IMPROVED FRAC EFFICIENCY USING CONVERGING PERFORATING

SLAP-16-6

2016 LATIN AMERICA PERFORATING SYMPOSIUM, BUENOS AIRES

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Conventional Perforating

- Perforating tunnels perpendicular to gun body and casing
- Design improvements to change this 90° angle
- Ultimate goal reducing friction and frac HP, or improve well flow and production
Converging (Focused) Perforating

- True Limited Entry – Balanced Configuration
- Significant energy to single / double point or centralized ring
- 0 degree, 0 – 180, or 60 degree rotational phasing
Ideal Perforations

- Sufficient friction/pressure drop to distribute fluid to all perforations/clusters
- Reduce fracture path tortuosity
- Allow early initiation of a single transverse fracture at the Preferred Fracture Plane
- Reduce multiple or longitudinal fractures
Ideal Perforations

- It has been proposed that perforations would be more effective if they could align on a single plane.
- Perforating charges cannot be aligned on a single plane within gun body (space and shaped charge interference).
- Alternative: change the shaped charge angles to converge the perforating tunnels at the center of the gun/cluster.
Why Converging Perforating?

- Aligns perforation tunnels on single plane at center of gun/cluster
- Reduce fracture path tortuosity that can block fluid flow
- Remove fluid flow restrictions that can lead to proppant accumulation and potential screen-outs
- Prevent high friction pressure losses near well-bore which can cause higher treatment pressures
The Converging Gun Configuration

- 32.78°
- 28.22°
- 23.23°
- 17.85°
- 12.11°
- 6.13°

24.0 First to Last
2.0 Shot to Shot
Technology Overview

- **Product goal**
  - Improve production
  - Reduce treatment pressures
  - Limit chemical usage
  - Quicker Frac times

- **Proprietary technology (US Pat. 9145763)**
- **350+ stages completed**
  - Marcellus, Utica, Woodford, Hunton, Eagle Ford
  - Zero pressure outs
  - Zero screen outs
  - All stages have pumped according to frac design
Test Shot Comparison

Converging

Conventional

Down Shot
Ballistic Testing Summary

- Perforating with shaped charge orientation angles (25°, 30°, 45°) did not make an appreciable difference in depth of penetration.
- No evidence of shaped charge interference. All perforation tunnels and entrance holes were complete (round / oval).
- Forces can / must be balanced within a perforation gun so that there is negligible upward or downward force on the entire gun carrier (gun with all 45° down shots had sufficient energy to shoot the entire carrier out of the test tube).
- The shaped charge orientation were maintained when perforation tunnels entered the formation (i.e. 30° oriented charge remained at that angle in the test target).
- Converging Perforating provided a significant amount of focused energy compared to conventional perforating (target turned to rubble by converging energy).
Case Study: Marcellus Shale

- 2 well pad
  - Two 1,250 m laterals, 1560 m TVD, 225 m spaced, drilled same direction
  - Frac design consistent well to well

- Gun design – Five 3-1/8” 6 spf 60° 2’ load guns, 12 shots
  - Conventional guns for all stages in well one
  - Converging guns for all stages in well two
Case Study: Marcellus Shale

Conventional vs. Converging perforation techniques are compared in the diagrams. The graphs illustrate the pressure (psi) and rate (bpm) changes over time for both methods. The converging perforation technique shows improved efficiency with a more stable rate and pressure profile compared to the conventional method.
Case Study: Marcellus Shale

Treating Pressures

Higher Cost to Pump
Case Study: Marcellus Shale

Production Comparison

- Conventional
- FocusShot

BOE

+13%
Conclusion

- What impact will converging perforating have on the frac?

- What impact will converging perforating have on production?

- What operational impacts are associated with running converging perforating?

- What approvals would be needed to run a test?

**Product Goal:** Increase Production and/or Reduce Frac hp
QUESTIONS? THANK YOU!