BIOGRAPHY

Bill Lywood
Crude Quality Inc.

Bill Lywood is president of Crude Quality Inc, an Alberta based company focused on crude quality related issues pertaining to the upstream, midstream and downstream sectors of the industry. Among Crude Quality's many projects is the flagship crudemonitor.ca website where detailed quality information on western Canadian crude streams is available through the sponsorship of the Canadian Association of Petroleum Producers (CAPP) and the Small Explorers and Producers Association of Canada (SEAPAC). Previously, Bill partnered in another consulting firm dealing with issues related to refinery processing impacts caused by crude contamination and quality variability. Bill holds a Bachelor of Applied Science degree from the University of Waterloo and is an avid saltwater and freshwater fly fisherman.

Crude Quality Inc.
201, 17850 – 105 Avenue
Edmonton, Alberta T5S 2H5 Canada
Phone: 780 991 9900
Email: lywood@crudequality.com
Website: www.crudequality.com
Quality Factors to Consider in Condensate Selection

Bill Lywood
Crude Quality Inc.

There are a host of factors to consider when evaluating condensates as a diluent for bitumen and/or heavy crude production blending. Apart from the commercial issues, the impact of condensate quality remains a key consideration in the evaluation. Condensate quality traditionally includes the obvious parameters of density and viscosity, however valuation decisions could be improved through the expansion of quality definitions and understanding.

This presentation is meant to provide expanded insight into condensate quality parameters of importance in the selection of a diluent grade product. In addition to a review of pipeline and industry specifications, this presentation will provide additional information relating to general properties, bitumen – condensate compatibility, sampling and quality testing requirements, and available information sources related to condensate quality.
Quality Factors to Consider in Condensate Selection

5th NCUT Upgrading and Refining Conference
September 16, 2009
Edmonton, Alberta, Canada

W.G. (Bill) Lywood
Crude Quality Inc.
Quality Factors to Consider in Condensate Selection

- Two principal quality groupings in the selection of condensate

- Characteristics that are required for the functional use of condensate as a diluent

- Characteristics that present POTENTIAL and REAL benefits and risks in the blended dilbit
Quality Factors to Consider in Condensate Selection

- Characteristics that are required for the functional use of condensate as a diluent
- Pipeline specifications for density and viscosity
  - Density (API gravity)
    - Density blending models for dilbit available
      - Need to take into account shrinkage factors (three step dilution)
  - Viscosity
    - Viscosity blending models for dilbit available
Quality Factors to Consider in Condensate Selection

Characteristics that present POTENTIAL and REAL benefits and risks in the blended dilbit

Much longer list of characteristics, including:

- Physical properties
  - RVP, sediment, BS&W
- Chemical properties
  - Aromatics (BTEX), olefins, benzene, sulphur compounds, additives/contaminants, compatibility/stability, organic chlorides, mercury, oxygenates
Quality Factors to Consider in Condensate Selection

Physical properties

- RVP (Reid Vapour Pressure)
  - High concentrations of “small” molecules increases RVP, potentially beyond dilbit pipeline specifications
  - Generally balanced off against density

- Sediment
  - Sedimentation, deposition in low flow zones and tankage
  - No benefits, only liabilities → MAX limits

- BS&W
  - Traditional, “non-oil” measurement
  - Important in crude accounting, no benefits → MAX limits
Quality Factors to Consider in Condensate Selection

Chemical Properties

- Olefins
  - Native only at miniscule levels in WCSB production
  - Consumes H₂ and can form gums/deposits in refineries
  - No benefits, valuation & operational liability → MAX limit

- Aromatics
  - Sum of vol% Benzene, Toluene, Ethylbenzene, Xylenes
  - Normally present at 2 – 10 vol% in WCSB condensates
  - Positively stabilizes condensate – bitumen blends
  - Real benefits, limited liability → MIN limit
Quality Factors to Consider in Condensate Selection

Chemical Properties (cont …)

- Benzene (component of BTEX)
  - Negative valuation implications in mogas
    - Negatives shared with Me-cycloC5, nC6, cycloC6
    - Negatives not generally shared with TEX portion of BTEX
  - → MAX limit

- Oxygenates
  - Not naturally present, sources include biodiesel (FAME), reformulated mogas, chemical production, methanol
  - Some pipeline rules & regs prohibit oxygenates
  - No benefit, value and operational liability → MAX limit
Quality Factors to Consider in Condensate Selection

Crude Compatibility

CAPP studies conducted at NCUT

Bluesky, Wabasca, Athabasca, McMurray, Coldwater, conventional heavy have identical stability numbers (+/-)

Use $I_N = 38$ and $S_{BN} = 114$ ($P = 3.0$) **FOR BASE BITUMENS**, not blended dilbit

Using Wiehe formulas, other references & healthy dose of conservatism, recommended

- $P \geq 2.0$ – green light, no anticipated compatibility issues
- $2.0 \leq P \leq 1.4$ – amber light, OK but increasing risk
- $P \leq 1.4$ – red light, may still be OK, but risks appreciable
### Quality Factors to Consider in Condensate Selection

- Crude Compatibility (cont ...)

- Example blending limit tables

<table>
<thead>
<tr>
<th>Sample description</th>
<th>Solubility (SBN)</th>
<th>Insolubility (IN)</th>
<th>P-Value (SBN/IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COND 01</strong></td>
<td>17.99</td>
<td>0</td>
<td>3.02</td>
</tr>
<tr>
<td><strong>Athabasca Bitumen</strong></td>
<td>115.34</td>
<td>38.19</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume Diluent</th>
<th>Volume Feed</th>
<th>SBNmix</th>
<th>P-Value (SBN/IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>115.34</td>
<td>3.02</td>
</tr>
<tr>
<td>5</td>
<td>95</td>
<td>110.47</td>
<td>2.89</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>105.61</td>
<td>2.77</td>
</tr>
<tr>
<td>15</td>
<td>85</td>
<td>100.74</td>
<td>2.64</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
<td>95.87</td>
<td>2.51</td>
</tr>
<tr>
<td>25</td>
<td>75</td>
<td>91.00</td>
<td>2.38</td>
</tr>
<tr>
<td>30</td>
<td>70</td>
<td>86.14</td>
<td>2.26</td>
</tr>
<tr>
<td>35</td>
<td>65</td>
<td>81.27</td>
<td>2.13</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
<td>76.40</td>
<td>2.00</td>
</tr>
<tr>
<td>45</td>
<td>55</td>
<td>71.53</td>
<td>1.87</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>66.67</td>
<td>1.75</td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>61.80</td>
<td>1.62</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>56.93</td>
<td>1.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample description</th>
<th>Solubility (SBN)</th>
<th>Insolubility (IN)</th>
<th>P-Value (SBN/IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COND 02</strong></td>
<td>3.44</td>
<td>0</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Athabasca Bitumen</strong></td>
<td>115.34</td>
<td>38.19</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume Diluent</th>
<th>Volume Feed</th>
<th>SBNmix</th>
<th>P-Value (SBN/IN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>115.34</td>
<td>3.02</td>
</tr>
<tr>
<td>5</td>
<td>95</td>
<td>109.75</td>
<td>2.87</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>104.15</td>
<td>2.73</td>
</tr>
<tr>
<td>15</td>
<td>85</td>
<td>98.56</td>
<td>2.58</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
<td>92.96</td>
<td>2.43</td>
</tr>
<tr>
<td>25</td>
<td>75</td>
<td>87.37</td>
<td>2.29</td>
</tr>
<tr>
<td>30</td>
<td>70</td>
<td>81.77</td>
<td>2.14</td>
</tr>
<tr>
<td>35</td>
<td>65</td>
<td>76.18</td>
<td>1.99</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
<td>70.58</td>
<td>1.85</td>
</tr>
<tr>
<td>45</td>
<td>55</td>
<td>64.99</td>
<td>1.70</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>59.39</td>
<td>1.56</td>
</tr>
<tr>
<td>55</td>
<td>45</td>
<td>53.80</td>
<td>1.41</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>48.20</td>
<td>1.26</td>
</tr>
<tr>
<td>65</td>
<td>35</td>
<td>42.61</td>
<td>1.12</td>
</tr>
<tr>
<td>70</td>
<td>30</td>
<td>37.01</td>
<td>0.97</td>
</tr>
</tbody>
</table>
Quality Factors to Consider in Condensate Selection

- **Test Methods**
  - When evaluating condensates, or when establishing specifications, one MUST specify the test method.
  - Test methods should be representative of the stream being evaluated.
  - Test methods must be widely available at reasonable costs.
  - ASTM methods provides interlab comparisons.
Quality Factors to Consider in Condensate Selection

Looking Forward

Industry, in co-operation with regulated pipeline, is establishing specifications for **ALL** condensate feeders “at the gate” to the blended (CRW) pool

- Will require ongoing feeder quality testing program and mitigation procedures
- Will require routine panel review of parameters & limits

Crudemonitor.ca has been operating a distinct section for CRW condensate since 1Q2008
Quality Factors to Consider in Condensate Selection

Thank you for your attendance and your attention

Questions ??

W.G. (Bill) Lywood
Crude Quality Inc.
www.crudequality.com
+1-780-991-9900