Composite Drill Pipe
A Technology to Revitalize Watered Out Gas and Oil Deposits

DEA
Houston
March 22, 2007

Dr. James C. Leslie
ACPT INC.
Huntington Beach, CA
Advanced Composite Products and Technology, Inc.
Serving Industry for Over 25 Years

- Custom Manufacturing
- Design
- Development
- Production
- Product / Process Development
- Manufacture to Print
Aerospace

Space Shuttle Components

Satellite Components

F.L.I.R. Gimbal

Cryogenic Dewars

UAV and Helicopter components

• Advanced Ballistic Reentry Vehicle
• Precision Ducting
• Hydraulic Actuators and Reservoirs
• Space Craft Arms
• Satellite Antennae
• Rocket Motors
• Launch Vehicle Components

Motor Rotor for Stealth Fighter
Industrial Power Transmission

Sacramento Municipal Utility District

Madison Paper – Cross Shaft

Cooling Towers

Composite Disc Flexible Element
AAA AV Propulsion Couplings

Gear Coupling with shear pin assembly
Development and Manufacture of Cost Effective Composite Drill Pipe

Program Sponsor: U.S. Department of Energy
Federal Energy Technology Center
Contract No: DE-FC26-99FT40262

- Extend Horizontal Reach
- Improve LWD and MWD
- Provide Enabling Technology and Cost Savings in Deep Water Drilling
Program Additions

• “SMART CAPABILITIES”
  ‣ Real Time Signals, up or down
  ‣ Power Transmission

• Horizontal Drilling
  ‣ Short Radius
  ‣ Ultra Short Radius
Winding Composite Drill Pipe

- Computer
- Controlled
- Filament
- Winding
- Scalable & Tailorable
Advantages of CDP

- Enabling Technology
- Light Weight
  - $\frac{1}{2}$ that of Steel
- Fatigue Resistant
  - Flexible
- Scalable & Tailorable
- Repairable
- Signal / Power - in Walls
Program Status

• Specifications Complete
• Scale Testing Complete
• Composite Tube / Metal Fitting
• Pilot Plant in Operation
• 2½” SR and USR Available
• “SMART” Demonstrated
• Full Size: Omsco
## Specifications: Current Designs

<table>
<thead>
<tr>
<th></th>
<th>6 Inch</th>
<th>2½ Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, k #</td>
<td>478</td>
<td>25/75</td>
</tr>
<tr>
<td>Compressive Strength, k #</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Temperature, F</td>
<td>325</td>
<td>325</td>
</tr>
<tr>
<td>Internal Pressure, kpsi</td>
<td>11</td>
<td>1/2</td>
</tr>
<tr>
<td>External Pressure, kpsi</td>
<td>6.5</td>
<td>1/2</td>
</tr>
<tr>
<td>Torque, kpsi</td>
<td>37.5</td>
<td>2/6</td>
</tr>
</tbody>
</table>
Cost / Value

- Enabling Technology
- Weight Reduction
  - Platform
  - Transportation
  - Torque Equipment
Cost / Value (cont.)

- Direct Comparison
  - 3 to 5 Steel
  - 1/3 Titanium
  - Tailor CDP

- Signal / Power Transmission
Materials Testing

- Basic Properties
- Down Well Exposure
- Wear Abrasion
Results of Abrasion Testing of Various Coatings

Comparitive Mass Loss

2 Hour Mass Loss - milligrams

4130  2201  2221  UV  SPG  2000

Urethane
Full Scale Tensile Tests – ER/DW CDP

Pipe Specimen

Pounds Tension

Tensile Test Result

Target - Ultimate
Extended Reach/Deep Water Product Data Sheet

Mechanical Specifications

Bending Stiffness \( EI \) 180 x 106 lb-in²
Torsional Stiffness \( GJ \) 115 x 106 lb-in²
Axial Stiffness \( EA \) 33.4 x 106 lb
Rated Tension Load \( P \) 450,000 lbs
Rated Torsion Load \( T \) 25,000 ft-lb
Rated Compression Load \( Pc \) 250,000 lbs
Rated Internal Pressure \( Pi \) 9,500 psi.
Max Service Temperature \( F \) 350°F

Design Specifications

Tube Inside Diameter \( ID \) 5 in
Tube Outside Diameter \( OD \) 6 in
Length (Pin-to-Box) \( L \) 360 in (30 ft)
Centralizers Optional
Weight/30 ft. \( LB \) 375 lbs

Connection Specifications

Pin/Box Diameter \( OD \) 7 in
Bore \( ID \) 4½ in
Thread \( IF \) NC 56
"SMART" 6" CDP
## Drill Pipe Weight Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Steel</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drill Pipe with 7&quot; OD joints</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube ID</td>
<td>5 5/8&quot;</td>
<td>5.0&quot;</td>
</tr>
<tr>
<td>Tube OD</td>
<td>6.0&quot;</td>
<td>6.0&quot;</td>
</tr>
<tr>
<td>Weight of a 30 foot section</td>
<td>826 lbs</td>
<td>358 lbs (3.9 lbs of Graphite/ft.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Steel</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drill Pipe with 3 3/8&quot; OD joints</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube ID</td>
<td>2.0&quot;</td>
<td>1 5/8&quot;</td>
</tr>
<tr>
<td>Tube OD</td>
<td>2 3/8&quot;</td>
<td>2.0&quot;</td>
</tr>
<tr>
<td>Weight of 30 foot section</td>
<td>157 lbs</td>
<td>76.4 lbs (Short Radius)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 lbs (Ultra Short Radius)</td>
</tr>
</tbody>
</table>
Steel wt = 157 lbs, Composite wt = 76.4 lbs
Tensile Test, Short Radius CDP

ACPT 2.5" Diameter Pipe

Ultimate Failure: 84,302 lb.
### Production SR/CDP and USR/CDP

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ACPT SR-CDP</th>
<th>ACPT USR-CDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Modulus-msi (10^6 psi)</td>
<td>4.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Shear Modulus msi (10^6 psi)</td>
<td>3.1</td>
<td>2.5</td>
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<tr>
<td>Tensile Ultimate-lbs.</td>
<td>75,000</td>
<td>65,000</td>
</tr>
<tr>
<td>Tensile Operating-lbs.</td>
<td>25,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Compression Ultimate-lbs.</td>
<td>100,000</td>
<td>65,000</td>
</tr>
<tr>
<td>Compression Operating-lbs</td>
<td>50,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Torque Ultimate-lb-ft</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>Torque Operating-lb-ft</td>
<td>2,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Internal Pressure Ultimate-psi</td>
<td>2,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Internal Pressure Operating-psi</td>
<td>1,000</td>
<td>1,500</td>
</tr>
<tr>
<td>Collapse Ultimate-psi</td>
<td>2,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Collapse Operating-psi</td>
<td>1,000</td>
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<td>325</td>
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</tbody>
</table>
Figure 1. Greater Length of Producing Formation Exposed to the Wellbore in a Horizontal Well (A) Than in a Vertical Well (B).

Source: Energy Information Administration, Office of Oil and Gas.
Production Run of Short Radius Composite Drill Pipe
Well Site

100 ft. high drill rig
Short Radius Composite Drill Pipe being added to the drill string.
160,000 cycles later, the pipe exhibits little to no signs of wear.
LWD / MWD Status

• Signal and Power Thru Pipe Wall: Laboratory Demonstrated with both 6” and 2 1/2”
  ▶ Make and Break Joints
  ▶ Flow Conditions

• Field Test: 1,000 ft 2 1/2” SR/CPD 2007
Current Efforts

• Complete Static Testing of 6 inch ER/DW CDP
• In ground proof of “SMART” Capability with USR/CDP.
Composite Drill Collars
Summary

• Enabling Technology
• Cost Effective
• Signal / Power Transmission
• 2½” SR/USR CDP : Now
• 6” ER/DW Spring of 2008
• Drill Collars: Now