Field Trial Results for Polyamide as a Velocity String In Medium Depth Gas Wells

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Outline

- Context of the problem
- The opportunity
- DuPont™ Pipelon® 401 material and specifications
- Identified risks
- Field deployment
  - Down hole tools
  - Well head equipment
- Results
- Summary
- Future opportunities
The Problem

• Corrosion in existing coiled tubing strings
  – 50% inside jointed tubing, remainder coil only
  – 50% have been identified as having holes (Echometer)
  – Low gas prices do not support replacement with jointed tbg

• Environment
  – Horizontal Gas Wells
  – 2% - 4% CO₂
  – Trace H₂S
  – Depth 1400 – 1600 meters TVD (4600-5250 ft)
  – 80°C (176°F) BHT
  – GLR 30 litres/e³m³ (5 bbl/mmcf)
The Opportunity

- **Options**
  - Do nothing (production losses)
  - Replace with heavier wall steel CT (implement inhibition)
  - Replace with jointed tubing (Expensive $$$)
  - Explore alternative materials (plastics)

- **Plastics**
  - HDPE (wells too deep, too hot)
  - Thermoflex™ (not suitable for -30C (-20F) installations)
  - DuPont™ Pipelon® 401 (no experience)
Advantages – DuPont™ Pipelon® 401

• Comparable in cost to steel CT
  – Similar material costs
  – Similar installation costs

• Corrosion resistance

• Lower frictional effects and potential uplift
  – Modeled with static well bore software
  – Reduction in friction can increase production on a well producing 7e3m3/d (250mscf/d) by 1 e3m3/d (35mscf/d)
## Physical Property Comparison

### PE vs. PA6,12

<table>
<thead>
<tr>
<th>Property</th>
<th>HDPE</th>
<th>DuPont™ Pipelon® 401</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, g/cc</td>
<td>0.95</td>
<td>1.06</td>
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<tr>
<td>Water Absorption, % (saturation)</td>
<td>0.01</td>
<td>1.3</td>
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<tr>
<td>Yield Strength, Kpsi</td>
<td>3500</td>
<td>6500</td>
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<tr>
<td>Tensile Elongation, %</td>
<td>800</td>
<td>200</td>
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<tr>
<td>Flex Modulus, Kpsi</td>
<td>160</td>
<td>101</td>
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<td>Deflection Temp, F</td>
<td>110</td>
<td>125</td>
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<tr>
<td>HDB psi 73F</td>
<td>1600</td>
<td>2500</td>
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<tr>
<td>Melt Temperature, F</td>
<td>270</td>
<td>415</td>
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DuPont™ Pipelon® 401 CT Specifications

<table>
<thead>
<tr>
<th>Temp F</th>
<th>OD, inch</th>
<th>ID, Inch</th>
<th>Wall, Inch</th>
<th>Pipelon 401 Yield Stress, PSI</th>
<th>Calculated Burst Pressure, PSI</th>
<th>Calculated Collapse Pressure, psi</th>
<th>Maximum Pull Loading, lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DF = 1.00</td>
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<tr>
<td>-40°F</td>
<td>1.5</td>
<td>1</td>
<td>0.25</td>
<td>11,700</td>
<td>3,900</td>
<td>18,056</td>
<td>11,486</td>
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<tr>
<td>73°F</td>
<td>1.5</td>
<td>1</td>
<td>0.25</td>
<td>5,000</td>
<td>1,667</td>
<td>7,716</td>
<td>4,909</td>
</tr>
<tr>
<td>176°F</td>
<td>1.5</td>
<td>1</td>
<td>0.25</td>
<td>2,800</td>
<td>933</td>
<td>4,321</td>
<td>2,749</td>
</tr>
<tr>
<td>-40°F</td>
<td>1.75</td>
<td>1.25</td>
<td>0.25</td>
<td>11,700</td>
<td>3,343</td>
<td>18,755</td>
<td>13,784</td>
</tr>
<tr>
<td>73°F</td>
<td>1.75</td>
<td>1.25</td>
<td>0.25</td>
<td>5,000</td>
<td>1,429</td>
<td>8,015</td>
<td>5,890</td>
</tr>
<tr>
<td>176°F</td>
<td>1.75</td>
<td>1.25</td>
<td>0.25</td>
<td>2,800</td>
<td>800</td>
<td>4,488</td>
<td>3,299</td>
</tr>
</tbody>
</table>
Creep Characteristics

Figure 17 - Flexural Creep at 80°C
Accelerated DMA Method
Pipelon® 401 vs HDPE

Time, h
Strain, %
Pipelon® 401 500 psi
HDPE 500psi
Critical Flow Rates for DuPont™ Pipelon® 401

Turner Critical Flow Rates for Coil Tubing (OD/ID)

- Pipelon 1.50”/1.00”
- Steel 1.25”/1.076”
- Steel 1.50”/1.31”
- Pipelon 1.75”/1.25”
Identified Risks

• Never used in production tubing configuration
• Creep major concern for “plastic” CT strings
• Installation and hanging
• Buckling/collapse when running into well
• Ability to re-start flow if submerged
Field Deployment

- Ambient temperature was -20°C to -30°C (-5°F to -22°F)
- Conventional coiled tubing unit
- Prior to installation in first well following tests completed
  - Pressure tested
  - Pull tests
  - shear test
  - buckling test
Field Installations

Six Planned
- Two 38.1mm
- Four 44.5mm

Four Installed
- Two 38.1mm
- Two 44.5mm

Conventional Coil Tubing unit for installation
Down Hole Check Valve & Connector

Parts
- Roll On Body
- Straight Bar
- Pipelon CT
- CT Profile
- Pump Off Plug
CT Hanger System

Parts
- Hanger Body
- Secondary Seal
- Re-entry guide
- Slips
Hanging Off Coil
Results

- No difficulties with running coil, no physical damage due to chains
- Hanger equipment performed well
- Have not yet tested for creep or reduction in cross section
- Significant issues during deployment due to well bore blockages (limited ability to push)
- Unable to flow one well (CT submerged in liquid)
Well 1 – Obstruction At 1435 mKB

Unable to regain production.
Will attempt to swab February 2012.

Cum 825, Res 575
Press 2250 kPa
1" ID CT
Land @ 1425 or 1745 mKB
Well 2 – Obstruction But Tubing Landed

Fluid Depth 1768 m
Fluid Depth 1938 m

Cum 400, Res 350
SI Press 6250 kPa
1” ID CT
Planned @ 1970 mKB
Actual @ 1787 mKB
Well 2 – Production History

DuPont™ Pipelon® 401 Installed
Well 3 – Landed On Depth

Cum 725, Res 925
Press 2500 kPa
1.25” ID CT
Land @ 1520 mKB
Well 3 – Production

DuPont™ Pipelon® 401 Installed
Well 4 – Obstruction But Tubing Landed

Cum 356, Res 200
SI Press 2130 kPa
1.25 “ ID CT
First Tag @ 1110 mKB
Land @ 1750 mKB
Well 4 – Production History

DuPont™ Pipelon® 401 Installed
Well 5 – Obstruction Tubing Not Landed

First Tag 504 m
Final Depth 1660 m
Well 6 – Obstruction at 1180 m
Tubing Not Landed
Summary

• **Hanger system**
  - No problems encountered

• **Deployment**
  - Two wells successfully deployed
  - Two wells landed higher due to obstructions
  - Two wells not landed due to obstructions

• **Production**
  - Two wells positive gain
  - One neutral
  - One well submerged not yet unloaded
Improvements for 2012 Program

• Better well selection
  – Insure no ledges
  – Minimize risk of obstructions

• Have ability to unload if submerged
  – Swab capability
  – Portable compressor

• Well head temperature monitoring
  – Identify temp change due to insulation quality

• 7 well program
  – 5 x 1.25” OD
  – 2 x 1.75” OD
Future Opportunities

- Need larger data base of installations
- Better identification of production impact of lower friction factor
- Consider addition of DuPont™ Kevlar® or other materials to modify strength characteristics
- Possible applications for RTP (reinforced thermoplastic piping)
- Possible lined pipe solution
Questions?

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