CCQTA June 2008: Crude Grades and Grade Management Policies/Procedures

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Petroleum Quality
<table>
<thead>
<tr>
<th>Commodity Type</th>
<th>Density</th>
<th>wt% S</th>
<th>MCR</th>
<th>TAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>910+ (23.9+)</td>
<td>2.6-4.5</td>
<td>8.5-11.3</td>
<td>0.5-1.05</td>
</tr>
<tr>
<td>Heavy Hi Tan</td>
<td>910+ (23.9+)</td>
<td>3.0-4.5</td>
<td>7.5-10</td>
<td>1.4-3.5</td>
</tr>
<tr>
<td>Heavy Lo Resid</td>
<td>933 (20.0)</td>
<td>3.0</td>
<td>&lt;1.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Medium</td>
<td>850-875 (30-35)</td>
<td>2.5</td>
<td>6.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Sour</td>
<td>850-875 (30-35)</td>
<td>1.1-1.8</td>
<td>4.0-6.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Sweet</td>
<td>825 (40)</td>
<td>&lt;0.5</td>
<td>2.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Lt Sweet Synthetic</td>
<td>850-875 (30-35)</td>
<td>0.1-0.25</td>
<td>&lt;0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Condensate</td>
<td>739 (60)</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Olefinic</td>
<td>933 (20.0)</td>
<td>3.0-3.5</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
</tr>
</tbody>
</table>
Enbridge controls quality of delivered crude in the following ways.

- **In the Pipe: Manage Interface** - number, type, size, cut
  - Line Splits: Like commodities in segregated lines
  - Line Rates: Turbulent flow to minimize interface sizes
  - Batch Sizes: Minimum 60KB, Multiples batch trains
  - Batch Sequence: Based on least contamination risk
  - Batch Cuts (Interfaces): Mid point

- **In the Tank**
  - Tank Bottoms Crossing
  - Tank Selection/Terminal Piping/Service Change
Pipeline System Configuration
Quarter 1, 2008

Core Liquid Pipelines
Number & Type

Line 1
- 37,000 m³/d
- NPS 12/36 1737 km
- RPL: Refined Products, Synthetics

Line 2
- 32,000 m³/d
- NPS 30 3256 km
- Gas: Light Crudes

Line 3
- 30,000 m³/d
- NPS 30 1248 km
- Gas: Medium, Heavy Crudes

Line 4
- 125,000 m³/d
- NPS 36/48 7464 km
- Gas: Heavy Crudes

Line 5
- 78,100 m³/d
- NPS 30 1067 km
- Gas: Condensate, Synthetics, Light Crudes

Line 6
- 110,000 m³/d
- NPS 30 752 km
- Gas: Medium Crudes

Line 7
- 27,000 m³/d
- NPS 16/24 1493 km
- Gas: Heavy Crudes

Line 8
- 23,000 m³/d
- NPS 30 989 km
- Gas: Condensate, Light Crudes, Medium Crudes

Line 9
- 55,200 m³/d
- NPS 36 949 km
- Condensate, Light Crudes

Line 10
- 70,000 m³/d
- NPS 36 770 km
- Condensate, Light Crudes, Medium Crudes

Line 11
- 15,000 m³/d
- NPS 12/20 706 km
- Condensate, Light Crudes, Medium Crudes

Line 12
- 27,000 m³/d
- NPS 16/24 1493 km
- Condensate, Light Crudes, Medium Crudes

Line 13
- 35,000 m³/d
- NPS 36 949 km
- Condensate, Light Crudes, Heavy Crudes

Line 14
- 58,000 m³/d
- NPS 36 949 km
- Condensate, Light Crudes, Heavy Crudes

Line 14/64
- 71,500 m³/d
- NPS 36 949 km
- Condensate, Light Crudes, Medium Crudes

Line 17
- 15,000 m³/d
- NPS 12/20 706 km
- Heavy Crudes
The Quality Matrix – Number & Type

<table>
<thead>
<tr>
<th>Heavy -TAN</th>
<th>Heavy</th>
<th>Medium</th>
<th>Sour</th>
<th>Sweet</th>
<th>Synthetic</th>
<th>Condensate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy -TAN</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Heavy</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Medium</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Sour</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Sweet</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Synthetic</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Condensate</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

The above numbers rank the order (as a guideline) that should be followed when changing from crude types. **One** being first choice. **Seven** being the last choice.

When making sequence decisions between crudes of the same type (Heavy-Heavy), reference the crude prices for best choice.
Reynolds No. - Laminar vs. Turbulent

- Definition - a dimensionless number characteristic of the flow of a fluid in a pipe or past an obstruction
- Laminar - <3000
- Turbulent - >3000

\[ \text{Re} = \frac{D \cdot v}{v} \]
\[ v = \frac{4Q}{\pi \cdot D^2} \]
\[ v = \frac{\mu}{\rho} \]

Re = Reyn. no.;
D = Pipe ID
v = Velocity
u = Flow Rate
\rho = Density
\nu = Viscosity(kin)
\mu = Viscosity(abs)
Line Rates at Turbulent flow – interface size

Turbulent Flow

Laminar Flow

Notice the increased size of the mixing area from the Turbulent to Laminar flow.
In The Tank

- **Tank Selection** - Determines the amount of contamination within station piping. This may increase or decrease depending on the location of the tank and the amount of common piping. Most sensitive crude types closest to manifold.

- **Tank Bottoms Crossing** - The procedure is located in the Service Levels (Table 5). Outlines how each commodity is treated through tankage at every location from receipt through delivery.

- **Tank Service Change** - Follows a rigid procedure to minimize contamination.

- **Tank Cleaning** – Potential for products to be delivered with high S&W, which can cause refinery problems. Procedure in place to monitor and restrict high S&W
• High TAN (Total Acid Number >1.0) commodities have dedicated tanks or flush batch (destined to same facility) is required if routed through a regular heavy tank.
• “Cracked” products contain olefins desired by very few refineries. Cracked products require both front and back buffers that are sized to contain the cracked crude interfaces. The whole train (buffers and crude) moves into the same refinery.
ITS Quality Metrics

- Reward/penalty based on meeting or exceeding targets set over 5 years (2005-2009). Targets negotiated based on baseline data on main lines only – to Sarnia & Chicago
- Targets set on formula which includes
  - Absolute change + (constant x std dev at delivery)
- Quality metrics parameters – receipt to delivery
  - Heavy: sulphur, MCR, TAN
  - Light Synthetic: sulphur, density
  - Refined products: diesel flash, ULSD sulphur pick-up
- Light Targets tighten by 50% and Heavy targets tighten by 30%
- Performance has been excellent – 23 out of 28 targets in 2007 were in bonus situation indicating gains in crude quality on delivery
- Connecting pipelines benefiting
Summary

- Many different crudes of wide variety (9 classes)
- 7 basic strategies to manage commodities through the system (5 in line, 2 in tankage)
- Special procedures required to manage downstream facility sensitivities (cracked, high TAN)
- ITS Quality metrics program to measure and improve quality during transport (benefiting connecting pipelines/facilities)