Coking Process & Safety

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& Simlie Foscolos
Coking Process & Safety
Nathan Ashcroft & Simlie Foscolos
Tuesday, September 9, 2008
Agenda

- Introduction
- Access, egress and design of coker structure
- Cold climate HVAC for coker structure
- Heat recovery
- Reliability of coker blowdown systems
- Q&A
Introduction

Who is Bantrel?

- Bechtel affiliate
- 25-year history
- Offices in Calgary, Edmonton, Toronto
- 5000+ employees
- Leading EPC company in oilsands business
- Extensive delayed coking experience
- In-house delayed coking technology group
Access and Egress of Coker Structure

Access
A means of approaching, entering

Egress
A path or opening for going out, an exit
Bantrel Design Coker Structure

- 21st century approach to coker structure design
- Coker structure is a building – not a shack!
- Coker structure to comply with applicable building codes: Alberta Building Code (ABC)
- 25-year + design life
- Maximize operations safety
- Ergonomic layout
Bantrel Design Coker Structure

- Separate operating areas
- Separate control room area
- Access/egress areas each side of structure
- Walls of separation between each area
- Fire-rated walls
- Integrated building design (HVAC, fire, deluge, ESD)
Access and Egress of Coker Structure

Plan - Ground Floor

W2 - 2H Fire-Resistant Rated Wall Assembly

Note: Dry or wet standpipe formed part of Bldg. Design.
Access and Egress of Coker Structure

PLAN - SWITCH DECK / UNHEADINGS DECK

Note: Dry or wet standpipe formed part of building design.
Access and Egress of Coker Structure

PLAN - COKE CUTTING DECK AREA

- 2H FIRE-RESISTANT RATED PARTITION WALL ASSEMBLY.
- 2H FIRE-RESISTANT RATED EXTERIOR WALL ASSEMBLY.
- 2H FIRE-RESISTANT RATED FLOOR/SOFFIT ASSEMBLY.
Access and Egress of Coker Structure

- Cutting deck control room
- Viewing windows
- Access/egress point
- Coke cutting panel
- Winch panel
- Fire-rated safety wall
Access and Egress of Coker Structure

Cutting deck control room
Access and Egress of Coker Structure

Cutting deck operating area
Egress points

- Minimum two points of egress (either side of structure – ladder not acceptable)
- Maintenance elevator optional
- Fire-resistant wall protection for exit stairwells
- Future studies to review Durasystems products
Cold climate HVAC for Coker structure
How Cold?

Really, Really, Really COLD!
Cold Climate HVAC for Coker Structure

Cold climate!
Cold Climate HVAC for Coker Structure

Cold climate!
Cold Climate HVAC for Coker Structure

Cold climate!
Cold Climate HVAC for Coker Structure

Cold climate!
Cold Climate HVAC for Coker Structure

Bantrel HVAC design coker structure:

- 21st century HVAC coker structure design
- Coker structure HVAC to comply with applicable building codes: ABC and API
- 25-year design life (24/7 X 365 days per year design)
- Design conditions (-44°F to 82°F)
- Maximize operations safety
Cold Climate HVAC for Coker Structure

- Cutting deck ventilation
- Maintenance elevator ventilation
- Switch deck ventilation
Cold Climate HVAC Design Basis

- All enclosed areas are mechanically ventilated to meet API 505 (hazardous area):
  - Cutting deck – operator corridor
  - Unheading deck
  - Elevator shaft – machine room
  - East and west stair shafts
- Ventilation rates are 6/12 air changes per hour for sour service to meet ABC/CAPP
Cold Climate HVAC for Coker Structure

- Cutting deck and unheading deck
  - Two air handlers each for normal/winter ventilation
  - Two additional air handlers each for emergency/summer ventilation
- West stair shaft and elevator shaft
  - One air handler
- East stair shaft
  - One air handler
Cold Climate HVAC for Coker Structure

- Operator corridor
  - One air handler with cooling
- Elevator machine room
  - One air handler to unclassify area to NFPA 496
Cold Climate HVAC for Coker Structure

- Air handling units draw in unclassified air and steam pre-heat to 50°F (even emergency air)
- South half of air handling deck is classified due to ejectors at that level
- Ventilation air is exhausted by fans or relief dampers in each area
- All areas are heated by steam unit heaters
Cold Climate HVAC for Coker Structure

South Elevation

- Air Intake Duct
- Air Handling Unit
- Air Supply Duct
Cold Climate HVAC for Coker Structure

Looking NE
Cold Climate HVAC for Coker Structure
Cold Climate HVAC for Coker Structure
Heat Recovery

- Use Pinch Analysis to
  - Maximize on process heat recovery
  - Minimize on utility requirements
Pinch technology?

How Does it Work?
Basic Concepts of Pinch Analysis

- Involves the transfer of heat either:
  - From one process stream to another process stream, or
  - From a utility stream to a process stream
- With the world’s current energy crisis, the target in any industrial process design is to maximize the process-to-process heat recovery and to minimize the utility (energy) requirements
Basic Concepts of Pinch Analysis

• To meet the goal of maximum energy recovery or minimum energy requirement requires an appropriate heat exchanger network
• Design of such a network is complex as most processes involve a large number of process and utility streams
Generating Composite Curves for PINCH

[Diagram showing the concept of generating composite curves for PINCH with temperature and enthalpy axes, and noting the importance of Hot Composite Curve, Hot Utility, PINCH, Process to Process Heat Recovery Potential, QCmin, and DTmin.]
Economic Analysis of Results

Graph showing:
- Annualized Cost vs. DTmin
- Total Cost
- Energy Cost
- Capital Cost
- Optimum DTmin
Optimized Process Heat Recovery

Coker Preheat Train Design with 48 Exchangers
Closed Blowdown System Design Optimization
Closed Blowdown System

- A closed blowdown system (CBS) minimizes air pollution during normal operation to:
  - Provide a means for cooling and warming up the coke drums
  - Maximize hydrocarbon recovery and water recycle
Closed Blowdown System

- Improve coker reliability through enhancements in the closed blowdown system
- Dual system provides the ability to achieve more aggressive coke drum cycle times
- Coker performance is improved and productivity is increased
Improvements on Design of Blowdown Line

- Newly revised cyclic service pipe specifications to address thermal bowing issues in steam out/quench line
- Stringent welding and inspection details as recommended by Bantrel’s Mechanical Welding (BMW) group
- Increases in the thermal fatigue design life of piping
Improvements on Design of Blowdown Line

- Twinning selected pieces of equipment in the CBS will allow the cokers to run at reduced cycle times
- Separate blowdown systems for the backwarm/vapour heat and water quench
- Provide adequate ejector capacity to send off-gases to gas recovery unit to minimize releases to atmosphere
Closed Blowdown System

Quench & Warm-up Vapours from Coke Drums

Quench water from Utility Water Header

Quench & Warm-up Vapours from Coke Drums

Fuel as from Header

To Flare Header

Off Ga

Settling Drum

Light Slop Oil

Sour Water to Water Treatment

Heavy Slop Oil

Steam out Vapours

Heavy Slop Oil

Closed Blowdown System
Model Shot of Twin Lines to CBS
Questions
Our Environment ...

IT’S WORTH PROTECTING
Agenda

- Introduction
- Environmental headlines
- Delayed coking and the environment
- Bantrel and environment
- Air emissions from delayed coking
- Water and slops Management
- Closed hydrocarbon drain system
- Secondary containment
- Dust suppression
- Q&A
NEWS ALERT from Pembina Institute!

Oilsands Fever Strikes Edmonton

• Ten-fold growth in bitumen upgrading will have major impacts on air, land and water
• Oilsands production in northern Alberta could triple by 2020, to four million barrels a day. As a result of this increasing oilsands production, a major industrial expansion of bitumen upgraders is underway northeast of Edmonton
• "Upgrader Alley" expected to handle nearly half the oilsands production on Edmonton’s doorstep.
Facts

- Upgraders require a large volume of water.
  - On average, four barrels of water is required for every five barrels of bitumen upgraded
- Main emissions of concern from the upgrading process are sulphur dioxide, hydrogen sulphide, nitrogen oxides and particulate matter
  - Other emissions include volatile organic compounds (such as benzene), polycyclic aromatic hydrocarbons, carbon monoxide and carbon dioxide
“Delayed coking itself is environmentally friendly in a refinery context in that it helps upgrade and recover heavy and waste oils that would otherwise be a problem for disposal.”

Quote by Principal Design Engineer
The Coker unit is very useful for reprocessing or disposing of all kinds of refinery streams:

- Heavy streams, such as cat cracker slurry oil
- Slop oils through the closed blowdown system
- Refinery wastes and sludges in the coke drum quenching step
Delayed Coking and the Environment

Current largest coke drum
- 31' in diameter and 130' F-F – China
- 31.5' diameter and 130' F-F drums at SinoPec Jinling: Weight ~ 2000 short tons
- 31' diameter drums at Yangzi

Largest coke drums in North America
- 30' diameter by 96' T-T, 130' F-F – largest in the world, designed by COP
- These may be still the largest in operation in North America at this point, although there may be some additional drums operating that are of same size now

32' ID coke drums slated for startup in 2012 in Alberta
Bantrel Environmental Mission Statement:

*Bantrel is committed to leading the EPC industry in environmental stewardship. We strive to educate, empower and promote an environmental consciousness in our employees, suppliers and clients. Our objective is to minimize our ecological footprint by practicing sustainable design and operations.*

*We can - we care!*
Bantrel Environmental Facts

- Project execution aligns with ISO14001 methodology
- Leading EPC experience in CO2 capture projects
- Utilize hybrid vehicles in place of traditional pick-up trucks on the jobsite to reduce the impact of CO2 on the environment
- Only EPC company in the world using See-It software to report our key performance indicators
Air emissions from delayed coking
Primary Sources and Types of Emissions

- Furnaces: CO, VOC, NOx, PM10
- Process Equipment: VOC, PM10, Fugitive Emissions
- Coke Handling System: PM10, Fugitive Emissions
- Pressure Relief / Vents: To Flare
- Closed Blowdown System: To Water Treatment & Slops Handling

CO – Carbon Monoxide
VOC – Volatile Organic Compounds
NOx – Nitrogen Oxides
PM10 – Particulate Matter
CBS – Closed BlowDown System
SOx – Sulfur Oxides
Furnace Emissions

- Numbers based on firing rate and fuel gas H2S less than 160 ppm

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>lbs/million BTU</th>
<th>lbs/hr (fired duty @400MMBtu/hr)</th>
<th>Tons/Year</th>
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<tbody>
<tr>
<td>NOx</td>
<td>0.01</td>
<td>4</td>
<td>17.5</td>
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<tr>
<td>CO</td>
<td>0.04</td>
<td>16</td>
<td>70.1</td>
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<tr>
<td>VOC</td>
<td>0.006</td>
<td>2.4</td>
<td>10.5</td>
</tr>
<tr>
<td>PM</td>
<td>0.0075</td>
<td>3</td>
<td>13.1</td>
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<tr>
<td>SOx</td>
<td>0.03</td>
<td>12</td>
<td>52.6</td>
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### Estimated Emissions from Flare during Upset

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emissions lbs/hr</th>
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</thead>
<tbody>
<tr>
<td>NOx</td>
<td>1,360</td>
</tr>
<tr>
<td>CO</td>
<td>7,400</td>
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<tr>
<td>VOC (Destruct Eff. 98%)</td>
<td>19,000</td>
</tr>
<tr>
<td>PM10</td>
<td>None (Smokeless flare)</td>
</tr>
<tr>
<td>SOx</td>
<td>600,000</td>
</tr>
<tr>
<td>CO2</td>
<td>1,900</td>
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</tbody>
</table>

**Basis:** Gas flow rate 1,000,000 lb/hr
Heat Value 20,000 Btu/lb
Heating value of waste gas 4,000 Btu/cubic ft
Emission factors from EPA AP-42
# Coke Drum Vapours Recovered in CBS

<table>
<thead>
<tr>
<th>Coke Drum ID</th>
<th>26'</th>
<th>30'</th>
<th>32'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Back Warm (lb/hr)</strong></td>
<td><strong>H2S</strong></td>
<td><strong>HC vapour</strong></td>
<td><strong>Steam</strong></td>
</tr>
<tr>
<td>1,800</td>
<td>96,650</td>
<td>600</td>
<td>2,340</td>
</tr>
<tr>
<td>295</td>
<td>14,330</td>
<td>302,850</td>
<td>393</td>
</tr>
</tbody>
</table>

*Rates are estimates only
* Assume 10 -15 % Backwarm
Air Emission Consideration #1

- Coker Furnaces
  - Use of low Nox burners – industry typically avoids ultra-low Nox burners to minimize reliability issues in a critical piece of equipment
  - Use of low sulphur fuel gas
  - Increase heat recovery from fuel gases by air preheat or steam generation
Air Emission Consideration #2

- Process equipment:
  - Heat recovery – use fractionator pump-arounds to preheat feed, drive gas plant reboilers or generate steam
  - Upgrade design to include double mechanical seals on Hydrocarbon pumps and compressors
  - Route intermittent process venting and emergency releases to flare
  - Avoid screwed pipe or connections wherever possible
Air Emission Consideration #3

- Coke handling:
  - Keep coke wet to minimize particulate emissions from dusting
  - Minimize and enclose transfer points
  - Gasify coke to generate electricity
Air Emission Consideration #4

• Flareless start-up (future):
  ▪ Still in developmental stages – potential big issue
  ▪ Concept is to have compressor running on recycle so wet gas are compressed and processed, instead of vented from the fractionator overhead
  ▪ Additional equipment may include an LPG vapourizer, to assist in flareless start-up by providing a gas at the compressor closer in MW to normal operating than from refinery fuel gas or natural gas
Air Emission Consideration #5

- Coke drum depressuring:
  - New regulation may require depressuring the coke drum to less than five psig prior to opening to the atmosphere for cutting
  - Coke drums are vented through the closed blowdown to a vapour recovery system or compressed for recycle to the gas plant
Water and Slops Management
Water Management

- Adopt “Reuse, Reduce, Recycle” mentality on plant
- Recycle coke cutting water
- Increase Sour Water Stripping
- Maximize air cooling where possible
- Maximize heat integration for cooling hot products from coker fractionator
Water Emissions

- Closed blowdown water:
  - Reuse part of closed blowdown water for coke drum quench
  - Send rest to Sour Water (SW) stripper
- Process water: send to SW stripper
- Stripped SW water:
  - Reuse as make-up to quench/cutting water
  - Reuse for fractionator top wash to remove chloride salts
Reprocessing Refinery Streams

- Refinery slop oil – recycle through closed blowdown system for use as coke drum overhead quench
- Refinery sludges (tank bottoms or separate sludge) – use for coke drum quench during initial part of quenching step
Slops Handling System
Secondary containment – Coker applications
Secondary Containment

- Definition of secondary containment:
  “A container or structural barrier placed under or around a vessel to contain the contents of the vessel in the event of an accidental spill or leak.”
Secondary Containment

- Environmental guideline – the overarching requirement for containment is from the Alberta Environmental Protection and Enhancement Act - Clause 109 stating, “No person shall knowingly release or permit the release into the environment of a substance in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect.”
Environmental issue: following environmental review with facility owner, the coke water basin was considered a permanent underground water storage facility as supposed to flow through – secondary containment was required for the coke fines settling basin.
Secondary Containment

• Coke fines settling basin:
  - Located just off coke pad
  - All coke water drained to settling basin
  - Settling basin is sloped to pump out low point
  - Dimensions 60ft long x 20ft wide x 30ft deep
  - Leak detection stand pipe required
Coke Fines Settling Basin

- Coke water drains from pad
- Weir wall and low point pump out
Secondary Containment

PLAN AT TDC EL 104"-0"

ELEVATION AT GRADE LINE 14 & 15

SEE DETAIL

LEAN DETECTION STRAP-OFF
SECONDARY CONTAINMENT LINER
LEAN DETECTION STRAP-OFF
SECONDARY CONTAINMENT LINER

Coking.com

BANTREL
25 Years of Excellence
Secondary Containment

- "HAZARD" preformed boot field welded to "HAZARD" liner
- "HAZARD" preformed boot around pile
- Non-woven geotextile
- "HAZARD" PVC liner
- Mudslab
- Preformed subgrade
- Soilform
- Backfill protection board

Details at base slab & pile

Details at wall & top attachment
Secondary Containment

- Design basis:
  - Layfield ‘Hazgard’ liner used – competent vendor with extensive experience of secondary containment
  - Customized design to fit tight to slope and piles
  - Panels fabricated off-site, joined on-site
Secondary Containment

- Final words:
  - Increasing integration in Coker design as environmental issues become more and more prevalent in oilsands development
  - Settling basin as well as cutting water tank
  - Deciding early if required for your facility – it will effect design, budget and installation sequence
Dust suppression – delayed coking
Dust Suppression – Environmental issue

- Recent Bantrel project: owner switched feed from sweet crude to oilsands feed, and went on to produce shot coke
  - Required loading railcars and shipping coke from Edmonton, AB to Prince Rupert, BC for shipment to far east
Dust Suppression – Environmental Issue

- Distance from Edmonton to Prince Rupert is approx. 1400km
  - Without dust suppression, coke dust would pollute the atmosphere as the coke particles dry out
  - Requires dust suppression!
Dust Suppression

Approx. 1400Km
Dust Suppression

Wilderness around Prince George area – no coke dust
Dust Suppression

Faces of people from B.C. without dust suppression?
Dust Suppression

Design basis:
- Use vendor with mining background
- Latex/water based solution
- Grid-spray system
- Deluge of solution immediately after coke loading
- Dust suppression skid within building
- Dust suppression application within closed shelter
**Dust Suppression System**

- Design basis:
  - Integrated system with rail car progression
  - Automated remote operation
  - Two pump operation, one solution, one water booster
  - Mixing ratio from 1:10 to 1:50
Dust Suppression

- Final words:
  - Increasing oilsands production will lead to increasing shot coke production = Increase in dust suppression requirements when shipping, be aware and integrate into design/operation – use mining industry experts as required, no requirement to re-invent the wheel
Questions