Understanding the Quality of
Canadian Bitumen and Synthetic Crudes

Pat Swafford
Spiral Software Limited

Crude Oil Quality Group Meeting
February 26, 2009
Introduction

- Canadian crude production is increasing
- Canadian crudes have some unique characteristics that cause processing difficulties
- Refiners need to understand the quality issues in order to have success (both from a processing and economic standpoint) with Canadian crudes
Classes of Canadian Crude Oil

- Some of the commonly accepted classes of crudes produced in the Western Canadian Sedimentary Basin (WCSB) are as follows
  - Condensate
  - Light sweet crude
  - Light sour crude
  - Medium sweet crude
  - Medium sour crude
  - Heavy sour crude
  - Synthetic crude
Heavy Sour Crude Production

- Volumetrically the largest classification of crudes produced in the WCSB
- Produced primarily from bitumen, most of them are blended to some extent
- The heavy sour crude class may be subdivided further into three categories:
  - Conventional heavy sour
  - Diluted bitumens (Dil-bits)
  - Synthetic crude / bitumen blends (Syn-bits)
Conventional Heavy Sour

- Includes LLK, LLB and Bow River, among others
- These crudes tend to behave similarly to conventional heavy sour crudes produced in other regions of the world
Conventional Heavy Sour Yield Profile

![Property Profile Graph](image)

The graph illustrates the yield of a conventional heavy sour crude oil blend and a 34 API blend, showing the cumulative yield as a function of boiling point in °F.
Dil-Bit Crudes

Dil-bits are blends of heavy bitumen with a lighter diluent, typically Canadian condensate, to reduce the viscosity so that it may be transported throughout the pipeline system.

Examples of Dil-bits include Cold Lake, Wabasca Heavy, and Peace Heavy.
Heavy Sour Dil-bit Yield Profile

![Graph showing cumulative yield (% vol) against boiling point (°F). The graph compares HEAVY-Dilbit CumYld(%v) and 34 AR BLE... CumYld(%v).]
Syn-Bit Crudes

Syn-bits are blends of heavy bitumen with a synthetic diluent.

The Syn-bit category includes blends such as Christina Lake, Mackay River Heavy, and Surmont Heavy Blend.

Western Canadian Select may also fall into this category, using both condensate and synthetic crude oil as diluent.
Heavy Sour Syn-bit Yield Profile
## Yield Profile of Heavy Sour Crude

<table>
<thead>
<tr>
<th></th>
<th>Naphtha</th>
<th>Distillate</th>
<th>VGO</th>
<th>Residue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Crude</td>
<td>31.3</td>
<td>27.7</td>
<td>24.2</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>(34 API)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Sour Crude</td>
<td>16.1</td>
<td>23.1</td>
<td>28.9</td>
<td>32</td>
<td>Lots of coker feed, more FCC feed, less naphtha and distillate</td>
</tr>
<tr>
<td>(22 API)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Difference from</td>
<td>-48.6%</td>
<td>-16.6%</td>
<td>19.4</td>
<td>90.5%</td>
<td></td>
</tr>
<tr>
<td>Conventional Crude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unique Characteristics of Heavy Sour Crude – Yield Profile

Property Profile Graph

Cumulative Yield (% vol)

Boiling Point (°F)

HEAVY SOUR CRUDE CumYld(%)
Synthetic Crude Production

- Produced in five major upgrading facilities in northwest Canada

<table>
<thead>
<tr>
<th>Upgrader</th>
<th>Primary Upgrading Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Husky</td>
<td>Coking, residue hydrocracking</td>
</tr>
<tr>
<td>Syncrude</td>
<td>Fluid coking, residue hydrocracking</td>
</tr>
<tr>
<td>Shell (Scotford)</td>
<td>Residue hydrocracking</td>
</tr>
<tr>
<td>Suncor</td>
<td>Delayed coking</td>
</tr>
<tr>
<td>NewGrade (Regina)</td>
<td>Residue hydrocracking</td>
</tr>
</tbody>
</table>
Typical Synthetic Crude Processing Scheme

- **Atmospheric Distillation**
- **Vacuum Distillation**
- **Hydrocracking**
- **Coking**
- **Hydrotreating**
- **Blending**

**Inputs:** Diluent Bitumen

**Outputs:** Synthetic Crude
Synthetic Crude Yield Profile

Property Profile Graph

Cumulative Yield (% vol)

Boiling Point (°F)

SYNTHETIC Typical Yield (%v) • 34 API BLEND Yield (%v)
Unique Characteristics of Synthetic Crude – Yield Profile

<table>
<thead>
<tr>
<th></th>
<th>Naphtha</th>
<th>Distillate</th>
<th>VGO</th>
<th>Residue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Crude</td>
<td>31.3</td>
<td>27.7</td>
<td>24.2</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>(34 API)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synthetic Crude</td>
<td>25.3</td>
<td>37.7</td>
<td>36.7</td>
<td>0.3</td>
<td>No coker feed, more FCC feed, lots of aromatic distillates</td>
</tr>
<tr>
<td>(33 API)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Difference from</td>
<td>-19.2%</td>
<td>36.1%</td>
<td>51.7%</td>
<td>-98.2%</td>
<td></td>
</tr>
<tr>
<td>Conventional Crude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unique Characteristics of Synthetic Crude – Diesel Quality

Spiral software

API for Crude (IBP-FBP)

Cetane Index for Diesel (500-650°F)

- Synthetic crude
Unique Characteristics of Synthetic Crude – Jet Fuel Quality

- **Synthetic crude**
Unique Characteristics of Synthetic Crude – Sulfur Content

Property / Property Scatter Graph

Sulphur (Total) (% wgt) for Crude (IBP-FBP)

API (none) for Crude (IBP-FBP)

• Synthetic crude
Using the Best Possible Assay Data to make Economic Decisions

- The ideal scenario would make accurate assay data available based on as-shipped quality.
- The reality is that comprehensive assays are performed only rarely and are never timely.
Dealing with Assay Variability

Statistical Reports

The 2001-2006 results for the Heavy Crude Quality Monitoring program have been summarized and statistically tested and reported. The results of the statistical review are available through the following selections.

Summary properties sheets are available for light streams and heavy streams.

Charts

To get charts of different parameters of different crude's over time, select them below. Note: the trend lines in all charts are 3rd order polynomial (cubic spline fit). This 3rd order regression method may not be the best method in all cases. However its applicability in trending seasonal changes across a wide range of properties does make it the best trending method for general and consistent use across all crude's and all properties.

![Cold Lake - API Gravity Chart](chart.png)
Updating Heavy Sour Crude Assays Based on Injection Point Test Data
**Synthetic Crude Assays**

- Synthetic crude quality tends to be fairly consistent.
- Batch to batch, there is some variability in quality due to operational variations in the production facility. This results in the producer varying the amounts of the “blendstocks” that are used to produce the synthetic crude oil.
Dealing with Assay Variability

**Statistical Reports**

The 2001-2006 results for the Heavy Crude Quality Monitoring program have been summarized and statistically tested and reported. The results of the statistical review are available through the following selections.

Summary properties sheets are available for [light streams](#) and [heavy streams](#).

**Charts**

To get charts of different parameters of different crude oils over time, select them below. Note: the trend lines in all charts are 3rd order polynomial (cubic spline fit). This 3rd order regression trendline may not be the best method in all cases, however its applicability in trending seasonal changes across a wide range of properties does make it the best trending method for general and consistent use across all crude oils and all properties.

Suncor Synthetic (OSA) ▼

![Suncor Synthetic A - API Gravity](image)
Updating Synthetic Crude Assays Based on Blend Components
Replacing a Base Crude Slate with Canadian Crudes

- Refinery configurations are unique and typically geared toward a certain type of crude slate.
- Some of the more challenging grades of Canadian Crudes cannot be processed in high percentages in a typical refinery.
- Understanding the possible combinations of crudes and the acceptable amounts of each gives refinery planners and traders information that can be used to make economic decisions.
Evaluating Blends of WCSB and Conventional Crudes

Example PADD V Refinery

- A 3-way blend of the following constituents is assessed
  - Alaskan North Slope
  - Suncor Synthetic “A”
  - Western Canadian Select

- The following quality constraints are set up in a Crude Approval Grid (CAG) for the blend:
  - Sulfur content: desirable < 1.2 wt%
  - Acidity: 0.5 mg KOH/g maximum
  - Yield of naphtha fraction: < 22 vol%
  - Yield of vacuum residue (coker feed): 10 – 18 vol%
Example Padd V
Crude Approval Criteria
Crude Approval Grid – Minimum ANS
Crude Approval Grid – Maximum ANS
Crude Approval Grid – Maximum OSA (with no WCS)
Conclusions

- Successful exploitation of West Canadian heavy crudes requires a good understanding of their qualities and how these interact with conventional crudes.
- Spiral’s advanced assay management tools enable this by:
  - Generating up-to-date assays of pipeline blends using batch testing data such as that available at CrudeMonitor.ca.
  - Evaluating blends with conventional crudes to match refinery constraints.