Delayed Coking Process Design, Operations and Optimization

Canada Coking Conference
October 22-26, 2012
Fort McMurray, Alberta
Solids Contamination – description and source

- **Organic**
  - Coke fines generated in the delayed coker
  - Asphaltene precipitation and agglomeration

- **Inorganic**
  - Bitumen silt which is a result the oil recovery process
  - FCC fines
  - Corrosion products from upstream operations
Some crude have extremely high levels of inorganic solid (i.e. clay, silt or sand)

- Athabasca Bitumen
- West Africa (Doba, Kuito)
- North Sea (Heidrun, Captain)
- China (Bohai Bay, Shengli)
- Indonesia (Serang)

Has high solids in Canadian crudes

- Western Canadian Select - 360 PTB
- Bow River North – 332 PTB
- Lloyd Blend - 333 PTB
- Albian Heavy Synthetic – 750 PTB
- Normally - less than 50 PTB

Crude blends with filterable solids levels significantly above 100 PTB can cause

- High desalter electrode current draw
- High solid content in crude tower product down stream
- Emulsion layer build up and carryover
- Oily desalter effluent water
Certain diluted bitumen (WCSB) feedstocks have been shown to contain organic or inorganic chlorides that are not dissolved in emulsified water (the desalter).

The exact identity of non-desaltable chlorides varies with specific feedstock. One source includes oil-wetted inorganic salt crystals and complex organic chlorides (asphaltene hydrochlorides).

Some convention product crude and diluted bitumen (Dilbit) crude have TAN greater than 1.0 mgKOH/g.
Asphaltenes Increase Desalter Emulsion Stability

- Diluted bitumen (WCSB) feedstocks can cause desalter problems, which are related to asphaltenes’ instability in the crude oil blends
- Asphaltenes are known to stabilize water-in-oil emulsions, primary due to high concentration of asphaltenes in the oil phase and oil/water interface.
- The result can be increased current draw, carryover of the emulsion layer into desalted crude oil, and the appearance of asphaltene
- The instability of asphaltenes is due in part to the addition of paraffinic diluents relative to heavy oils and bitumen
  - Blends are done to meet crude oil pipeline specifications
  - Typically gas well condensate mixed with thermally produced oil sands bitumen
  - Blending Dilbit crudes with other dissimilar feedstocks in refinery crude oil storage tanks or in the feed to the crude unit
Thermal stability of the heavy oil in the vacuum unit make it difficult to cut deep.

- The vacuum heater is usually limited to 710°F to 750°F in a highly optimized unit design
- Thermal cracking in the fired heater has been reported to be as low as 680°F
- High temperatures will result in excessive thermal cracking and heater fouling
- This results in excessive amounts of gas oil being sent to the delayed coker

KBC has developed a detailed heater fouling model

- Predicts coke deposited on the heater tubes
- Used to estimate run length based on feed quality, operating conditions and heater geometry
- Includes transfer line from the heater outlet to the vacuum tower
Desalter operating parameters
- Desalter operating temperature
- Mix valve
- Mud washing
- Solids removal in the desalter
- Emulsion issues
- Desalter design issues

![Desalter operating parameters diagram](chart)

- **Oil Flux - BPD per Ft²**
- **Desalter Outlet BS&W**
- **Crude Outlet Salt - ptb**
- **Crude Inlet Salt - ptb**
- **Best In Class**
- **Typical**
- **One Stage**
- **Two Stage**

*~20 API High TAN Crude*
# Canadian Crude Quick Reference Guide

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<th>Name</th>
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*NP1 indicates no available data
*NP2 indicates no available data

Results based on average from Jan 1, 2007 to March 31, 2012 from crudesensor.ca, created on June 2, 2011.
1. Viscosity based on regression calculations of Enbridge 2010 Crude Oil Characteristics
2. RVP based on Enbridge 2010 Crude Oil Characteristics, converted from MPa to psi
3. Enbridge samples are from January, June, and September of 2010
4. See the Enbridge 2010 Crude Oil Characteristics report for more information on how viscosity and RVP are obtained
5. More Production - Less Risk

Click on [http://www.crudesensor.ca](http://www.crudesensor.ca) for up-to-date information

Oct 2012
Solids Contamination - Problems

- Feed line and furnace charge pump
- Bottom circulation system
- Furnace charge pump
- Feed control systems to heater
- Heater tubes return bends
- Transfer line to drum
- Drum switch and isolation valves

Erosion due to high solids entering with the delayed coker feed
Solids Contamination - Problems

Heater fouling

- Inorganic solids deposit in the convection section and upper radiant section
- Online spalling and steam air decoking is ineffective with inorganic solids
- Fouling can be rapid (less than one month) depending on the solids concentrations which can be as high as 1 to 2 wt% during desalter upsets and 0.1 wt% in normal operations
- Pigging is the most effective method for removing inorganic solids that deposit in the fired heater.
  - A combination of online spalling and pigging can be practiced if the solids are not extreme.
  - Online pigging or isolation of an individual fire box for pigging can be designed to minimize the coker feed disruptions

KBC has developed a detailed heater fouling model

- Predicts coke deposited on the heater tubes
- Used to estimate run length based on feed quality, operating conditions and heater geometry
- Includes transfer line from the heater outlet to the coke drum inlet
Drum foaming

Small (less than 10 microns) inorganic solids in high concentrations can cause increased foaming. The foaming problem can also be made worse because of the reduced heater operations in an effort to reduce the heater fouling problems. In an effort to reduce heater fouling some operators with lower the heater outlet but in doing so will increase the coke drum fouling. This can be a difficult balance - heater fouling vs. increased coke drum foaming. Some operational step/changes can be made to reduce the risk of a foam over such as continuous level detectors, improved antifoam injection methods, increased outages and changes to drum switching methods.
Coke drum overhead line fouling

- Fouling in the overhead line is due to poor foam control, high drum velocities and entrained solids. High concentrations of inorganic solids can significantly add to the fouling of the overhead line.
- The fouling is generally located at the throat of the overhead line – just before the quench nozzle.
- The design of the quench to the coke drum overhead line is critical in preventing coke deposits.
- High overhead line pressure drops can cause line fouling further in the transfer line – closer to the fractionator inlet.
Solids Contamination - Problems

Fractionator fouling

- The bottom section of the fractionator – the flash zone section can build large deposit on any shed decks or trays which can restrict flow in the tower and shut down the tower.
- Best design practice is to minimize any exposed surfaces which minimizes the fouling and restrictions
- In extreme cases, wetting of fouling surfaces is possible
- Solids, which get past the wash or flash zone, can deposit or settle in the heavy gas oil draw pan.
Gas oil quality problems – small (less than 10 microns) inorganic particles can work their way out of the fractionator and into the heavy gas oil product.

Significant technical improvements have been made in the filtering of coker gas oil. It is critical to have a good backwash and sufficient surface area.
Solids Contamination - Solutions

• Simplify flash zone section design
  - Simple spray chamber
  - Minimize and dry surface

• Design feed system, bottoms circulation system and furnace charge piping for high solids and erosion in mind
  - The solids are generally too small to remove
  - High line velocities will increase erosion

• Design the fired heater for frequent mechanical cleaning
  - Convection section will need frequent cleaning due to the very fin solids
  - The radian section will need frequent cleaning due to the high asphaltenes
  - Design the heater so that individual boxes can be easily isolated

• The drum foam control must be well design
  - Continuous level detector
  - Well place antifoam injection
  - Best in class antifoam type
  - Heavy Gas Oil antifoam carrier – will require steam tracing

• Drum Overhead line with a well placed spray nozzle to keep the line wet
KBC Can….

Identify the operating and reliability gaps
- Conduct a cold eyes review or benchmarking
- Molecular management tool Petro-Sim
- Subject matter experts in every area of the refining process
- Provide detailed design requirements (examples - well placed spray nozzle in the drum overhead line and the flash zone section)

• Overall Cold Eyes Methodology
Questions?