Reinforced Thermoplastic Tubing for Velocity String and Downhole Tubing Applications for Oil and Gas Production

Technical Background and Case Studies

2nd European Conference on Gas Well Deliquification
September 26, 2007
Why Use Thermoflex® Tubing For Gas Wells?

- Reduced Pressure Drop & Increased Gas Flow Rates
- Excellent Corrosion Resistance
- Minimum Ongoing Maintenance
- Low Cost Installation
Why Thermoforming Plastics?

• Polyethylene Should not be used in Wells
  – Poor Hydrocarbon Resistance
  – 60C Max Operating Temperature

• Higher Temperature/Corrosion Resistant Polymers Available
  – Polyphenylene Sulfide (Fortron/PPS) (120C)
  – Nylon (85C)

• Extrusion Options for Engineered Plastics
Mechanical Properties - Yield Stress

![Graph showing yield stress vs temperature for PPS SKX-382 and PPS 0214](image)

- Temperature, °C
- Yield stress, psi

**Legend:**
- X: PPS SKX-382
- O: PPS 0214
Target Applications

• Low Pressure Wells
• Wells with Liquid Loading Issues
• High H2S and CO2 Environments
• Wells with Paraffin or Scale Buildup Issues
• Used In Conjunction with a Submersible Pump to Remove Water and Solids from CBM Wells
What Are Thermoflex Strings

• Multi-layer Reinforced Polymer Coiled Tubing
  – Inner Layer Corrosion/Flow Layer
  – Aramid Fibers for Strength and Creep
  – Center Layer for Strength to 120C max.
  – Sizes Compatible with Coil Tubing Injectors
  – Less Force Requirements
  – Required Couplings on Each End
Couplings and Terminations

- Couplings Swedged on Both Ends
- Plated Carbon or Duplex Stainless
- Any Thread or Connection Available
- Swedged in the Field or Plant
Channeling the Gas

- Small Diameter Tubes
- ... No U-Tubing
- Set Above Lowest Gas
- Packer or Cone
Benefits of Thermoflex® For Velocity Strings

Reduced Surface Roughness of Engineered Plastics vs. Steel

- Steel Relative Roughness .005
- Thermoflex Relative Roughness .00005

• Material Compatibility of Polymers . . .
  - Enhanced Corrosion Resistance
  - Minimizes Buildups of Paraffin and Asphaltenes
Interesting Findings

Well Energy Balance

\[ \text{cp} \cdot \text{Tbh} := \text{cp} \cdot \text{Tsc} + \frac{V_{sc}^2}{2} + g \cdot L + \left( f \cdot \frac{L}{\text{IDtubing}} \cdot \frac{V_{sc}^2}{2} \right) + \left( k \cdot \frac{V_{sc}^2}{2} \cdot \frac{2L}{40 \cdot \text{ft}} \right) + \text{cp} \cdot \text{Tloss} \]

- **Velocity**
- **Exit Energy**
- **Gravity**
- **Friction**
- **Couplings**
- **Thermal Transfer**

Bottom Hole Energy
Where is the Energy Lost
Dye #2 Well @ 8ft/sec.

Steel Pipe Energy Loss

<table>
<thead>
<tr>
<th>Source</th>
<th>Energy Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>0.1%</td>
</tr>
<tr>
<td>Friction</td>
<td>2.5%</td>
</tr>
<tr>
<td>Couplings</td>
<td>0.1%</td>
</tr>
<tr>
<td>Thermal</td>
<td>70.3%</td>
</tr>
<tr>
<td>Gravity</td>
<td>27.0%</td>
</tr>
</tbody>
</table>
Where is the Energy Lost
Dye #2 Well @ 27ft/sec

Steel Energy Loss

- Velocity: 0.1%
- Friction: 40.5%
- Couplings: 0.5%
- Thermal: 38.9%
- Gravity: 20.0%
Pressure Drop 1 3/4

Thermoflex

WHP=5ps, WHT=60°F, 3500ft Dp., Ø1.75 Tubing

![Graph showing pressure drop vs. velocity for Steel and Thermoflex materials.](image)
Liquid Loading Example

- 1.75” Velocity String for 2,591M Well
- Weight 1,560Kg
- Thermoflex inside of 2 3/8” Steel
- Conventional Coil Tubing Unit
Safety Considerations

- Diamond Cut Slips Only
- Same Pack Off
- Shears Work
- 5,818Kg Tension Before Pipe Slipped in Coil Tubing Blocks
Installation

- Install at 30M/min
- Couplings Through Injector
- Bottom Plugs Float Tubing
- Set 3 Meters above Perf Zone

![Image of installation process]
Reed A1 Performance

- MCF/day: 160 (Steel) vs. 240 (Polymer)
- psi: 50 (Steel) vs. 65 (Polymer)
Slim Hole Completion Case

Background

• 1,959M, 2 7/8” Casing
• 28 Bar Shut In
• Liquid Loading
• Swabbing or Shut in to Reduce Water Level
Results From Thermoflex®
Multi-Zone Case

- Five Perforation Zones over 304M
- Weekly Soaping and Blowing/ Monthly Swabbing
- Where to Set the Tubing?
Results of Multi-zone Case

Benefits of Thermoflex Tubing

![Graph showing MCF/day vs. Cumulative Days]
Injection Applications

- Gas Injection
- Chemical/ Fluid Injection
- Banded to Tubing or Free Hanging
- Submersible Production Applications
Utilizing Submersible Pumps off of Thermoflex Tubing

- Increases Fluid Velocity to Lift Solids
- Rapid/Low Cost Installation and Removal
- Suitable for CBM
- Resists CO2
Key Issues for Region

- Managing Collapse
- Subsurface Valves
- Acceptable Barriers
  - Pipe Can Float in 200 Meters of Water with Plug
- Max Temp 120C