Woodford Shale Casing Conveyed Perforating Western Oklahoma

Case History of the World’s First Totally Interventionless Completion

AADE Presentation - Oklahoma City
January, 2009
Woodford Shale – Western Oklahoma

Cana 1-15H Excape Completion with 10 Modules (all with disappearing isolation valves)
External Perforating Gun & Isolation Valve

- Firing the gun actuates a lower isolation valve.
- Valve actuates when a protective sleeve shifts.
  - Compatible with cementing and fracturing operations
- RECENT IMPROVEMENT: Lower Isolation Valve Removed when NEXT GUN Fires.
  - Firing Module 3 Removes Module 2 Isolation Valve.
Typical Excape® Module

- Control Line
- Firing Head
- Excape® Perforation Module
- Isolation Valve Assembly
Zonal Isolation Device - Original

- Remotely actuated from the surface
- 7,500 to 14,000 psi differential rating
- Allows upward flow for cleanup w/o removing
- Removable w/ coil tubing or slickline
Eliminates coiled tubing for isolation valve removal

Successfully used in multiple wells
Developed for and successfully used in Alaska
System Components

Perforating Gun on “Y” Blocks

“Y” Block with RA Marker

Lower Gun Guide Assembly

3 ½ Straight Vane Eccentric
Control Line Placement

¼” Stainless Steel Control Line

7/16” Protective Line
Protection across Collars

- Protectors /centralizers on the joints
  - Pre-installed on the pipe rack
  - Run on every joint
Cementing Operations

- Using Cement. Not advocates of most open hole packer systems
  - tubing movement during stimulation can damage them.

- Wells are Tapered String Completions
  - With multiple ID’s across modules (3.75” casing, X nipples)

- Important to insure no cement is above wiper plug
  - Flush clean to rig floor, and clean up ALL lines
  - Used two stage wiper plug with ball

- PUMP ‘TILL YOU BUMP

- Marathon has had excellent success
  - Seems to be a concern to others in non – Excape wells?
Control Line Termination

Previous location for control lines before the Feed Through Control Line System

Tree Bonnet

Pack Off

Hanger
Pack-off in Place above hanger
Installing Tree Bonnet
Control Line Termination at Tree Bonnet
Control Line Valves Protected with Deflector Plate
Woodford Shale – Western Oklahoma

Woodford Shale – Western Oklahoma

Cana 1-15H Excape Completion
With 10 Modules (all with disappearing isolation valves)
Marathon’s First Horizontal Woodford Shale Well Utilized Casing Conveyed Perforating Technology

- A significantly more challenging application
  - 17,300 feet deep, 14 lb/gal mud, 10 modules, 5.5” x 3.5” tapered string
  - everything worked as designed
Why This Approach was Utilized: Pre-Job Estimates

❖ **Cost Reduction**

- Estimated $380,000 lower completion costs
- Actual Savings were an additional $300,000

❖ **Safety – Reduced personnel exposure**

<table>
<thead>
<tr>
<th></th>
<th>Excape - Cana 1-15 H Well COMPLETION Phase</th>
<th>Conventional - Cana 1-15H Well COMPLETION Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAN DAYS</td>
<td>205 man days</td>
<td>321 man days</td>
</tr>
<tr>
<td>Man Hrs.</td>
<td>4,908 man hours</td>
<td>7,692 man hours</td>
</tr>
<tr>
<td>High Risk Man Days</td>
<td>8 man days</td>
<td>51 man days</td>
</tr>
<tr>
<td>High risk Man Hours</td>
<td>192 man hours</td>
<td>1,224 man hours</td>
</tr>
</tbody>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Man Hr. Reduction for Completion</td>
<td>2,784 man hours</td>
<td></td>
</tr>
<tr>
<td>Personnel Exposure Reduction</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>High risk Man Hr. Reduction for Completion</td>
<td>1,032 man hours</td>
<td></td>
</tr>
<tr>
<td>High Risk Personnel Exposure Reduction</td>
<td>84%</td>
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</table>
Interesting Highlights

- Cana 1-15H is believed to be the world’s first totally intervention-less completion.
  - Individually perforated each interval remotely (10)
  - Individually fracture stimulated each interval (10)
  - Actuated each isolation valve remotely (9)
  - Removed each isolation valve remotely (9)
  - Placed the well on production
    - With nothing, (not even a ball) being run or pumped inside the well.
Some Woodford Shale Learning’s First Job

- Hardware worked well. Numerous concerns did not materialize.
  - Could detect all guns firing fairly easily.
  - Overlap of firing pins did not present a significant problem.
    - Possible to add two or three additional modules.
  - Currently Marathon is at ~550 modules installed
    - with a 99.8% firing success

- Two examples in the Cana 1-15H well where being able to remotely fire allowed operations to continue without having to mobilize coil
  - ~$300K savings.

- Concern about eroding disappearing isolation control line apart did not materialize

- Woodford Shale does not like it when you stop / start pumping.

- Strategy to space modules farther apart toe to heel was reasonable.
Some Lessons Learned
Woodford Shale Excape Well

- Chemical Tracers were of high value
  - Allows one to know all zones are open without well intervention.

- Cement Zonal isolation was effective.

- Replace Tree Saver with 15K frac valve assembly
  - Much better operational flexibility, especially with Excape®
  - Probably lower cost and lower risk.

- Don’t shoot Module 1 ahead of time.

- Many fracture stimulation learning’s
  - Not discussed as part this presentation
Path Forward: Woodford Shale

- Two Additional Wells are drilling
- Plan to again utilize Casing Conveyed Perforating
- Next Well: Fiber Optics to be included
- Plan to run 11 or 12 Modules
Casing Conveyed Toe Guns

- Firing Head
- Perforating Gun
- Detonating Cord inside 3/8” Control line

**Option 1**

5.5” csg.

**Option 2**

Float Equipment
# Technical Operating Efficiencies

<table>
<thead>
<tr>
<th></th>
<th>Marathon</th>
<th>Total Industry</th>
<th>Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modules Attempted to Install</td>
<td>501 modules</td>
<td>1001 modules</td>
<td>329 modules</td>
</tr>
<tr>
<td>Modules Actually Installed</td>
<td>501 modules</td>
<td>984 modules</td>
<td>312 modules</td>
</tr>
<tr>
<td>Module Installation Success Statistics</td>
<td>100.0%</td>
<td>98.3%</td>
<td>94.8%</td>
</tr>
</tbody>
</table>

| Modules Attempted to Fire | 493 modules | 946 modules | 303 modules |
| Modules Successfully Fired | 491 modules | 923 modules | 290 modules |
| Firing Success Statistics | 99.6% | 97.6% | 95.7% |

Successful Well Installation Count

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<th>Marathon</th>
<th>Total Industry</th>
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<tbody>
<tr>
<td></td>
<td>44 wells</td>
<td>96 wells</td>
<td>32 wells</td>
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*Review Date 10/4/2008*
Conclusion

- The technology worked in this difficult well
- There are cost benefits
- There are safety benefits