
<td>Confirmation of negligible UBHO/gun rotation.</td>
</tr>
<tr>
<td>Set completion packer</td>
<td></td>
</tr>
<tr>
<td>Re-Run Gyro to confirm direction of Keyway</td>
<td></td>
</tr>
<tr>
<td>Drop Bar to fire guns</td>
<td>Successful Flow to surface</td>
</tr>
</tbody>
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ACKNOWLEDGEMENTS

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QUESTIONS?
THANK YOU!

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