Increasing Operational Efficiency in Low Angle Orientated Perforating

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EWAPS, Amsterdam, 2012
Programme

- Applications of Orientated Perforating;
- Current Technology;
- Orientated Perforating System Technology;
- Case Studies:
  - Well Gu 39-98;
  - Well Yuan 288-43;
  - Well Bai 97-64;
  - Well Yuan 311-51.
- Results;
- Conclusions.

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Applications of orientated perforating:

- Avoiding casing external control lines

Metal Anomaly Tool (MAT) Data

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Applications of orientated perforating:

- Limited entry perforating;
- Steam-Assisted Gravity Drainage (SAGD);
Applications of orientated perforating:

- Dual/Triple completion perforating;
Applications of orientated perforating:

- Multi-lateral wells;
Applications of orientated perforating:

- Align perforation tunnels with rock fractures/bedding planes;
- Align perforation tunnels with principal rock stresses;
  - Optimise frac’ing.
Frac’ing – 60° / 90° Guns

60 Deg Phased Gun

Casing

Cement

Cramer, IPS-10-002

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Frac’ing – Orientated 180° Guns

180 Deg Phased Gun

Casing

Cement

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Current Technology

- High Angle Wells:
  - Gravity-based system

Oriented Perforating Tool

Courtesy of Wireline Engineering

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Current Technology

- High Angle Wells:
  - Gravity-based system
  - Pros:
    - Single RIH;
    - Simple, mechanical system;
  - Cons:
    - No positive orientation indication prior to detonation;
    - Suitable only for medium to high deviations;
    - Basic orientation confirmation mechanisms only available;
    - Single orientation angle per run only;
    - Significant additional string length;
Current Technology

- Low Angle Wells:
  - Grooved Sleeve-based system;
  - Setting Tool & Sleeve
  - Gyro & Alignment Pin
  - Gun & Alignment Pin
Current Technology

- **Low Angle Wells:**
  - Grooved Sleeve-based system
  - **Pros:**
    - Can be deployed in all well deviations;
    - Little additional string length;
  - **Cons:**
    - Multiple runs required (Between 2 and 4);
    - No positive orientation indication prior to detonation;
    - Basic orientation confirmation mechanisms only available;
    - If sleeve run in completion – little or no depth flexibility;
    - Limited to one orientation/depth per sleeve setting.
Low Angle, Low Permeability Wells;
  - 0.8 - 1.5 millidarcy

Objective: Align perforation tunnels with bedding planes;
  - Has shown to improve productivity up to 50%

Conversion of bedding plane azimuth to high-side via dipmeter logs;

Traditionally grooved sleeve system deployed:
  - Run 1 – RIH and set sleeve;
  - Run 2 – RIH with gyro and tag sleeve;
  - Run 3 – RIH with guns & sub. Latch into sleeve;
  - Run 4 – (Optional) RIH to retrieve sleeve.
CNPC/Chongqing Requirement

- Increased operational efficiency;
  - Reduced number of runs;
- Confirmation of orientation prior to detonation;
- Dictated an ‘intelligent’ system to orientate and perforate in one run.

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System Selected

- Orientated Perforating System (OPS);
- Toolset selected enabled:
  - Anchoring of string;
  - Detection of high-side (Calibration);
  - Orientation to specified angle;
  - Confirmation of orientation prior to detonation;
- Specification:
  - Orientation Accuracy +/-3 ° at >15 ° Deviation;
System Selected

- Toolstring:

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Four Candidate Wells (All 5 ½”):

1. Gu 39-98 - Single zone

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>Deviation</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2031</td>
<td>2037</td>
<td>9.4°</td>
<td>NE - 75°</td>
</tr>
</tbody>
</table>

2. Yuan 288-43 – Three zones

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>Deviation</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2343</td>
<td>2346</td>
<td>5.5°</td>
<td>NE - 60°</td>
</tr>
<tr>
<td>2352</td>
<td>2355</td>
<td>6.6°</td>
<td>NE - 90°</td>
</tr>
<tr>
<td>2360</td>
<td>2363</td>
<td>7.1°</td>
<td>NE - 60°</td>
</tr>
</tbody>
</table>
Case Studies

Four Candidate Wells (All 5 ½”):

3. Bai 97-64 - Two zones

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>Deviation</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2374</td>
<td>2378</td>
<td>6.6°</td>
<td>NE - 65°</td>
</tr>
<tr>
<td>2384</td>
<td>2388</td>
<td>6.3°</td>
<td>NE - 85°</td>
</tr>
</tbody>
</table>

4. Yuan 288-43 – One zone

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>Deviation</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2360</td>
<td>2364</td>
<td>13.4°</td>
<td>NE - 70°</td>
</tr>
</tbody>
</table>

- Guns: 4”/102mm, 16 SPF, 44 grms HMX, 180° Phasing;
- Gyro Deviation accurate to +/-3°.
• Make up gun-string & OPS string
Measure Offset Angle - Gun Top Shot to OPS Reference;
(C/W looking down);
Enter value into software.
Operations

- RIH, tie in and pull up to shooting depth;
- Open IDC to anchor string;
- Calibrate Powered Swivel Joint;
- Rotate gun string;
- Fire the gun;
- Close IDC, record post-shooting log, POOH.
User Interface

[Image of a user interface screen with various controls and indicators, including current, panel voltage, head voltage, and tool position.]

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Results

1. Gu 39-98 (Single Zone)
   • Zone 1 (Dev. 9.4°) Successful calibration & orientation;
   • All shots fired;

2. Yuan 288-43 (Triple Zone)
   • Calibration failed at all shooting depths (Deviation 5.5-7.1°);
   • Grooved sleeve system deployed.
Results

3. Bai 97-64 (Dual Zone)
   • New PSJ firmware and MPP software installed;
   • Zone 1 (Dev. 6.3°) - Successful calibration & orientation;
   • All shots fired;
   • Zone 2 (Dev. 6.6°) - Successful calibration & orientation;
   • All shots fired;

4. Yuan 311-51 (Single Zone)
   • Zone 1 (Dev. 13.4°) Successful calibration & orientation;
   • All shots fired.
Conclusions

1. Previous tests showed orientating shots with bedding plane gave oil production 6.5m³/d higher than comparable wells (approx 50%);
2. Initially the OPS was effective in orientating guns in low angle wells deviated >9°;
3. Improved firmware enabled the OPS to effectively orientate guns in low angle wells deviated >5-6°;
4. RIH reduced from 4 to 1 using the OPS;
5. Operational Efficiency improvement 75%;
6. Running single or dual Shock Absorbers significantly reduced operational problems.
China National Petroleum Company and Guardian Global Technologies would like to thank you for your attention.

Any questions?