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Refining company perspective & approach to high quality asphalts

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Americas Asphalt Group & Discipline Technical Leader
Imperial & ExxonMobil: Funding Members of Asphalt Institute
Global Asphalt Operations

In NA Imperial & ExxonMobil manufacture asphalt at Joliet, Billings, Nanticoke & Strathcona Refineries
- Produce over 2MTa of premium asphalt
- Utilize high quality WestCan crudes
- Committed to product quality & integrity

Sarnia Technology Applications & Research
- Canada’s first & largest petroleum research est. 1924
- 700+ patents
- ~40+ PhDs out of ~100 employees
- Global Centre of Excellence for Asphalt
- Long heritage & deep expertise in asphalt research
Crude Oil

• “Crude oil is a naturally occurring, yellowish-black liquid found in geological formations beneath the Earth's surface”
• It is a mixture of a large number of different hydrocarbons
• Each oil has a unique mix of molecules, which define its properties, like color and viscosity

Composition by weight

<table>
<thead>
<tr>
<th>Element</th>
<th>Percent range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>83 to 85%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>10 to 14%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.1 to 2%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.05 to 1.5%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0.05 to 6.0%</td>
</tr>
<tr>
<td>Metals</td>
<td>&lt; 0.1%</td>
</tr>
</tbody>
</table>
Crude Oil Origin

300 to 400 million years ago

50 to 100 million years ago

Present time
Crude Oil Reservoir

Saturated porous reservoir rock (e.g. sandstone)

Impermeable layers (e.g. granite)
Types of Crude Oils & Recovery Methods

Types of Crude Oils:
- Conventional Crude Oil (API>25°)
- Medium Crude Oil (API~20-25°)
- Heavy Crude Oil (API~10-20°)
- Extra Heavy Crude Oil (API<10°)
- Extra Extra Heavy Crude Oil (API<10°)

Recovery Methods:
- Primary Recovery
  - Conventional Crude Oil (API>25°)
  - Medium Crude Oil (API~20-25°)
  - Heavy Crude Oil (API~10-20°)
  - Extra Heavy Crude Oil (API<10°)
- Secondary Recovery
  - In-situ (CSS, SAGD*)
  - Fracking
- Tertiary (EOR)
  - Oil Sand
  - Bitumen

Viscosity, Density,
Cost of Production**

*Cyclic Steam Saturation
Steam Assisted Gravity Drainage
**Excl. fracking
Further Oil Sand Bitumen Processing

- Bitumen (in-situ)
- Bitumen (mining)
- Solids Treatment
- Upgrader (Coker)
- Blending
- Diluent
- DilBit
- SynBit
- Synthetics
- Petcoke
- Tailings
Asphaltic crude quality is a critical factor in high quality asphalt production.
Crudes Vary in Composition & Value

Distillation Yield, % vol.

- Synthetics
- Light
- Medium
- Heavy
- Extra Heavy
- Bitumen

- naphtha
- distillates
- oils
- residuum

Price, Fuels Yield & Ease of Refining

Viscosity, Sulphur, Metals, Asphalt Yield & Quality

ExxonMobil

Imperial
Refineries Optimize Inputs & Outputs, Configuration Limited

Average Output (%) from Oil in Canada

- Gasoline: 36%
- Diesel: 26%
- Others*: 14%
- Light Fuel Oil: 7%
- Heavy Fuel Oil: 7%
- Jet Fuel: 4%
- Asphalt: 4%
- Propane/Butane: 3%

*Lubes, Petrochemical Feeds, etc.
Source: Canadian Fuels Association, 2017
Refinery Configuration Drives Input & Output Choices

- Fuel Gas
- LPG
- Ethylene/Propylene
- Naphtha
- Gasoline
- Kerosene
- Diesel
- BTX
- Raffinate
- Lubes
- Fuel Oil
- Asphalt
- Pet coke

- Crude
- ADU
- HDS
- Reforming
- Iso/Alky
- Steam Cracking
- DHDS
- Catalytic cracking
- Aromatics Extraction
- VDU
- Hydrocracking
- Lube plant
- Hydro-treatment
- Coking

- Hydro-treatment
- Raffinate
- Lubes
- Fuel Oil
- Asphalt
- Pet coke
Asphaltic Crude Quality & Distillation Target = The Two Levers to Target a PG Asphalt

Western Canadian Crudes*
Testing needs to be based on science & field validation, & also must be fast, practical & reproducible

Test duration & variability increase cost
• More tanks, heating, corrections, delays, disputes etc.

Simple parameter change may invalidate the test outcome

17 laboratories
2 samples
Two plate sizes
Product Integrity – We are Responsible from Cradle to Grave

- Production of top tier asphalt crudes
- Crude assays & selection process
- Straight-run asphalt State-of-art process control
- Certified laboratories Robust PQ systems
- Trusted advisor Performance testing in customer application

Century-long commitment to customers & industry – Expertise, Research & Leadership
Investment to future: Asphaltic crude production, dedicated asphalt facilities, R&D (internal/external) & people
Industry Trends

International Maritime Organization Low Sulphur Fuel Oil
• Effective Jan 1, 2020, Sulphur content limit in marine fuel reduces from 3.5 to 0.5 %

Increasing recycling rates vs. refining objectives to produce more fuels & petrochemicals
• Many new “softeners” enter market

Asphalt market globalization
• Large refineries become competitive trans-regionally (e.g. EU imports to US East Coast)
Key Takeaways

• ExxonMobil/Imperial has over a 100 years long history of asphalt manufacturing

• Canadian oil sands yield top-tier asphaltic feedstock

• Straight-run refinery operation yield premium asphalt grades

• Refineries exist to produce fuels, asphalt is 4% → maximize residual molecule uplift

• Imperial & ExxonMobil heavily invest in asphalt R&D to help to sustain the industry

• Support science based, field validated, practical & reproducible specifications

• Responsible manufacturer ensures product integrity beyond sales specification

• New challenges on the horizon: IMO, more conversion, global market