Holistic Drilling Fluid and Drilling Waste Management in the Fayetteville Shale

SPE - 144036
Key Components

• Holistic Fluid Management (HFM) Considerations

• Roles of the Project Team

• Project Phases and Results

• Conclusions
Holistic Fluid Management Considerations
Fayetteville Shale Play

Discovered by Southwestern Energy Company (SWN) (Arkansas 2004)
Project Background

• Program time period from Jan 2009 - Dec 2010
• Average 15 rigs drilling ± 35 wells per year each
• Well measured depth 8000 to 9000 feet
• Lateral sections ± 4500 feet
• 705 wells drilled with oil-based mud (OBM)
• 4,200,000 ft drilled
Expectations and Objectives

- Reduce drilling wastes
- Move fluid management operations to closed-loop systems
- Reduce combined cost
- Improve the rate of drilling progress
- Establish best practices
- Build internal core competency
- Manage change
HFM Plan Basis

- Manage interaction of fluids and related systems
- Establish best practices and KPIs
- Measure progress against established goals
- Align expectations of all parties
- Identify training requirements and opportunities
- Encourage teamwork
- Generate a culture of continuous improvement
Mud on Cuttings
Mud Dilution, Dumping and Tank Bottoms
Wash water and Run-off
Cement, Completion Fluids
Other wastes

Influenced by mud type, rig equipment, solids control efficiency and technology, drilling practices, crew

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Roles of the Project Team
HFM Team

- Commitment from management
- Project team with expertise to execute
- Unencumbered by affiliation to related services
- The HFM project team is comprised of:
  - Champion from SWN
  - Project Manager & drilling fluid/process specialists from (Performance Fluid Management – PFM)
Project Phases and Results
Project Phases

- Objectives: Expectations, KPIs
- Opportunities: Survey & Evaluate Operations
- Benchmark: Costs, Volumes, Performance
- Build a Plan: Targets, Efficiencies, Practices
- Execute: Implement the Plan, Innovate
- Assessment: Scorecard, Focus, Changes
- Improvement: New Benchmarks, New Targets

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Establish Benchmarks

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Fluid System</td>
<td>$26.92/ft</td>
</tr>
<tr>
<td>Solids Control System</td>
<td>$4.62/ft</td>
</tr>
<tr>
<td>Waste Management</td>
<td>$13.93/ft</td>
</tr>
<tr>
<td>Combined Cost</td>
<td>$45.47/ft</td>
</tr>
</tbody>
</table>
Identify Opportunities

• Evaluate baseline conditions
• Rig surveys
• System operations
• Practices
• Awareness
• Identify changes required
• Identify communication tools
## KPIs and Targets

<table>
<thead>
<tr>
<th>Financial KPIs</th>
<th>Targets</th>
<th>Stretch Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Costs</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>Drilling Fluid Costs</td>
<td>13%</td>
<td>25%</td>
</tr>
<tr>
<td>SCE and Rental Costs</td>
<td>35%</td>
<td>25%</td>
</tr>
<tr>
<td>Total Combined Cost</td>
<td>14%</td>
<td>35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance KPIs</th>
<th>Targets</th>
<th>Stretch Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mud Dilution</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Waste Volume</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>Low Gravity Solids</td>
<td>&lt; 5.0% by vol</td>
<td>80% SRE</td>
</tr>
</tbody>
</table>
HFM Plan

- Establish technical/operational standards
- Standardize equipment on all rigs
- Increase cost and waste reduction awareness
- Establish mud and waste tracking mass balance
- Maximize solids removal efficiency
- Utilize high performance centrifuges
- Control low gravity solids mechanically
Performance Timeline

SWN Fayetteville Project
24 Month Scorecard

- BENCHMARK
- PERFORMANCE RESULT

New Systems. Max SRE, Mud Recovery, Reduce Dilution

Best Practices, Waste Reduction. Equipment Upgrade

PHASE 1

PHASE 2

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## Review Results and Progress

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Combined Cost /ft</th>
<th>Reduction</th>
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</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>$45.47</td>
<td>n/a</td>
</tr>
<tr>
<td>Jan – June 2009</td>
<td>$36.60</td>
<td>19.5%</td>
</tr>
<tr>
<td>July – Dec 2009</td>
<td>$28.53</td>
<td>37.3%</td>
</tr>
<tr>
<td>Jan – June 2010</td>
<td>$26.66</td>
<td>41.4%</td>
</tr>
<tr>
<td>July – Dec 2010</td>
<td>$24.20</td>
<td>46.7%</td>
</tr>
<tr>
<td>Project Average</td>
<td>$29.00</td>
<td>36.2%</td>
</tr>
</tbody>
</table>
Results

**Before Implementation**

**After Implementation**

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Performance Indirect Results

• Contributions to improved drilling ROP performance:
  – Extended service life of drilling fluids
  – Reduction of drilling fluid dilution
  – Recovery and reuse of liquid waste
  – Improved rheology

• Improved wellbore conditions decreased trip times

• These factors were reflected by the following:
  – Drilling time intervals decreased from 12.2 to 8.3 days
  – Drilling performance improved from 607 to 781 feet/day

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Conclusions
Summary of Results

• Increased drilling fluid lifecycle
• Reduced drilling waste volumes 45%
• Reduced combined costs 36%
• $69 million net savings
Conclusions

• Important elements of success:

  – Project team, managed by an independent consultant, with a strong mandate.

  – Development of a holistic strategy in the early planning stages.

  – Identify and manage performance parameters to understand how changes potentially affect the entire drilling process.
Conclusions

• The HFM program was successful as measured by the achievement of all first-level targets and some stretch targets.

• Overall combined cost reduction was reduced from $45.47/ft to $24.20/ft over 24 months.

• Verified net cost savings realized by SWN of over $69 million.

• SWN realizes the value of HFM to control and reduce costs in unconventional plays.