BIOGRAPHY

Joey D. Pierce
ConocoPhillips Specialty Products Inc.

Joey Pierce holds a Bachelor of Science in Chemistry from Southwestern Oklahoma State University and a Master of Science in Physical Chemistry from the University of Texas at Austin. He began his career with Phillips Petroleum Company working in the Specialty Chemicals Division. Since then, Joey has been in commercial development, plant operations, lab management, sales and sales management and refinery economics and planning. In 2004, Joey transferred to ConocoPhillips Specialty Products Inc. (CSPI) as Director, Marketing. In that position, he worked to define and understand the global heavy oil market. In 2008, Joey moved into his current role of Director, Sales, Heavy Oil Flow Improvement. He has published several papers, written technical articles on flow improvers and their uses and presented at major conferences and associational meetings.

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New Heavy Crude Oil Flow Improver Increases Delivery – Application Scenarios

Ray Johnston, Joey Pierce, Peter Lauzon
ConocoPhillips Specialty Products Inc.

For more than 25 years, Flow Improvers (also known as drag reducing agents) have been used to increase fluid flow in hydrocarbon pipeline systems. The existing technology is effective in refined products, light, (and to a limited extent) medium crude oils. This paper discusses the breakthrough in flow improver technology that allows treatment of heavy crude oil slates. Case studies of flow improver treatment of heavy oils in various pipeline systems will be discussed and factors influencing commercial success will be highlighted.
New Heavy Crude Oil Flow Improver Increases Delivery – Application Scenarios

5th NCUT Upgrading and Refining Conference 2009

Ray Johnston
Peter Lauzon
Joey Pierce

ConocoPhillips Specialty Products Inc.
Drag Reduction Mechanism

Laminar Sublayer
Buffer Region
Turbulent Core

with DRA

Diminished turbulent bursts
DRA’s (Traditional)

- Low viscosity
- High Turbulence
- Excellent performance

Light/Moderate Crude Oil

- High viscosity
- Low turbulence
- Poor or no performance

Heavy Crude Oil
The Key to Performance:

**Interaction between the DRA polymer and the crude oil**

<table>
<thead>
<tr>
<th>Crude Oil Sample</th>
<th>LiquidPower™ Flow Improver Compatibility</th>
<th>ExtremePower™ Flow Improver Compatibility</th>
<th>API Gravity</th>
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</thead>
<tbody>
<tr>
<td>West Texas Intermediate</td>
<td>High</td>
<td>Moderate</td>
<td>41.6</td>
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<tr>
<td>West Texas Sour</td>
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<tr>
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<td>Bow River</td>
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<td>21.8</td>
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<td>Apiay</td>
<td>Moderate</td>
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<td>21.8</td>
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<tr>
<td>WCS (Western Canadian Select)</td>
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<td>High</td>
<td>20.9</td>
</tr>
<tr>
<td>Castilla</td>
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<td>High</td>
<td>18.0</td>
</tr>
<tr>
<td>Merey</td>
<td>None</td>
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<tr>
<td>SJVH (San Joaquin Valley Heavy)</td>
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<tr>
<td>Petrozuata</td>
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Scenario 1:

Increasing Delivery of Produced Heavy Crude Oil
Apiay – El Porvenir Pipeline

16-inch, 120 km, 91,000 barrel linefill

Batching 2 crude oils:
Apiay ("light", 21 °API)
Castilla blend ("heavy", 18 °API)

~35% “light” / 65% “heavy”

Base Capacity: 94,000 BPD avg.

LP™ 300 Flow Improver:
103,000 BPD
(in Apiay batches only)

Apiay-El Porvenir pipeline samples were evaluated for interaction in the lab.

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Flow Improver Solutions

Pipeline Regime Profile
With Castilla blend

Reynolds Number

Pipeline Viscosity (cSt)

45°C 29°C

Apiay pump station

Monterrey pump station
Pipeline Model – Capacity Trend with Batch Cycle

Basis: 70K BBLs Castilla blend → 31K BBLs Apiay →

Baseline: 94,000 BPD avg.

118,000 BPD avg.

75 ppm ExtremePower™ FI
## Field Test Results

### October 2007

**Performance exceeded model**

Achieved 26 - 32% throughput over baseline operation

<table>
<thead>
<tr>
<th>Pipeline System Condition</th>
<th>Baseline (Thousands of BPD)</th>
<th>ExtremePower™ DRA Dosage (ppm)</th>
<th>LP™ 300 DRA Dosage (ppm)</th>
<th>Model (Thousands of BPD)</th>
<th>Result (Thousands of BPD)</th>
<th>Percent Flow Increase</th>
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<tr>
<td>Test Pipeline Operations – ExtremePower™ injected into Castilla Blend</td>
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<td>100% Castilla Blend</td>
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<td>ExtremePower™ injection</td>
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<td></td>
<td>107</td>
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<td>65% Castilla Blend/35 % Apiay</td>
<td>93.6</td>
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<td>ExtremePower™ injection in each crude</td>
<td>68</td>
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<td>118.0</td>
<td>121.0</td>
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<tr>
<td>LP™ 300 in Apiay</td>
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<td>Combination injection 2</td>
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<td>123.4</td>
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</tbody>
</table>
Scenario 2:

Increasing Heavy Crude Oil Delivery via Dilution to Optimum Viscosity tied with Drag Reduction
Transition Pipeline Hydraulics

Frictional Pressure Drop vs. Reynolds Number

- Constant viscosity
- Laminar
- Turbulent

Increasing flow

Reynolds Number

1000 2000 3000 4000 5000 6000
Transition Pipeline Hydraulics

- Constant viscosity
- Laminar
- Turbulent
- Drag Reduction
- "Laminar extension"

Increasing flow vs. Reynolds Number

Frictional Pressure Drop vs. Reynolds Number
Example Pipeline: Throughput Versus Viscosity
Example Pipeline: Throughput Versus Viscosity

- Pipeline Capacity (BPD)
- Crude Oil Viscosity (cst)

- DRA treated

Parameters:
- 10” diameter
- 50 miles
- 1400 MAOP
Impact of Diluents on Viscosity

WCS Crude Oil

Viscosity (centistokes)

Dilution Level (Volume %)

WTI 41 °API
Naphtha 54 °API
Example Pipeline: Dilution Effects on Flow Capacity

- WCS crude oil diluted with WTI crude
- 47,300 BPD (DRA treated)
- 38,500 BPD
- 10" diameter
- 50 miles
- 1400 MAOP
Example Pipeline: Dilution Effects on Net Throughput

Net Heavy Oil Throughput (BPD)

- WCS crude oil diluted with WTI crude
- DRA treated

Net WCS volumes increased

10" diameter
50 miles
1400 MAOP
Summary

★ New DRA developed for heavy crude oil
- Strong interaction with heavy crude oil (<23 °API)
- Performance in transition flow ($N_{RE} \geq 2100$+)

★ Successful field trials for production flow increase
- Demonstrated 20 to 30% flow increase during test
- 50 ppm with ~25% flow increase in application

★ Combine ExtremePower™ Flow Improver with further dilution to an optimized viscosity
- Utilizes drag reduction in transition flow
- Increases NET heavy crude oil throughput capacity
CSPI would like to thank Ecopetrol and Delrio for partnering with us on the flow improver test and allowing CSPI to share the results of the test with the participants of the 2008 International Pipeline Conference.

CSPI would like to thank ConocoPhillips Pipe Line Co. for the numerous field tests and ongoing application to provide valuable data of heavy crude oil and transition flow performance.
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