Aluminum Alloy Enhanced Drill String Enables Small Rig to Reach KOP in the Marcellus, Saving Operator $500K

Jeffry K Lehner, Alcoa Energy Systems, Inc.

Thanks to: Joe Garcia, Vantage Energy LLC
Founded in 1888, 127yrs in business
200+ locations in 30 countries

$23.9B in 2014 Revenue

Invented the Modern Aluminum Industry

Fortune Magazine’s #1 “Most Admired” Metals Company

Acquired RTI International Metals for $1.5B in 2015
RTI one of the world’s largest titanium producers

Number of Employees (2014)

<table>
<thead>
<tr>
<th>Region</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>24,000</td>
</tr>
<tr>
<td>Europe</td>
<td>17,000</td>
</tr>
<tr>
<td>Other Americas</td>
<td>11,000</td>
</tr>
<tr>
<td>Pacific</td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59,000</strong></td>
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</table>
Alcoa Energy Systems (AES) Business Unit

- Located in Houston, Texas
- Combined business units from RTI Energy and Alcoa Oil & Gas
- Mission: Provide light weight, cost-saving solutions to our customers
  - Titanium Stress Joints
  - MaxReach™ Drilling Riser
  - FarReach™ Drill Pipe
  - World-class forging and extrusion capabilities
FarReach Alloy Drill Pipe
What is FarReach™ Alloy Drill Pipe Technology?

Benefits
• Increased drilling depth of smaller rigs
• Reduced Surface Torque by 30%
• Drilled 36% farther than steel
• Increased over pull margin 43% & improved safety

Applications
• Top Hole Drilling—drill deeper
• Unconventional Shale Laterals—improved ROP in slides
• Offshore Complex ERD—torque limitations
• Offshore Cementing Operations—weight and torque
JUSTIFICATION

PURPOSE
• Maximize cost saving benefits of using small top hole rigs to reach top of curve

CONTEXT
• Top hole rigs are limited by their 200,000# hook load capacity
  • Pad drilling results in long tangents before reaching curve

OBJECTIVES
• Field deployment of 3,000’ of Aluminum Drill Pipe (ADP)
• Reduction of hook load weight
• Capture operational learnings and optimize use of pipe
• Capture cost savings benefits
OPERATIONS BACKGROUND

- Marcellus Shale in southwest Pennsylvania, primarily gas drilling
- Low gas prices driving need for economics in drilling
- High cost for pad preparation ($2.5M) necessitates pad drilling (as many as 30 wells at one site), inclinations to 50 degrees
- Spread rate and increased productivity of small vs. large rig translates to $500,000 cost savings
- Challenge is reach top of curve on long tangents with small rig

<table>
<thead>
<tr>
<th>Hole Sections</th>
<th>Drilling Rig</th>
<th>Hookload &amp; Depth Rating</th>
<th>Circulation Medium</th>
<th>Average ROP</th>
<th>Spread Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Hole &amp; Tangent</td>
<td>Schramm T200XD</td>
<td>200,000 lb 6,000 ft</td>
<td>Air or Mist</td>
<td>Air: 75 ft/hr Mist: 55 ft/hr</td>
<td>$33,794/day plus $8.50/ft bit cost</td>
</tr>
<tr>
<td>Curve &amp; Lateral</td>
<td>MD525 Super Single</td>
<td>500,000 lb 12,000 ft</td>
<td>SBM fluid</td>
<td>45 ft/hr</td>
<td>$49,383/day plus $44.50/ft for mud and directional services</td>
</tr>
</tbody>
</table>
Well Design

Figure 1: Geology of Green County, Southwest Pennsylvania

- PERMIAN
  - Dunkard Gr.
  - Monongahela Gr.
  - Conemaugh Gr.
  - Allegheny Gr.
  - Potsville Gr.

- PENNSYLVANIAN
  - Venango Gr.
  - Catskill Fm.
  - Bradford Gr.
  - Elk Gr.
  - Hanover Sh.

- MISSISSIPPIAN
  - Mahantango Fm.
  - Marcellus Fm.
  - Venango Fm.
  - Utica Chs.
  - Otiskany Ss.
  - Heiderberg Gr.

EXPLANATION
- Yellow: Mixed clastics
- Gray: shale and siltstone
- Green: Dolostone
- Dark gray to black: Shale
- Orange: Mixed red clastics
- Pink: Evaporites

Active Coal Mining

Source of Water Influx

BIG INJUN

ELK

RHINESTREET/KOP

MARCELLUS

ONDG

Figure 2: Typical Well Profile

- Active Coal Mining
- Source of Water Influx
- BIG INJUN
- ELK
- RHINESTREET/KOP
- MARCELLUS
- ONDG

Modified after DCNR PA Generalized Stratigraphic Column
PAD SPIDER PLOTS

Note tangents up to 50 degrees
## ADP – Geometry and Special Features

<table>
<thead>
<tr>
<th>Size</th>
<th>Weight, lb/ft</th>
<th>Torsional Yield Strength, lb</th>
<th>Tensile Yield Strength, lb</th>
<th>Wall Thickness, in.</th>
<th>Young's Modulus, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 in</td>
<td>11.3</td>
<td>33,300</td>
<td>479,000</td>
<td>0.5</td>
<td>10,600,000</td>
</tr>
<tr>
<td>4.5 in</td>
<td>16.6</td>
<td>55,500</td>
<td>595,000</td>
<td>0.337</td>
<td>30,000,000</td>
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<tr>
<td>5 in</td>
<td>19.5</td>
<td>74,100</td>
<td>712,100</td>
<td>0.362</td>
<td>30,000,000</td>
</tr>
</tbody>
</table>

- **2014 Alloy Drill Pipe**
- **S-135 Steel Drill Pipe**
- **S-135 Steel Drill Pipe**

High-strength tapered aluminum alloy pipe

Internal service connection

Standard API or proprietary thread connection

42% Lighter

- Internal service connection
- Standard API or proprietary thread connection

Proven to go Farther™

ALCOA | ALCOA ENERGY SYSTEMS
Pulling Out of Hole

POOH 0.3ff 4.5"

Benefit from 3000’ ADP at top

Added benefit from 3000’ ADP at bottom

26K# Reduction

38K# Reduction

Drillers View—Hook Load #X1000

Measured String Depth (ft)

Hook Load Reduction

Proven to go Farther™
Cumulative Footage Not Drilled by Top Hole Rig

Missed Footage Eliminated

SDP: 16 of 19 wells missed target KOP

2000’ ADP: All wells achieved KOP

$509,880 Savings
CONCLUSIONS

• Use of a portable rig to batch drill surface holes on pads for shale development is a viable strategy to reduce overall cost.

• Use of aluminum drill pipe, due to its lighter weight and greater flexibility, extended the depth rating of the portable rig by 2000 ft, enabling significant operational savings. Wells drilled using ADP reached measured depths that averaged 607 ft deeper than wells drilled with all-steel drill strings.
CONCLUSIONS (continued)

• Improvements to be implemented on the operator’s next drilling campaign include **eliminating mist in favor of dry air drilling to KOP**; having a minimum of 3000 ft of ADP available for string make-up; and switching to 4-in SDP from 4½-in SDP for the remainder of the string to further reduce hookload weight.

• The operator is **considering using ADP in the lowest portion** of the drill string instead of at the top to leverage ADP’s lighter weight and greater flexibility to further reduce torque and drag.
Proven Product
Saves Money

Acknowledgements / Thank You / Questions

Management of Vantage Energy
Joe Garcia—Vantage Energy