CHARACTERISTICS OF OIL SANDS PRODUCTS

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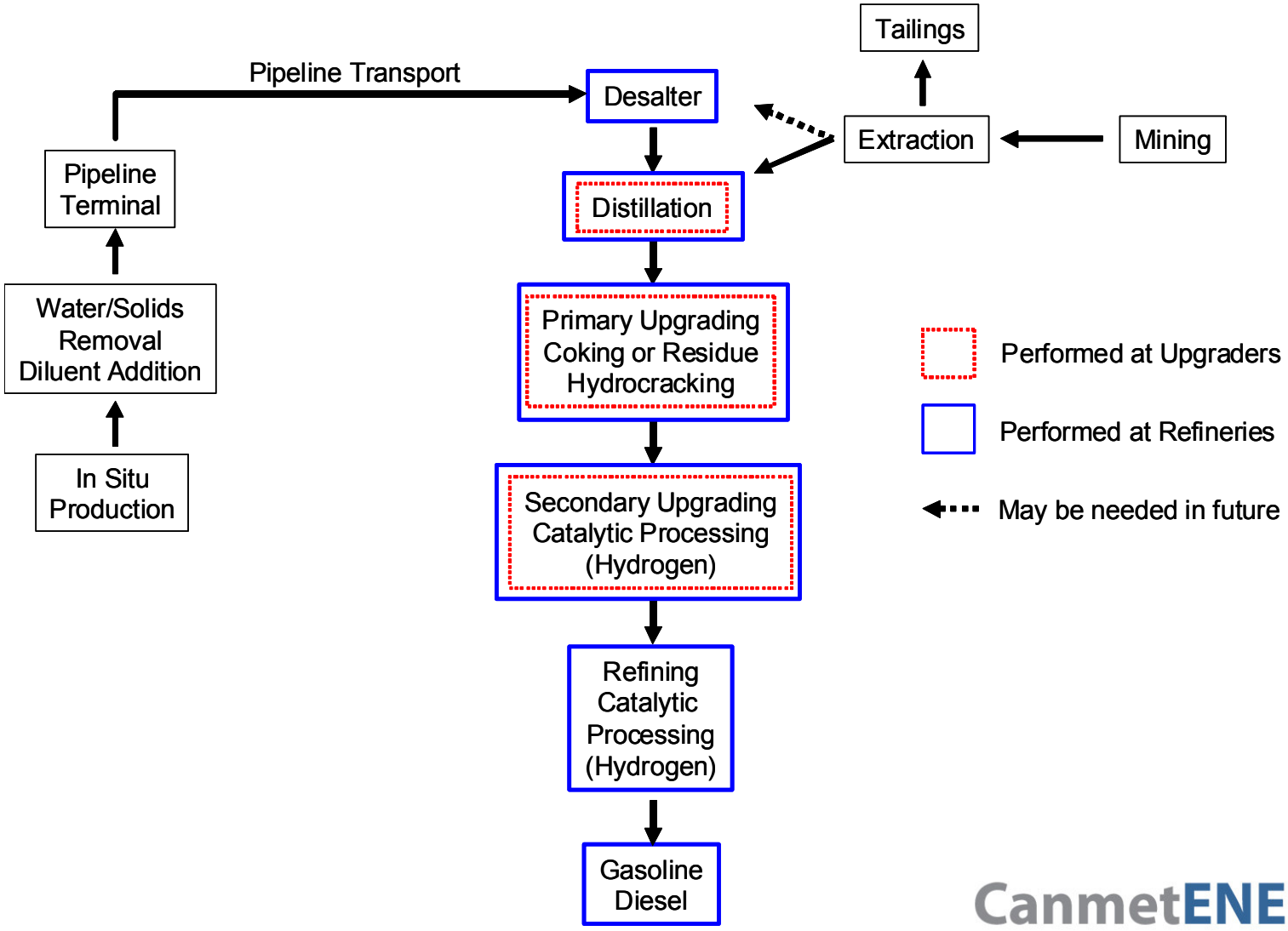
Simplified "Oil Sands to Motor" Value Chain



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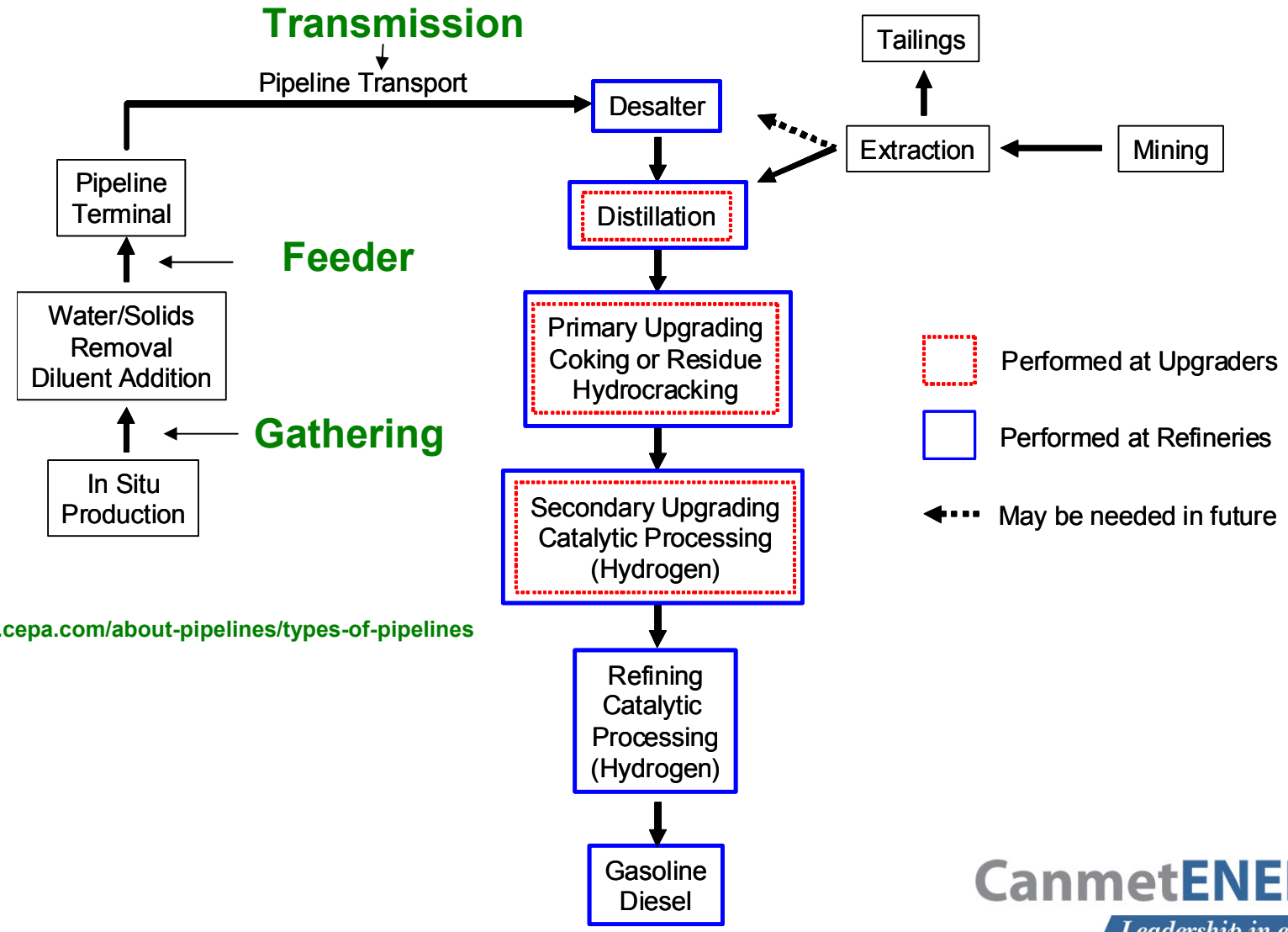
Pipeline Definitions



http://www.cepa.com/about-pipelines/types-of-pipelines

What Is Bitumen?

- Bitumen is the "extra heavy" crude oil that remains after the biodegradation of oil in Northern Alberta
  - Initial boiling point is 204°C/399.2°F
  - Approximately 50wt% of the oil boils at temperatures below 524°C/975.2°F
  - Biodegradation has resulted in organic acids being left behind in the oil
    - Total acid number (TAN) is 3mg KOH/g which corresponds to an organic acid content of 3wt% in the oil
      - Organic acid species in bitumen are relatively large molecules with 70wt% boiling above 524°C/975.2°F
      - [By comparison, vinegar for our salads is 5wt% acetic acid which corresponds to a TAN of 47mg KOH/g (by calculation)]

What Is Used to Dilute the Bitumen?

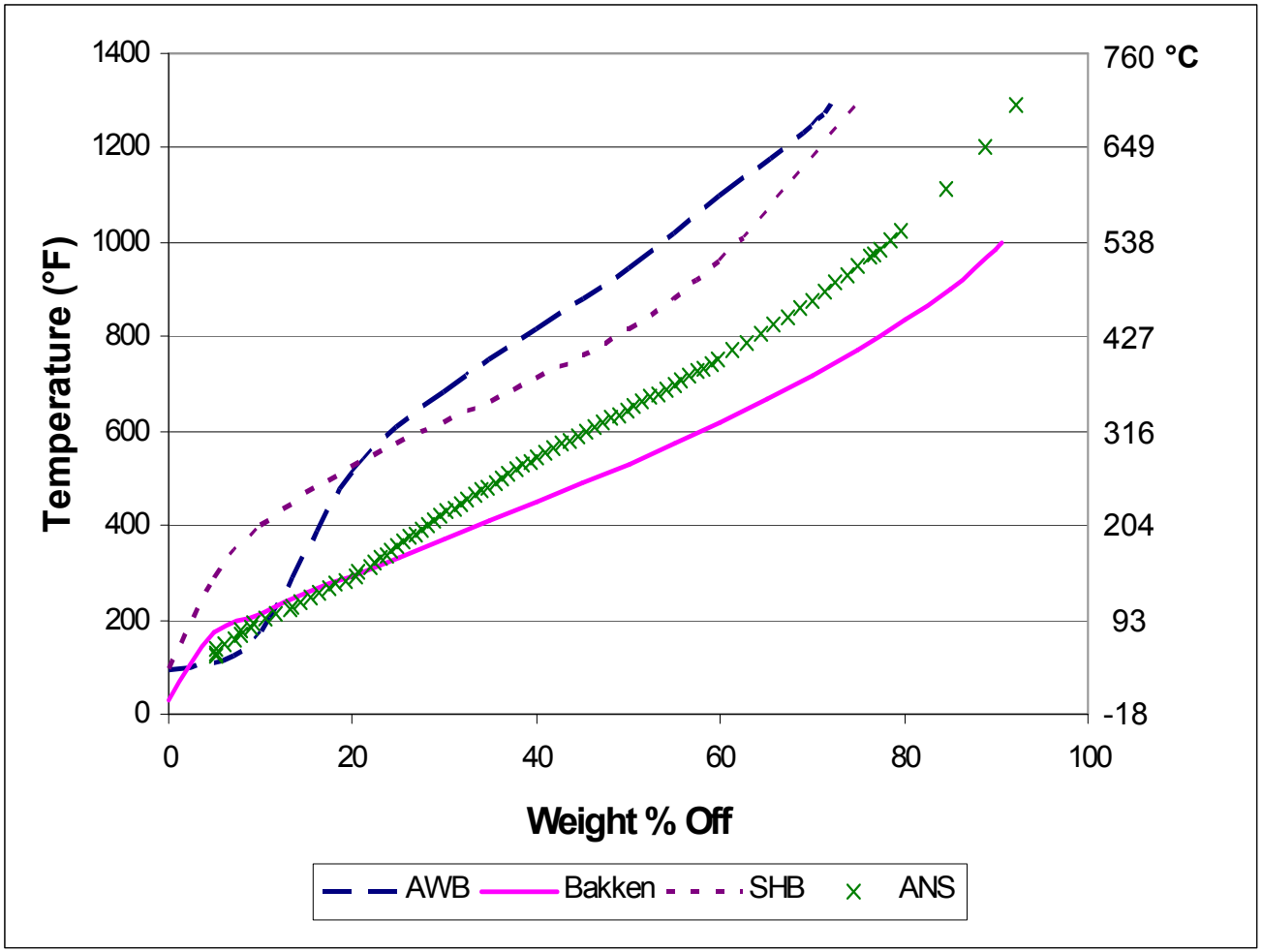
- Diluent such as CRW condensate to make "dilbit"
  - "Naphtha"-based oil which can include natural gas condensate
    - Natural gas condensate is the "liquid" that is produced with natural gas where the lowest boiling component is butane which boils at -0.5°C/31.9°F
  - Approximately 75wt% of the condensate boils at temperatures less than 204°C/399.2°F
  - Final boiling point is approximately 524°C/975.2°F
- Synthetic crude oil, an upgraded product from an upgrader/refinery, can also be used to make "synbit"
  - Less than 50wt% of the synthetic crude oil boils at temperatures less than 204°C/399.2°F
  - Final boiling point is approximately 524°C/975.2°F

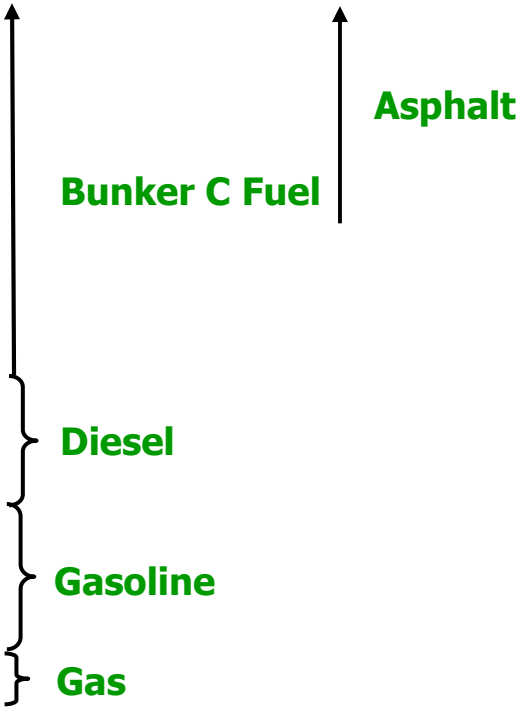
Dilbit and Synbit Definition

- Bitumen is diluted with light oil to meet transmission pipeline specifications for density and viscosity
  - Needs 30% by volume of diluent for dilbit
  - Needs 50% by volume of synthetic crude oil for synbit
- Characteristics of dilbit/synbit are in the range of
  - TAN value of 1.6mg KOH/g
  - Sulfur content of 3.9wt%

For composition information for Alberta transmission pipeline commodities, see http://www.crudemonitor.ca/

Boiling Ranges of Petroleum Products





Access Western Blend Dilbit (AWB) Surmont Heavy Blend Synbit (SHB)
Bakken and Alaskan North Slope (ANS) are included for comparison

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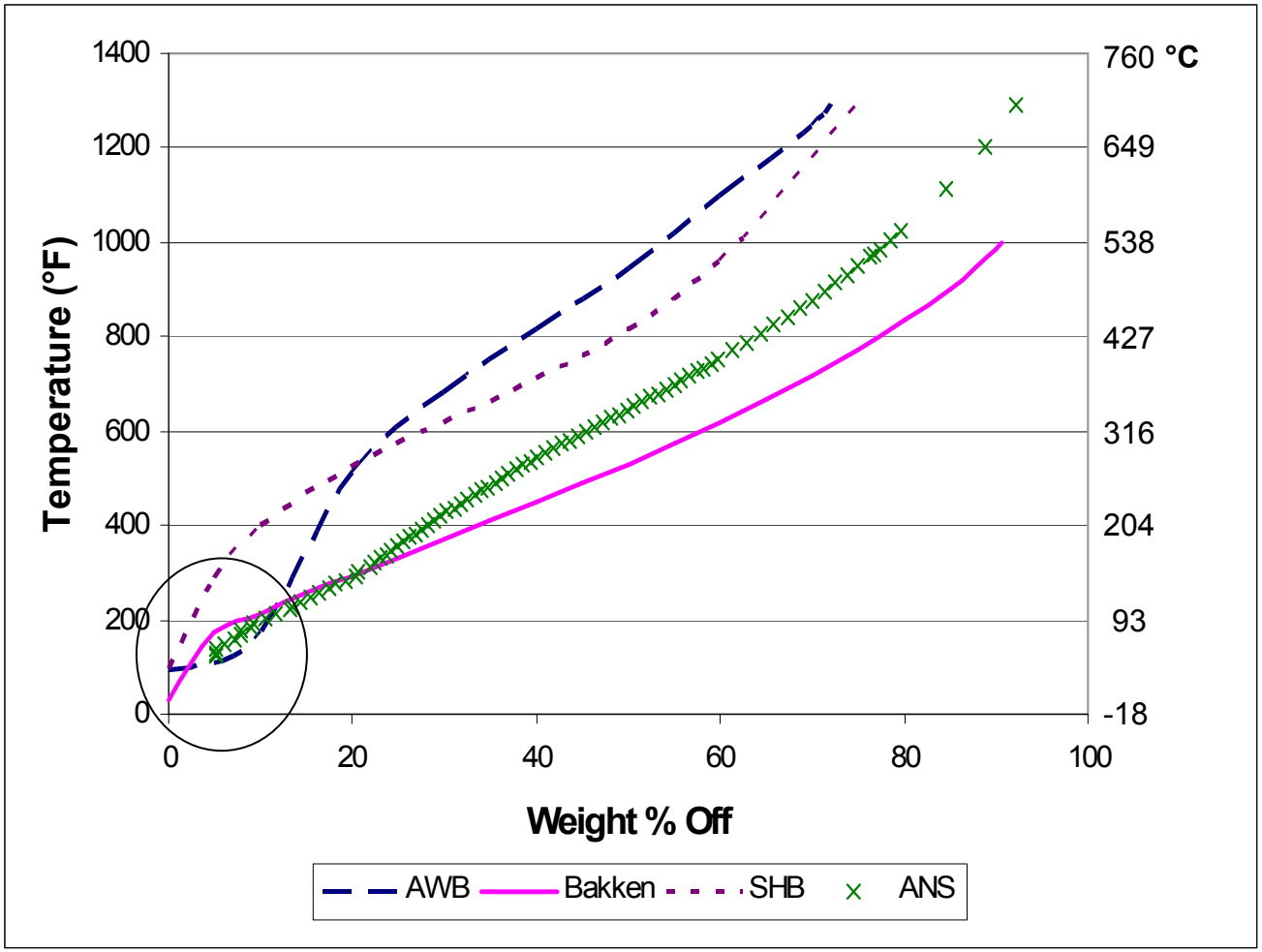
"Light" Crude Does Not Mean "Good for You" Crude!



	Benzene Content (%)
Dilbit	0.03 - 0.3
Synbit	<0.5
Bakken	0.1 - 1.0
ANS	0.3

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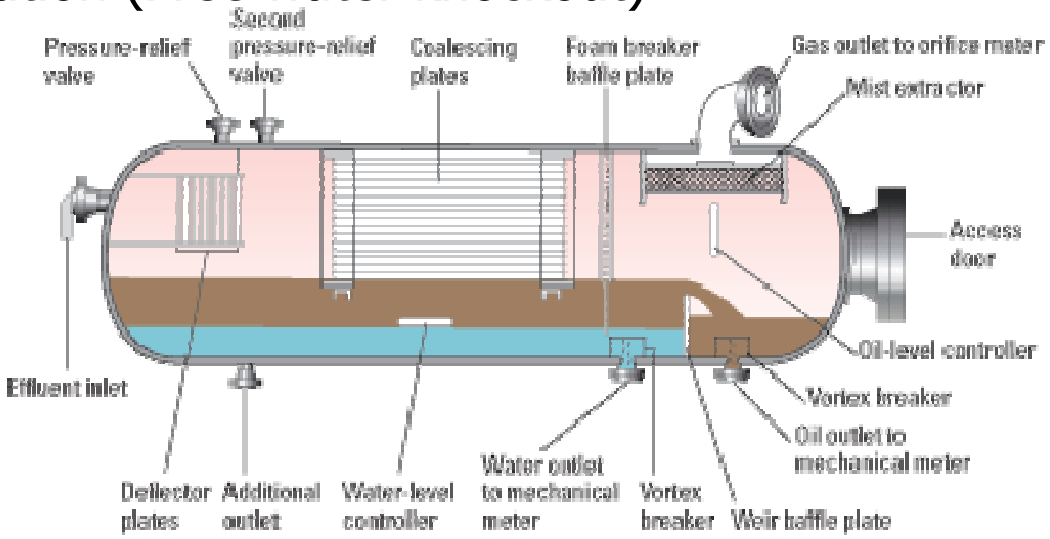
Transport of In Situ Production

- For example, steam-assisted gravity drainage (SAGD) produces an oil-water mixture that comes out of the ground at approximately 230°C (446°F)
- For transportation by transmission pipeline:
  - Water and solids have to be removed
  - Final transmission pipeline specifications for dilbit/synbit require:
    - Density @ 15°C/59°F ≤ 940 kg/m^3
    - Viscosity @ pipeline temperature ≤ 350cSt
    - Basic sediment & water content (BS&W) ≤ 0.5% by volume
- For transportation by train, oil sands products are shipped either as diluted bitumen or as pure bitumen

Sediment and Water Removal

- Sediment (mud and sand) and water are removed in two steps:
  - Floatation (Free water knockout)



Schlumberger website - http://www.glossary.oilfield.slb.com/DisplayImage.cfm?ID=630

  - Dehydration/gravity separation/emulsion breaker (Heater treater)

What Can Cause Internal Transmission Pipeline Corrosion

- Water is a key component that can cause corrosion in all types of pipelines for all types of commodities (i.e. light, heavy, or oil sands products)
  - Oil-wet pipelines have negligible corrosion rates
  - If sludge starts to settle out, then water contents can increase at that location and the pipe can become water-wet
  - Water corrosivity can be increased if water-soluble organic acids are present
    - For oil sands products, the content of water-soluble organic acids in the oil is very low due to extensive washing with hot water during production, and the use of floatation during the dewatering process

Are Oil Sands Products More Corrosive Than Other Crudes?

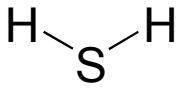
- Due diligence work performed in 1995 indicated that all oil commodities being transported in Alberta transmission pipelines had low corrosivity under pipeline conditions
- Current understanding of possible contributions of organic acid, sulfur, and sediment contents to oil corrosivity under pipeline conditions support the earlier results; new measurements show that oils sands products have similar results to those of other crudes
- Industry experience has been consistent with these results
- Useful references are at http://www.nrcan.gc.ca/pipeline/6698

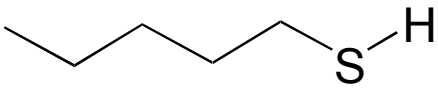
When Can Organic Acids in Crudes Cause Corrosion?

- Organic acids (also called "naphthenic acids") in crude oils can cause corrosion if they get concentrated
  - This can occur in a refinery during distillation at temperatures above their boiling points which are generally temperatures greater than 200°C/392°F
    - For bitumen, initial boiling point of its organic acids is 280°C/536°F
- Global crude corrosivity in refineries also depends upon organic acid size and structure
  - Bitumen has been found to have relatively low corrosivity under refinery conditions despite its high TAN value [Dettman *et.al.* CORROSION/2012, paper no. 01326 (Houston, TX:NACE 2012, pp.1-15]

What about Sulfur?

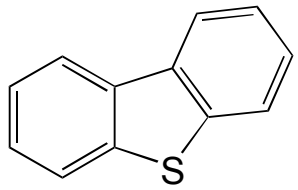
- Acidic sulfides like hydrogen sulfide (H_2S) and mercaptans can interact with iron to form iron sulfides

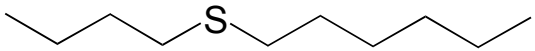




- Similar to most crudes, diluent and thermally-treated bitumen (i.e. SAGD production) can contain H_2S

- However, most of the sulfur in oil sands products is bound in hydrocarbon structures that require refinery processes including heat (i.e. over 300°C/572°F), high pressure hydrogen, and catalysts to remove it





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What about Sand?

- All crude oils come out of the ground so can contain sediment (mud, sand, salts)
  - Sediment carried by the oil-water mixture is separated from the oil by the floatation of the oil from the water, and gravity separation of solids
  - Once the oil sands product meets pipeline specification for BS&W, the remaining sediment in the oil is in the size range of silt (mud) to very fine sand

    [http://en.wikipedia.org/wiki/Particle_size_(grain_size)]
  - As sand particles are very small and are low in concentration, erosion is not a concern in transmission pipelines

Conclusions

- Oil sands products being transported out of Alberta by transmission pipelines
  - Are petroleum products that consist of blends of extra heavy oil (bitumen) and light oil (diluent or synthetic crude oil) to make dilbit or synbit, respectively
  - Meet quality specifications for density, viscosity, and basic sediment and water (BS&W) content
  - Are not more corrosive than other crudes