Challenges of Desalting Canadian Crudes

Gary W. Sams
Director R&D
**Heavy Oil PFD**

- Smallest water drops
- Mostly emulsified
- Solids stabilized

- Oil lighter than water
- High inlet water cut
- Oil internal
- Temperatures < 143°C

**FWKO**

- 25% Oil
- 75% Water

**Separator**

- 72% Oil
- 28% Water

**Gas**

**Treater**

- 99% Oil
- 1% Water

- 90% Oil
- 10% Water

**Gas**

**FWKO**

- 25% Oil
- 75% Water

**Separator**

- 65% Water

** Treater**

- 9% Water

Crude Oil Quality Association
Degassing / Dehydration

Inlet

Gas

Oil

Dual Frequency

Collector

Electrodes

HiFlo Spreader

Water

Water

Crude Oil Quality Association
Cyclonic Gas Removal
Desalter Design Issues

Settling Rate = \frac{K(\rho_w - \rho_o)gd^2}{\mu}

\text{Temperature vs. Viscosity}

\text{Stoke’s Law}

E_c < \varepsilon \sqrt{\frac{\sigma}{d}}

\text{Chemical Treatment Program}

F_{\text{coalescing}} = \frac{KE^2r^6}{d^4}

\text{Emulsifying Factors}

\text{Water Solubility}
Solids & Oil in Effluent

Small micron particulates, crystalline salt, and heavy solids loads

Substantial asphaltene precipitation
Reverse Emulsion
16 API SAGD DilBit

Crude Oil Quality Association
**Water Droplet Growth**

Initial Droplet Distribution

Final Droplet Distribution

Droplet Diameter, microns

Droplet Population, %
### Demulsifier Selection

**Kuwait Oil - 25ºAPI**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Bottle Test</th>
<th>Electrostatic Bench Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water in Oil</td>
<td>BS&amp;W</td>
</tr>
<tr>
<td></td>
<td>% By Difference</td>
<td>Measured %</td>
</tr>
<tr>
<td>Brand A</td>
<td>3.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Brand B</td>
<td>4.0</td>
<td>1.51</td>
</tr>
<tr>
<td>Brand C</td>
<td>4.8</td>
<td>1.51</td>
</tr>
<tr>
<td>Brand D</td>
<td>5.5</td>
<td><strong>0.7</strong></td>
</tr>
</tbody>
</table>

Based on lab tests – Initial BS&W – 10%

**Best Performance**
Electrostatic Field Selection

Our Choices Include…

• AC – Conventional & Deep-Field
• DC Only (with refined products)
• Dual Polarity® - Combination AC/DC
• Modulated Dual Polarity®
• Electro-Dynamic Desalting®
• Dual Frequency®
**AC Electrostatic Forces**

**Positive Forces & Velocities**

**Negative Forces & Velocities**

- Electrostatic Voltage Field, \( V/ \text{m} \)
- Drag Force
- Dipole Force
- Drop Velocity
- Drop Spacing, \( S \)
- Drop Weight, \( W_D \)
- Vertical oil velocity, \( v_v \)
- Electrode #1
- Electrode #2

**Droplet Radius, \( r \)**
DC Electrostatic Forces

Positive Forces & Velocities

Electrostatic Voltage Field, V/m
Drag Force
Drop Velocity
Droplet Weight, \(W_D\)

Electrophoresis Force
Drop Spacing, \(S\)
Droplet Radius, \(r\)
Vertical oil velocity, \(v_v\)

Negative Forces & Velocities

Electrode #1
Electrode #2

Crude Oil Quality Association
**Gradient Electrostatic Forces**

- Positive Forces & Velocities
- Electrostatic Voltage Field, $V/\text{m}$
  - Di-electrophoresis Force
  - Drag Force
  - Vertical oil velocity, $v_v$
- Drop Velocity
- Drop Spacing, $S$
- Droplet Radius, $r_D$
- Electrode #1
- Electrode #2
- Negative Forces & Velocities
- Di-electrophoresis Force
- Droplet Weight, $W_D$

Crude Oil Quality Association
Net Electrostatic Forces

Positive Forces & Velocities

Di-electrophoresis Force

Electrostatic Voltage Field, V/m

Droplet Weight, W_D

Electrophoresis Force

Droplet Velocity

Drop Spacing, S

Droplet Radius, r

Drag Force

Vertical oil velocity, v_v

Di-electrophoresis Force

Electrode #1

Electrode #2

Negative Forces & Velocities

Crude Oil Quality Association
**Electrostatic Coalescence**

Net Drop Forces in Voltage Field

<table>
<thead>
<tr>
<th>Voltage Field</th>
<th>Dipole</th>
<th>Electrophoretic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direction</td>
<td>Force</td>
</tr>
<tr>
<td>Alternating Current</td>
<td>Oscillates</td>
<td>0.4 weight</td>
</tr>
<tr>
<td>Direct Current</td>
<td>Constant</td>
<td>0.4 weight</td>
</tr>
</tbody>
</table>

Crude Oil Quality Association
**AC/DC Electrostatic Field**

Bulk Water Removal

Crude Oil Quality Association
Desalter Hydraulic Efficiency

Crude Oil Quality Association
Excessive Oil Conductivity

Temperature, F

Conductivity, nS/m

Typical
High

Crude Oil Quality Association
Heavy Oil Dehydrator Performance

Ref: SPE Paper 97786

Crude Oil Quality Association

Solid Curves Predicted by Electrostatic Dehydrator Computer Model

Oil API – 21
TAN - 4

Outlet BS&W (%)

Oil Flux (bopd/sf)

AC
Dual Polarity
Modulated Dual Polarity

Field AC Dehydrator @ 239 F
AC Dehydrator @ 219F
AC/DC @ 218F
Modulated AC/DC @ 220F
Bimodal AC/DC @ 220F

Crude Oil Quality Association
Technology Retrofit
A Commercial Installation

Gravity = 12ºAPI

<table>
<thead>
<tr>
<th></th>
<th>Before Retrofit*</th>
<th>After Retrofit*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology:</td>
<td>Dual Polarity</td>
<td>Dual Frequency</td>
</tr>
<tr>
<td>Temperature:</td>
<td>220ºF</td>
<td>200ºF</td>
</tr>
<tr>
<td>Oil Flow:</td>
<td>4000 BOPD</td>
<td>9200 BOPD</td>
</tr>
<tr>
<td>Outlet BS&amp;W:</td>
<td>1%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

*Data is per vessel. There are four vessels.*
# SAGD - Dilbit Desalting Pilot Results

**Process Parameters:**
- Dilbit API: 16 °, Temp: 280°F, Flux: 70 bopd/ft²

<table>
<thead>
<tr>
<th>Stage</th>
<th>Tech.</th>
<th>Feed</th>
<th>Outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BS&amp;W, %</td>
<td>Salt, ppm Cl⁻</td>
</tr>
<tr>
<td>1</td>
<td>AC</td>
<td>5.8</td>
<td>220</td>
</tr>
<tr>
<td>2</td>
<td>DF</td>
<td>0.4</td>
<td>6</td>
</tr>
</tbody>
</table>

- Wash Water: 5%
- Recycle: 5%
- Valve DP: 10 psi

**Mixing Efficiency = 25%**
**Desalter Technology Comparison**

### Technology vs Salt Removal Efficiency

<table>
<thead>
<tr>
<th>Technology</th>
<th>Inlet Salt</th>
<th>Outlet Salt</th>
<th>BSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>258</td>
<td>41</td>
<td>0.5</td>
</tr>
<tr>
<td>AC-pAC</td>
<td>258</td>
<td>12</td>
<td>0.4</td>
</tr>
<tr>
<td>DF</td>
<td>211</td>
<td>6.3</td>
<td>0.4</td>
</tr>
<tr>
<td>EDD-EDD</td>
<td>200</td>
<td>3.2</td>
<td>0.4</td>
</tr>
<tr>
<td>DF-DF</td>
<td>210</td>
<td>2.8</td>
<td>0.3</td>
</tr>
<tr>
<td>EDD-DF</td>
<td>200</td>
<td>2.4</td>
<td>0.3</td>
</tr>
<tr>
<td>DF-EDD</td>
<td>210</td>
<td>2</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Crude Oil Quality Association
Conclusions

Heavy Canadian crudes pose unique challenges:

- High Oil Conductivities
- Asphaltene Precipitation
- High Solids Loading
- Reverse Emulsions
- Increased Interface Rag
- Poor Effluent Water Quality