ORIENTED PERFORATING SYSTEM FOR SAND PREVENTION IN VERTICAL WELLS

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Outline

- Background
- Customer Requirements / Challenge
- Solution
- Results
- Questions
Background: Why Orient?

- Beneficial to orient perforations to formation geomechanics
  1. SPE 28555 (Abass, et al. 1994)

1. Improved frac treatment in some formations
   - Fractures grow perpendicular to least stress
   - Reduced tortuosity
   - Perforate in line with maximum stress

2. Reduced production of sand in other formations
   - Perf in direction to produce most stable tunnels
   - Minimize contrast between normal stresses
Background: Why Orient?

- Why Orient, stated another way:
  - 6spf, 60 deg, non-oriented gun
    - 2 SPF in line with fracture plane
    - 2/3 shots ineffective
  - 6spf, 0-180, oriented gun
    - 6 SPF in line with fracture plane
    - All shots effective
Background: How do we Orient?

- 2 main methods to orient perforations are gravity based

1. Finned or eccentric tandems

2. Internally oriented gun systems (bearings and counter weights).
Customer Requirements

- Customer in Middle East-North Africa
- Orient perforating guns in a vertical well

Flexibility of service:
- Post-detonation options
- Gun string lengths
- Formation types
  - Hard rock (frac)
  - Weak rock (sand production)

Time is money:
- Deep wells: 14-16,000 ft
- Short project lead time: 36 weeks or less

Challenge

- How do we orient guns in a vertical well?
Solution: Vertical Orientation

- Gyro tools?
  - Work well vertical
  - Not robust

- Need to measure orientation before guns are RIH

**Solution:** Integrated system to place Gun Hanger (anchor) with measurable orientation feature in well
Solution: Sequence of Operations

Shoot-and-Pull

1. Set Hanger
Solution: Sequence of Operations

Shoot-and-Pull

2. Run Gyro, Measure Lug Position, Calculate Offset
Solution: Sequence of Operations

Shoot-and-Pull

3. Adjust Skirt to Offset
Solution: Sequence of Operations

Shoot-and-Pull

1. Insert OSL (orientation skid) and orient skid to 75°
2. Insert F. Head and orient F. head to 90°
3. Insert CCL and orient CCL to 0°
4. Run guns
   - Sequence of Operations
     - ORIENTING LUG
     - ORIENTING LUG
     - ORIENTING LUG
     - ORIENTING LUG
     - ORIENTING LUG

OFFSET
120° - 45° ↔ 75°

ORIENTING SKIRT

STINGER SLOT

CHARGE ORIENTATION
Solution: Sequence of Operations

Shoot-and-Pull

5. Shoot and retrieve guns
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Solution: Sequence of Operations

Shoot-and-Pull

6. Retrieve hanger
Solution: Flexibility of service

- Post-detonation options
  1. Shoot and pull
  2. Shoot and drop
  3. Pull guns, drop hanger

1. Mechanical retrieval tool

3. Mechanical release after gun retrieval
Solution: Flexibility of service

- Post-detonation options
- Gun string lengths

Modular guns with skirt and stinger

Skirt with orienting slot

Stinger with orienting lug

Skirt with orienting slot
Solution: Flexibility of service

- Post-detonation options
- Gun string lengths

- Multiple formations:
  - Precise orientation
  - Works for any formation
  - Formation type only influences calculation after gyro
  - Adjusted in minutes, any direction.
Solution: Flexibility of service

1. Shoot-and-Pull
2. Shoot-and-Drop
3. Pull guns, Drop hanger
Results: Deliverables

- Gun Hanger with orienting lug
- Setting adapter kit
- Explosive release tool with orienting skirt
- Orienting skirt and stinger between gun modules
- Prongs for mechanical release
- Validation testing
- Training for operations

- Overall product realization in 24 weeks
Results: Customer feedback

Operational results and customer feedback

- 45 jobs over 23 months.

- From 1st well “The well was put on production flow back and did not produce any significant amount of sand at high flow rates.”

- “The production result is excellent, the technology helped them to achieve their main objective in which to improve frac result on [one] formation and reduce sand production of [another unconsolidated] formation.”
QUESTIONS? THANK YOU

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