Coking Process & Safety

Nathan Ashcroft
& Simlie Foscolos

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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

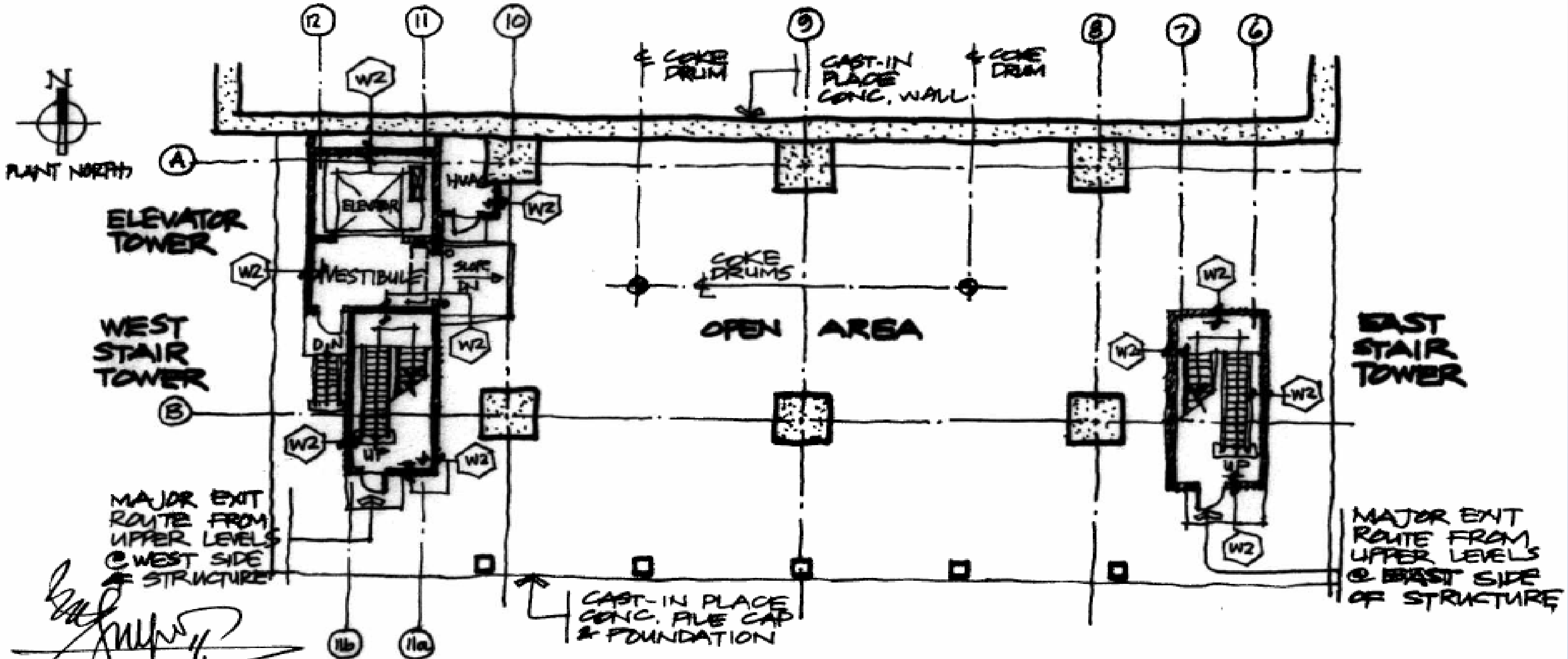
Bantrel Design Coker Structure

- 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



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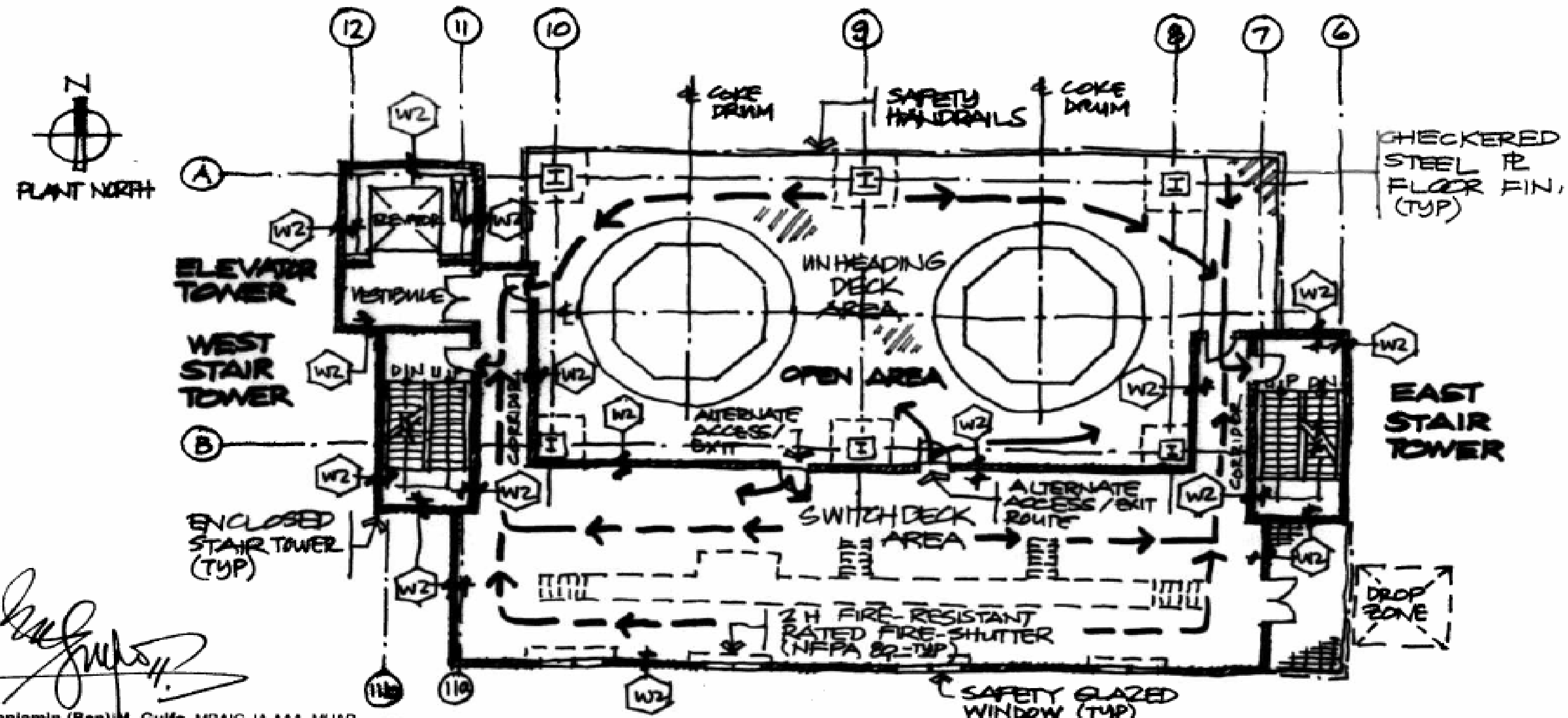
PLAN - GROUND FLOOR

W2 - 2H FIRE - RESISTANT RATED WALL ASSEMBLY
NOTE: DRY OR WET STANDPIPE FORMED PART OF BLDG DESIGN.

Access and Egress of Coker Structure



PLAN - SWITCHDECK / UNHEADING DECK

W2 - 2H FIRE-RESISTANT RATED WALL ASSEMBLY

NOTE: DRY OR WET STANDPIPE FORMED PART OF BUILDING DESIGN.

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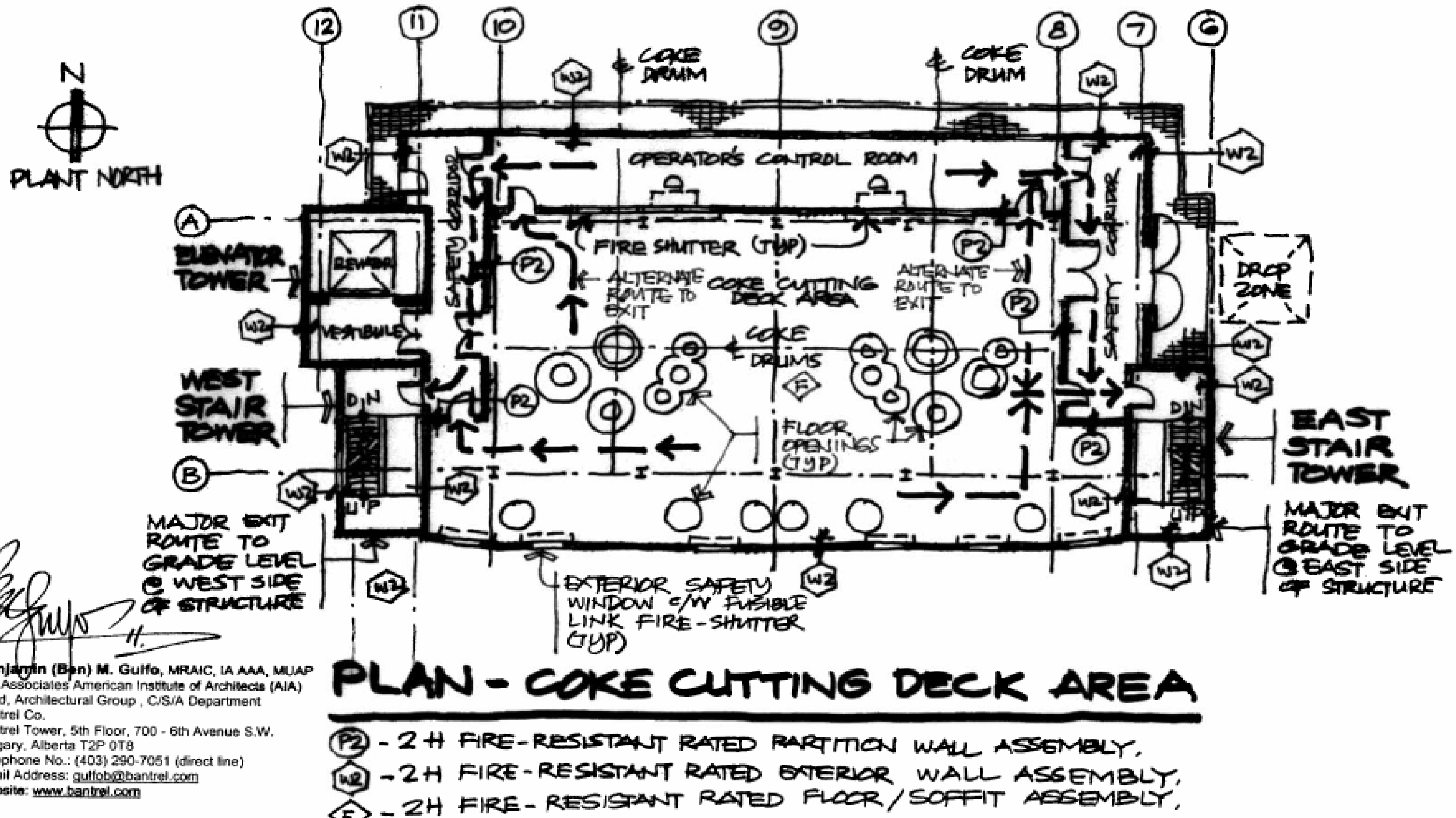

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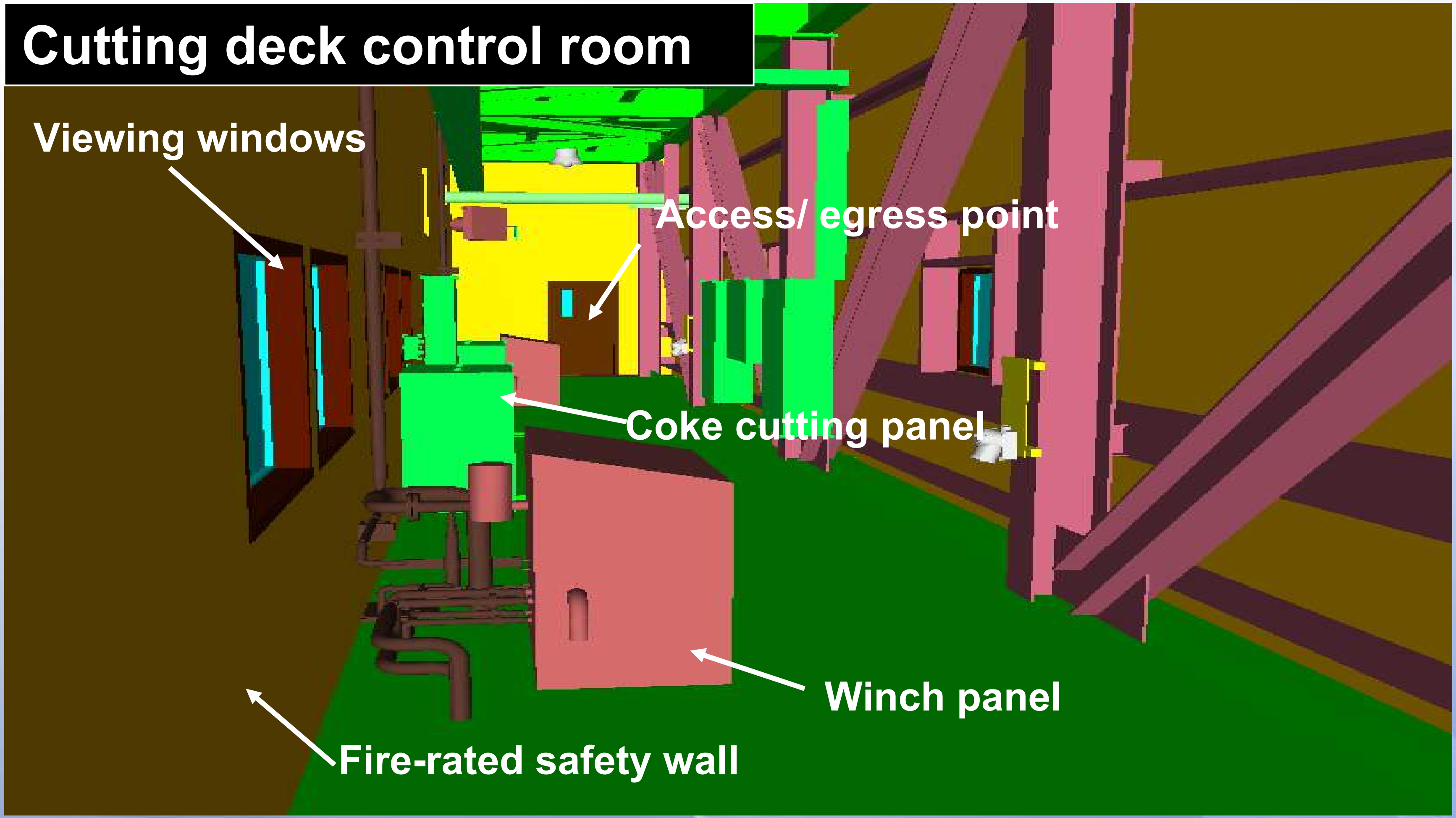

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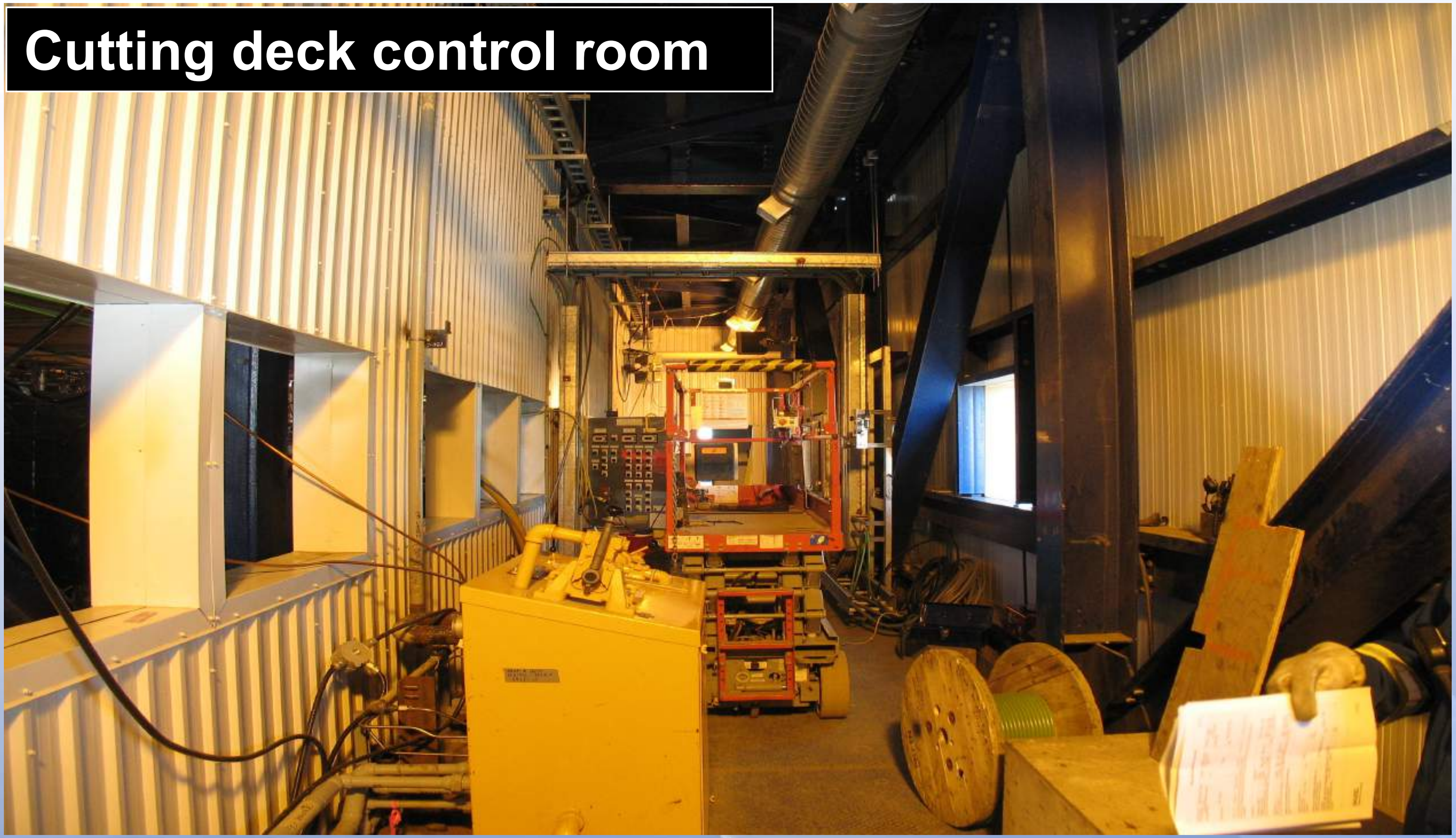

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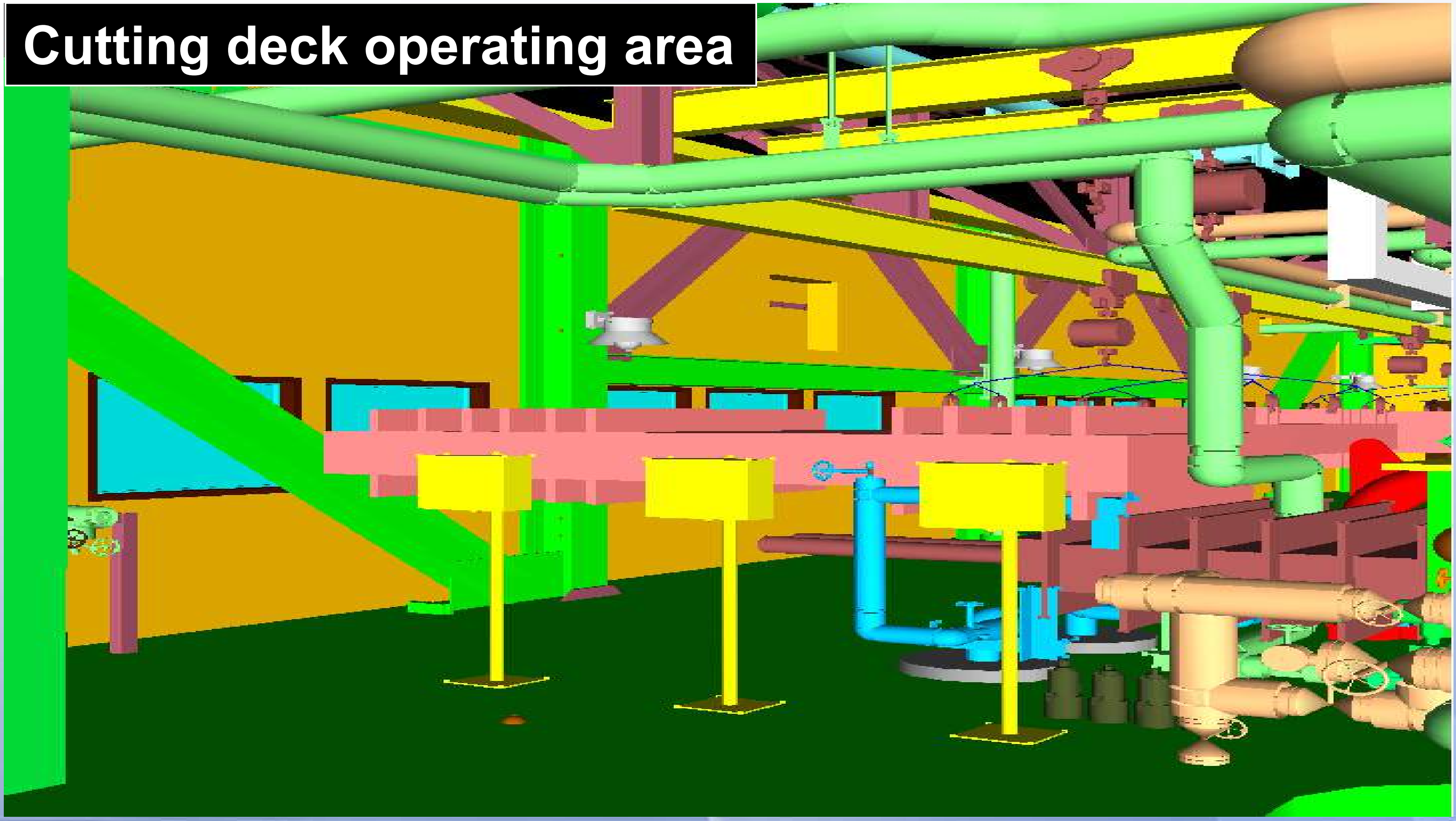

Access and Egress of Coker Structure

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

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Cold climate HVAC for Coker structure

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How Cold?

Cold Climate HVAC for Coker Structure

Cold Climate HVAC for Coker Structure

Cold Climate HVAC for Coker Structure

Cold Climate HVAC for Coker Structure

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

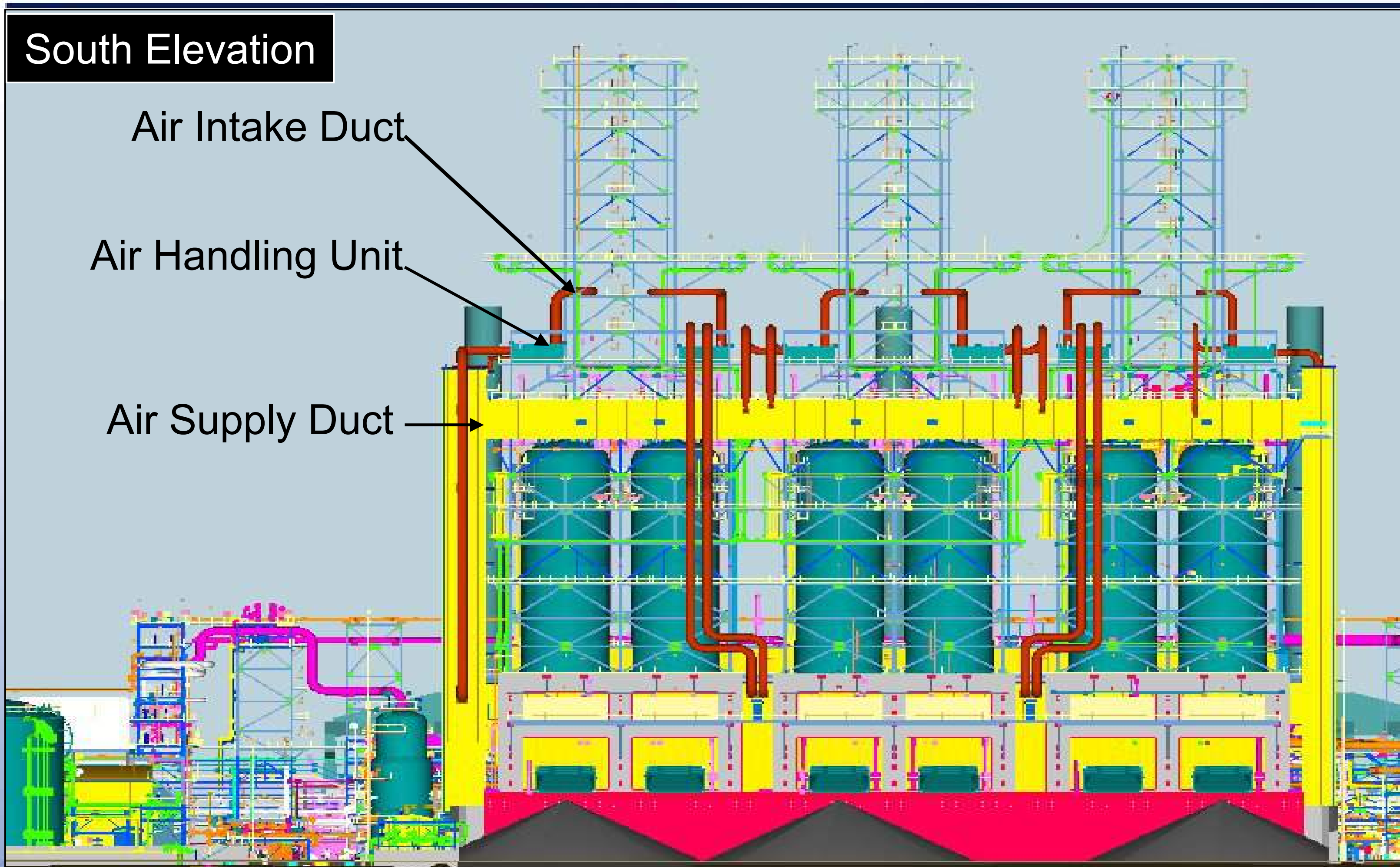
Cold Climate HVAC for Coker Structure

- 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



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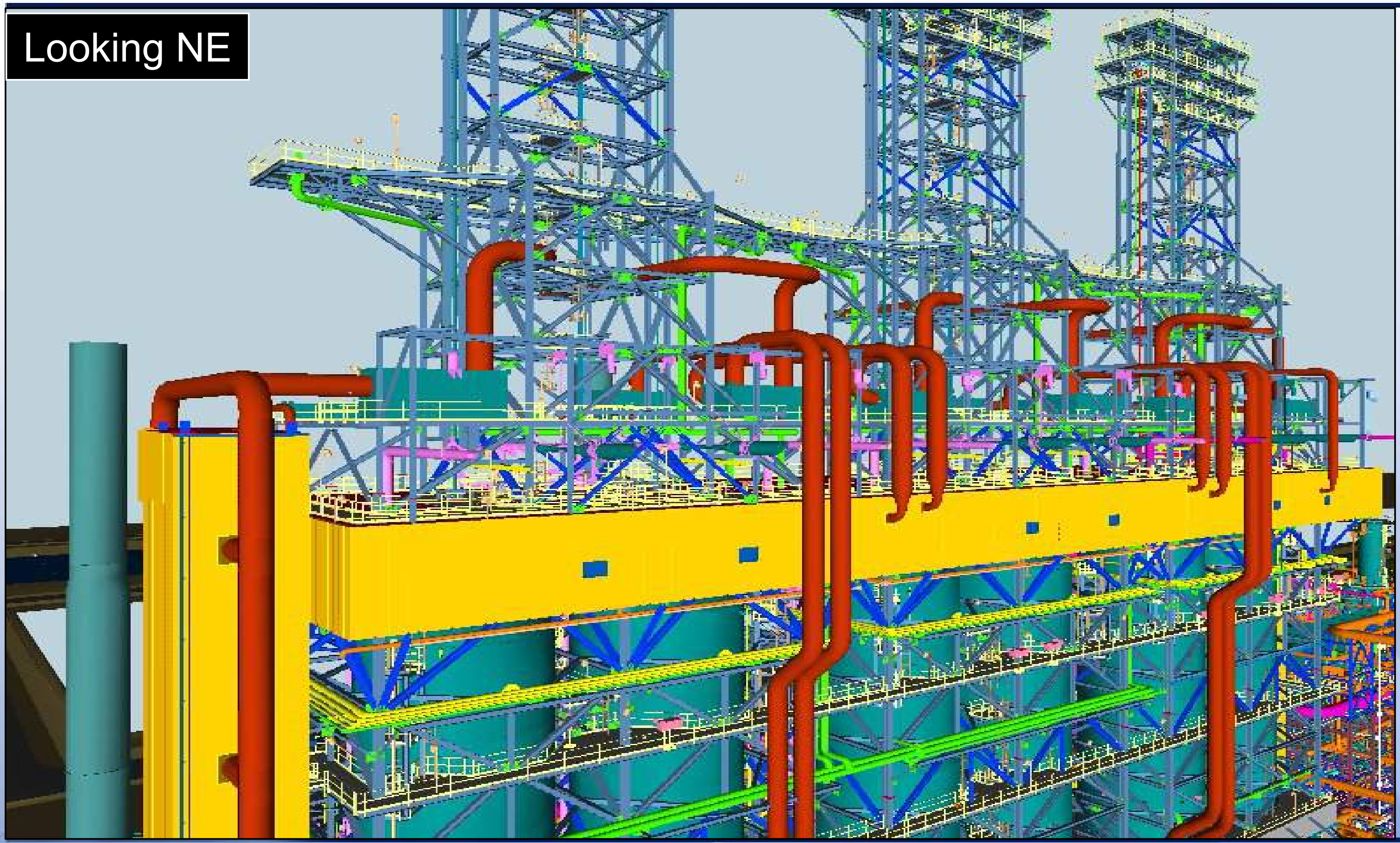

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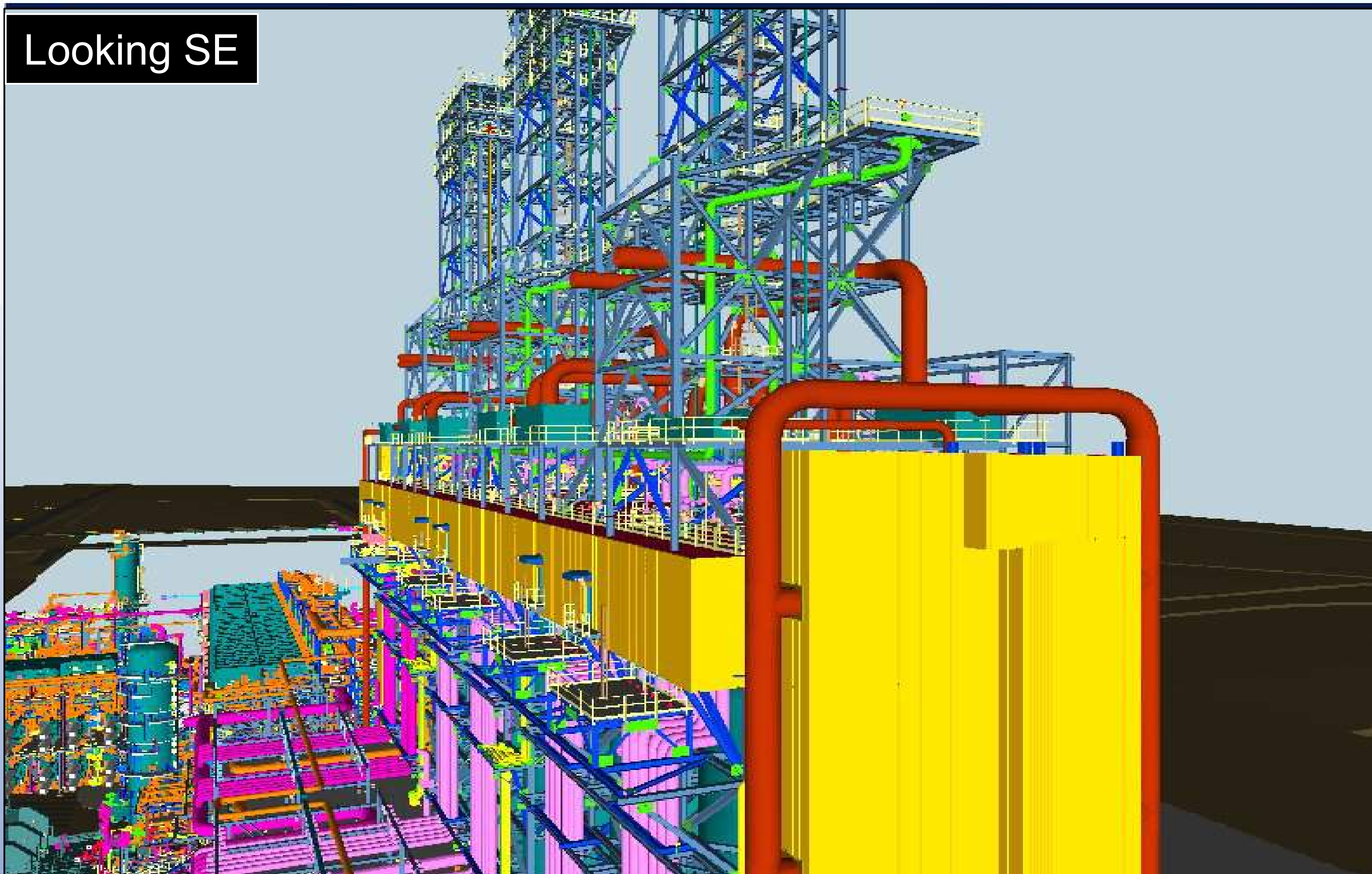

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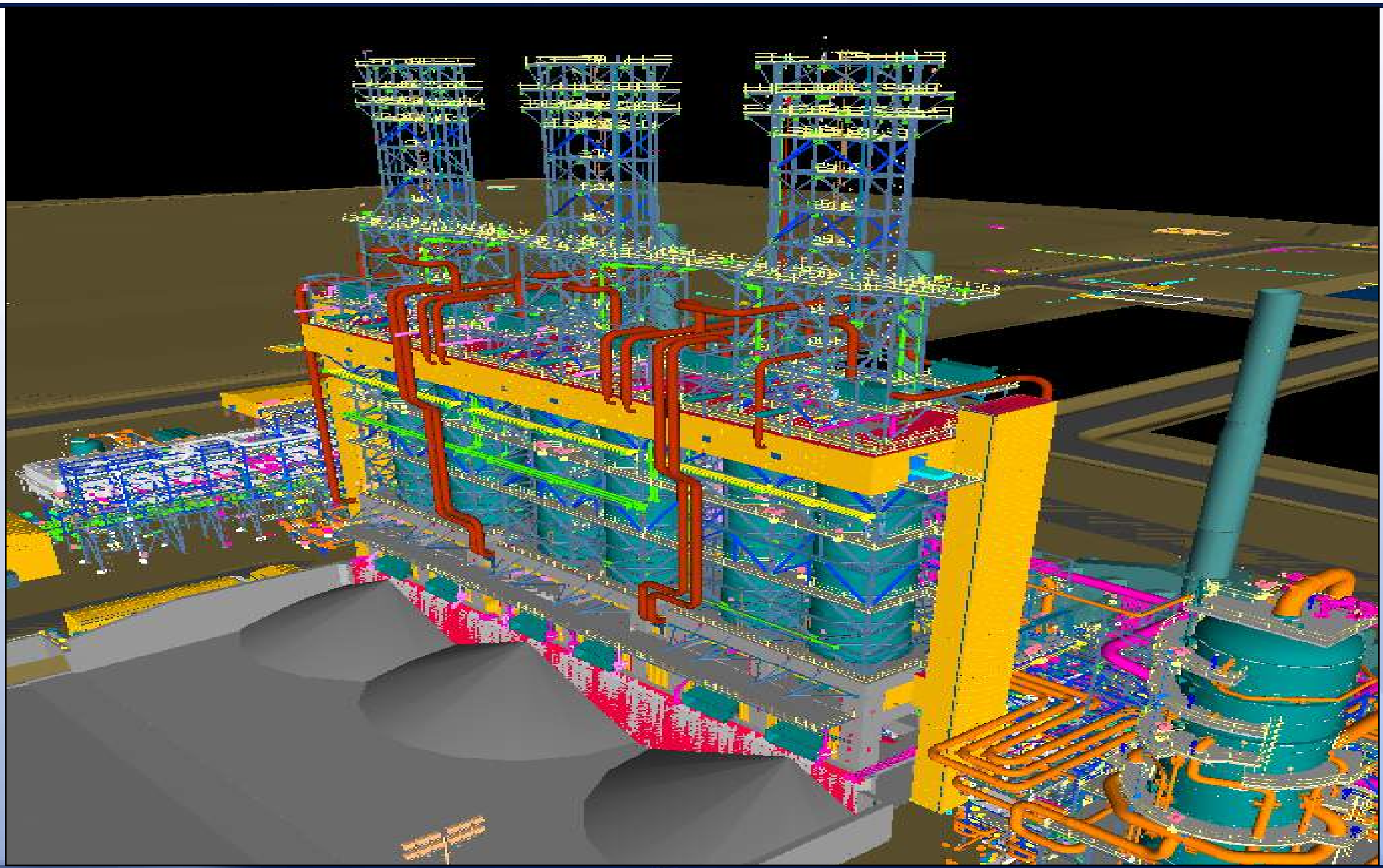

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Heat Recovery

Heat Recovery

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

Pinch technology?

How Does it Work?

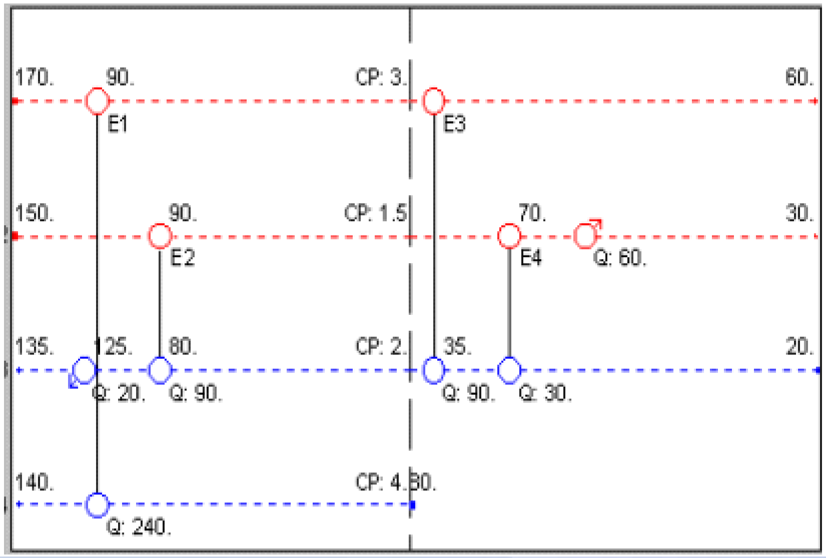
Basic Concepts of Pinch Analysis

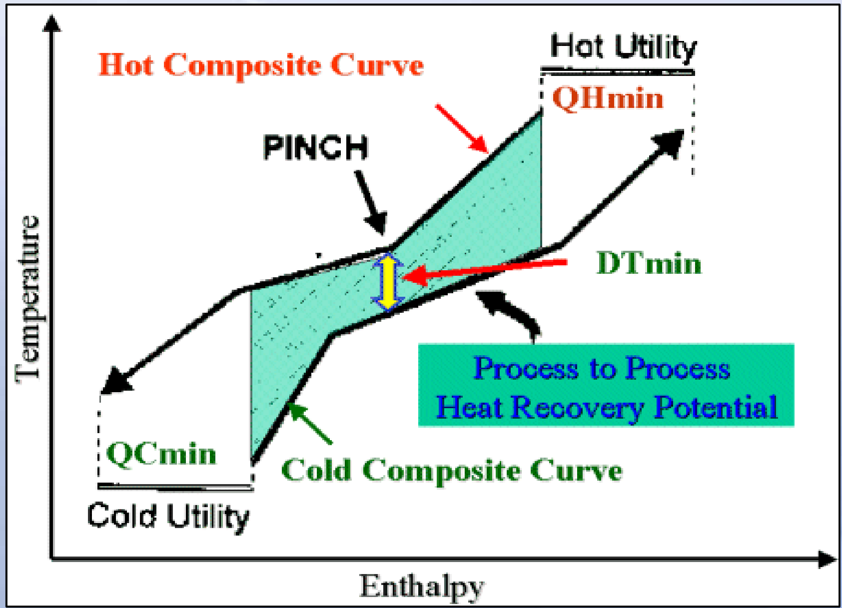
- Involves the transfer of heat either:
  - From one process stream to another process stream, or
  - From a utility stream to a process stream
- With the world's current energy crisis, the target in any industrial process design is to maximize the process-to-process heat recovery and to minimize the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

Basic Concepts of Pinch Analysis

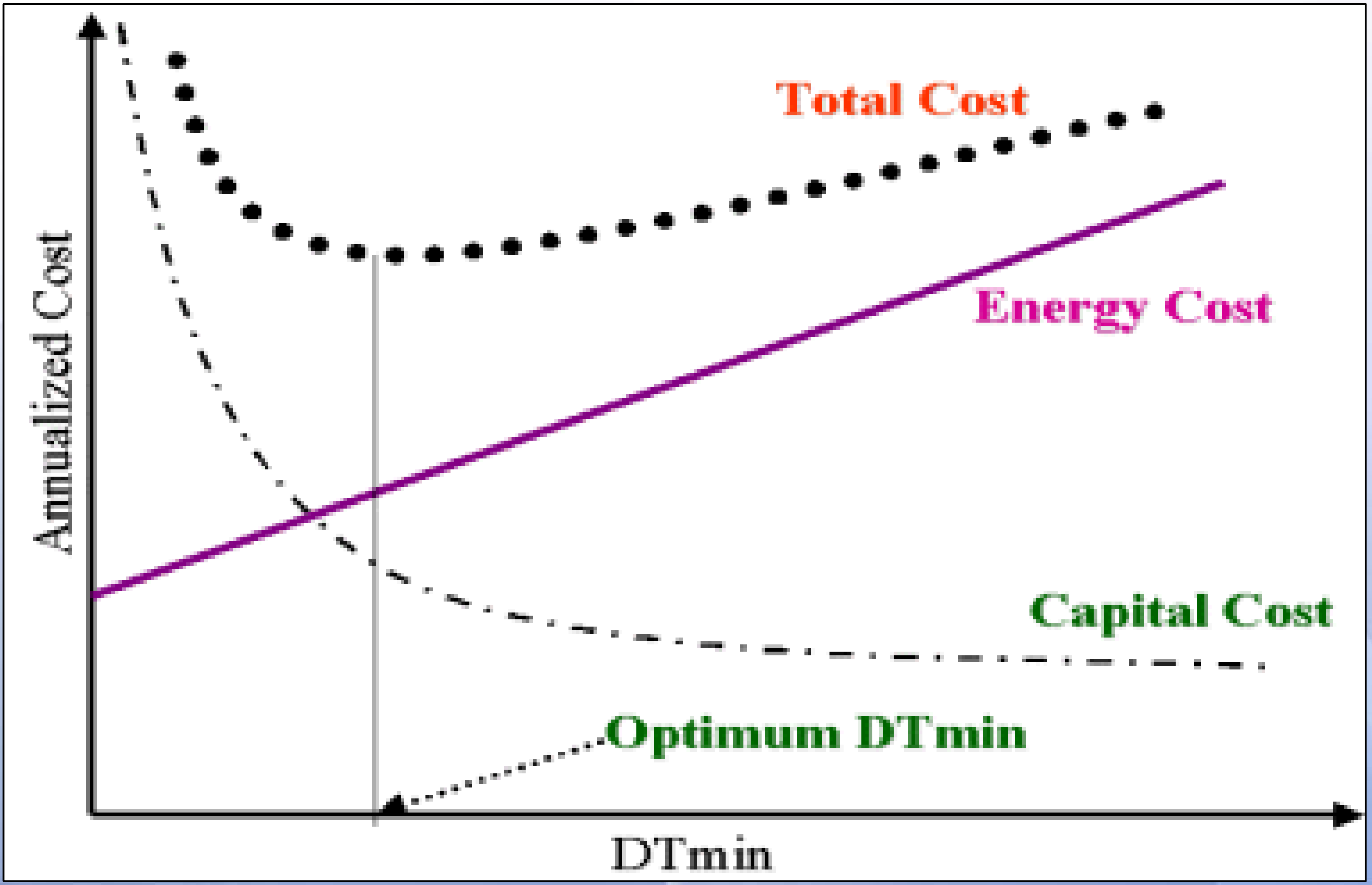
- To meet the goal of maximum energy recovery or minimum energy requirement requires an appropriate heat exchanger network
- Design of such a network is complex as most processes involve a large number of process and utility streams

Generating Composite Curves for PINCH



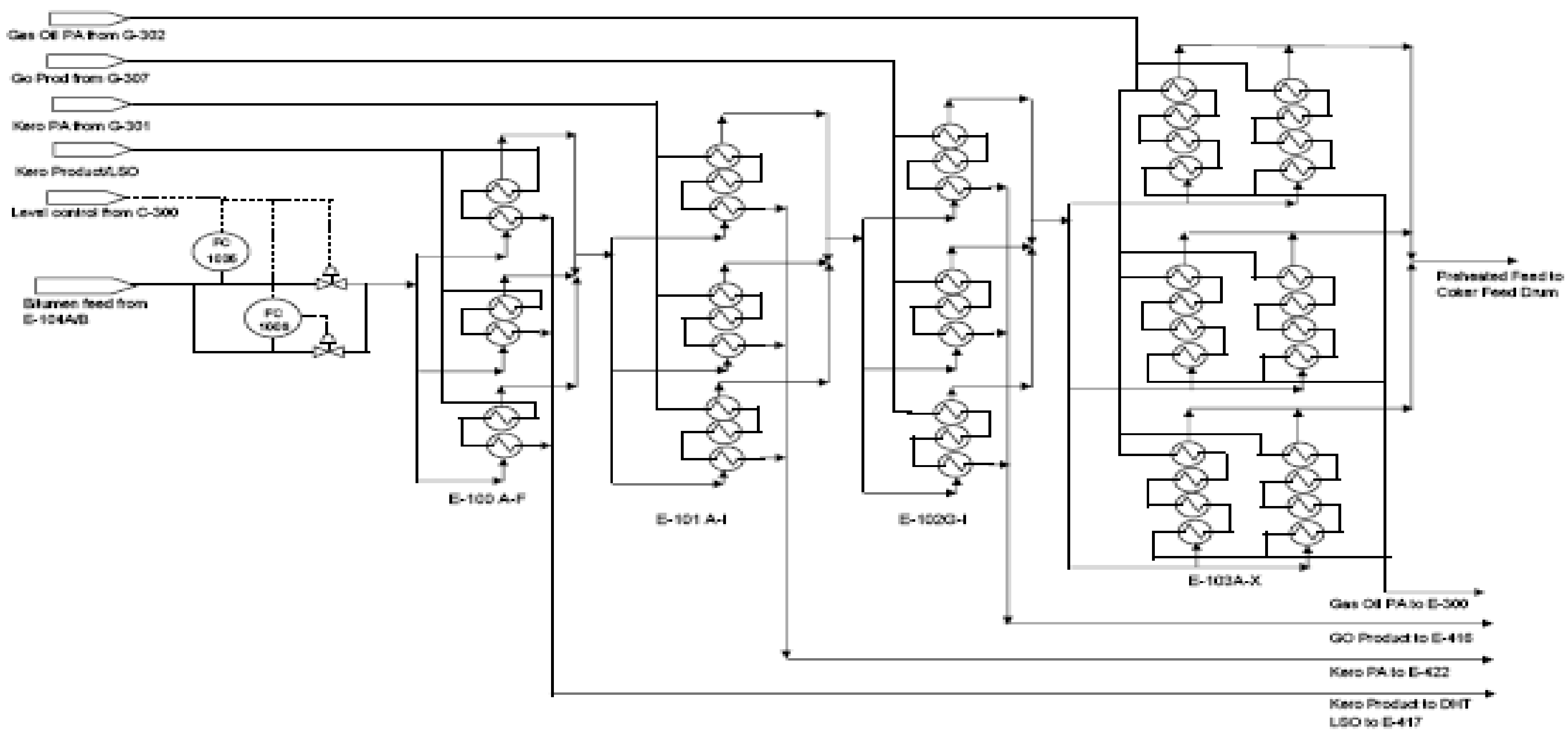


Economic Analysis of Results



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

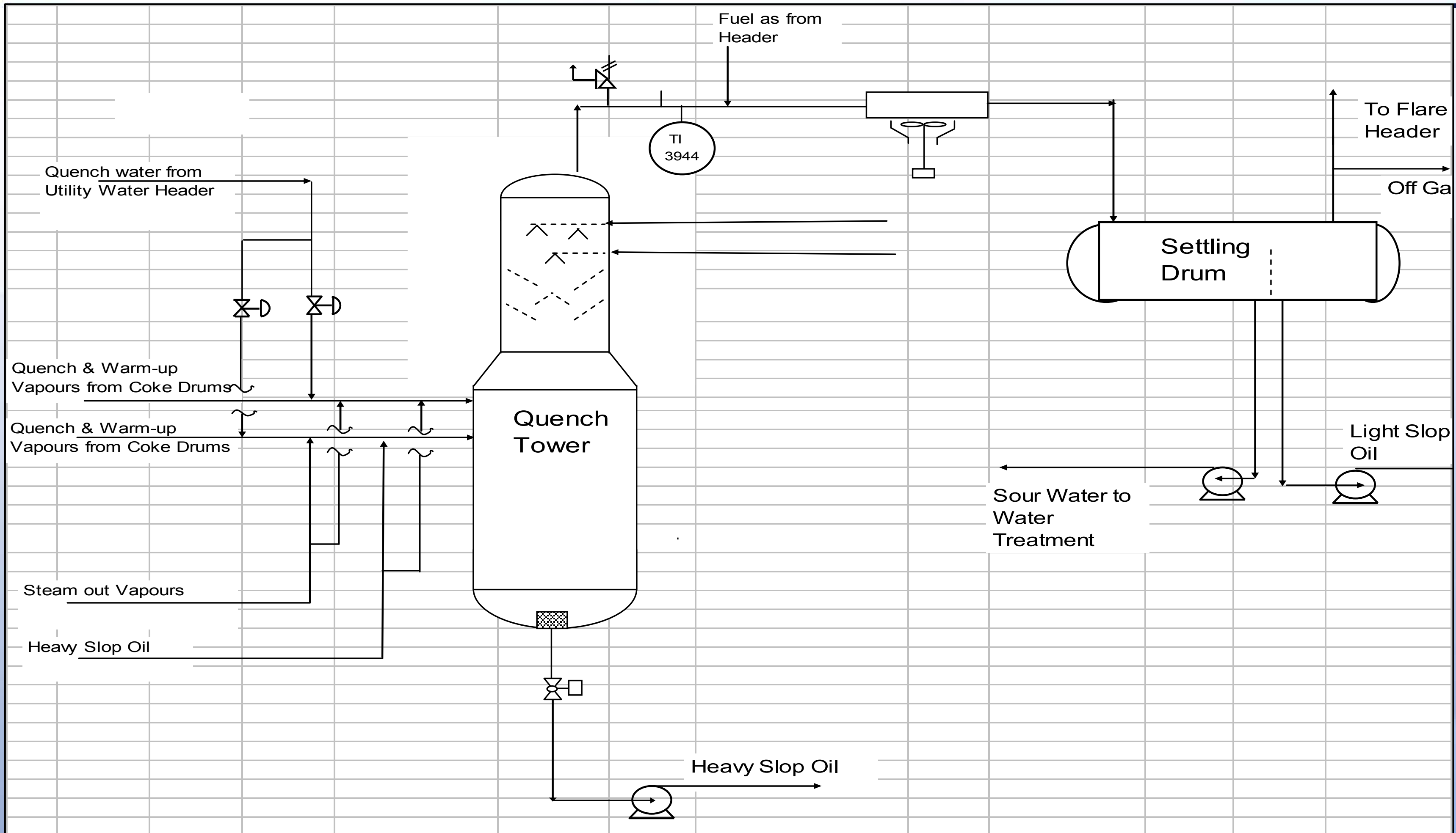
Improvements on Design of Blowdown Line

- 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

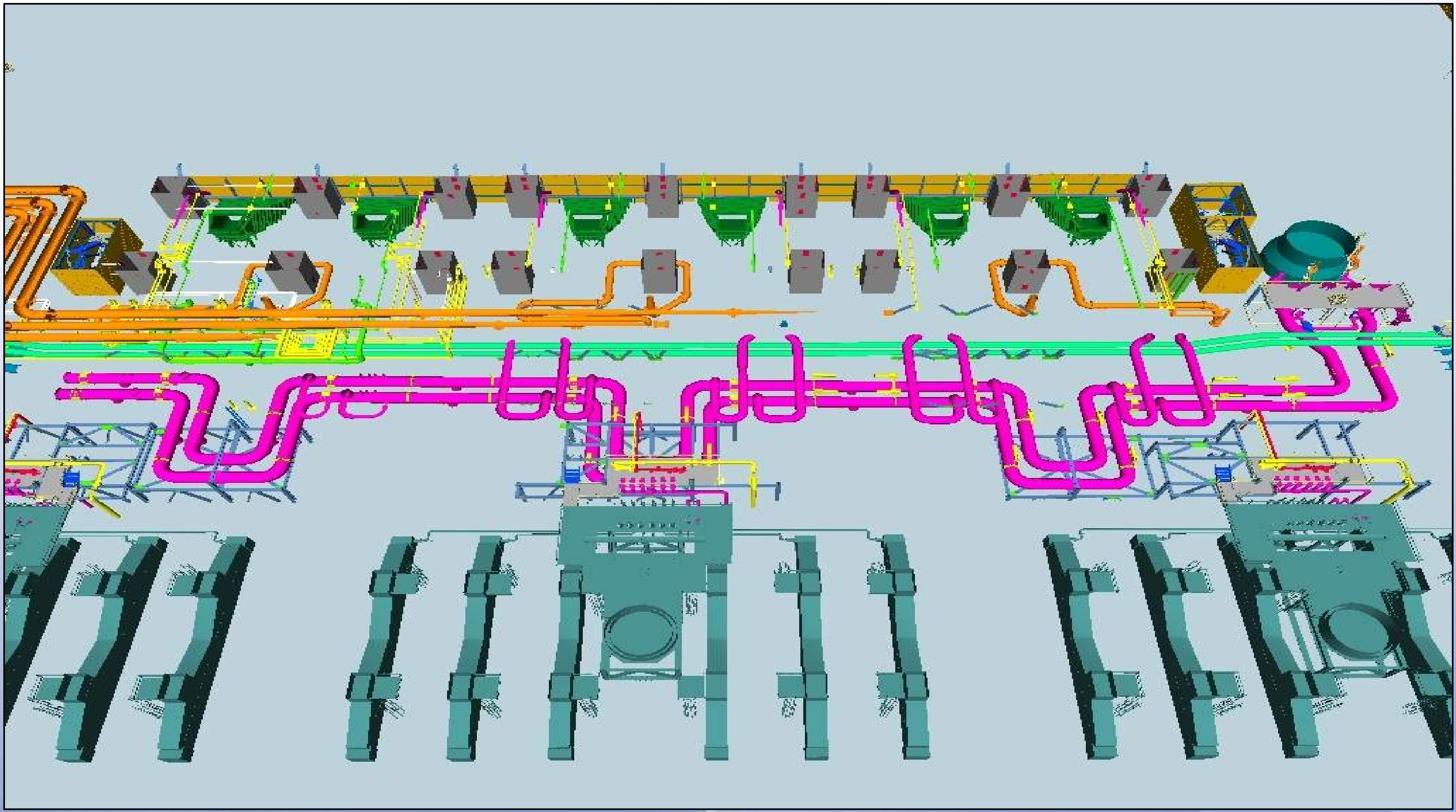
Improvements on Design of Blowdown Line

- 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



Model Shot of Twin Lines to CBS



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Questions

Our Environment …

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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

Environmental Headlines

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 and the Environment

"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

Delayed Coking and the Environment

- 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 and the Environment

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 CO_2 capture projects
- Utilize hybrid vehicles in place of traditional pick-up trucks on the jobsite to reduce the impact of CO_2 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 H_2S less than 160 ppm

Pollutant	lbs/million BTU	lbs/hr (fired duty @400MMBtu/hr)	Tons/Year
NOx	0.01	4	17.5
CO	0.04	16	70.1
VOC	0.006	2.4	10.5
PM	0.0075	3	13.1
SOx	0.03	12	52.6

Estimated Emissions from Flare during Upset

Pollutant	Emissions lbs/hr
NOx	1,360
CO	7,400
VOC (Destruct Eff. 98%)	19,000
PM10	None (Smokeless flare)
SOx	600,000
CO2	1,900

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

Coke Drum ID	26'			30'			32'		
	H2S	HC vapour	Steam	H2S	HC vapour	Steam	H2S	HC vapour	Steam
Back Warm (lb/hr)	1,800	96,650	600	2,340	128,700	790	2,660	146,400	900
Water Quench (lb/hr)	295	14,330	302,850	393	19,076	403,200	450	21,700	460,000

*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

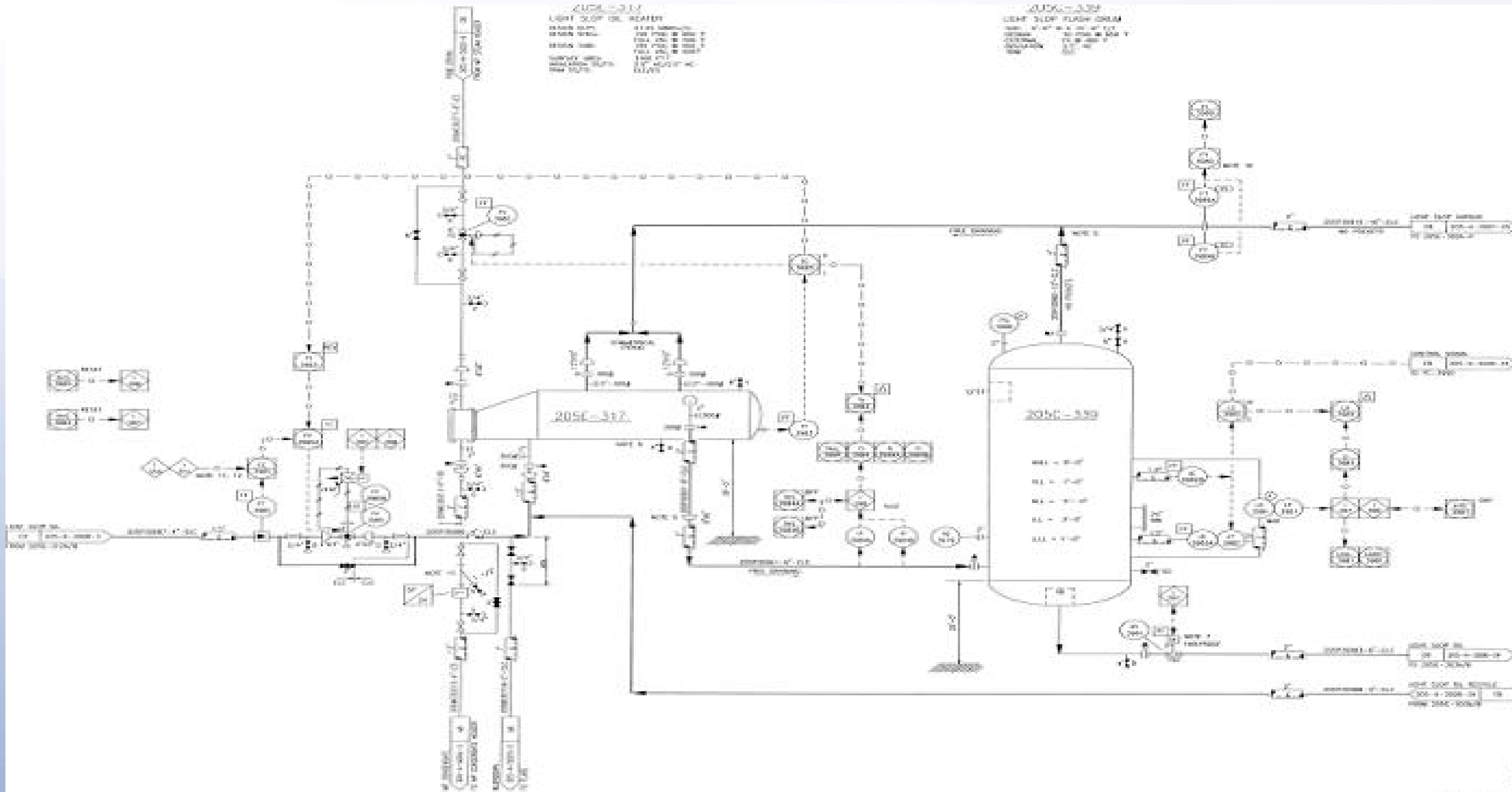
Water Emissions

- 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.”

Secondary Containment

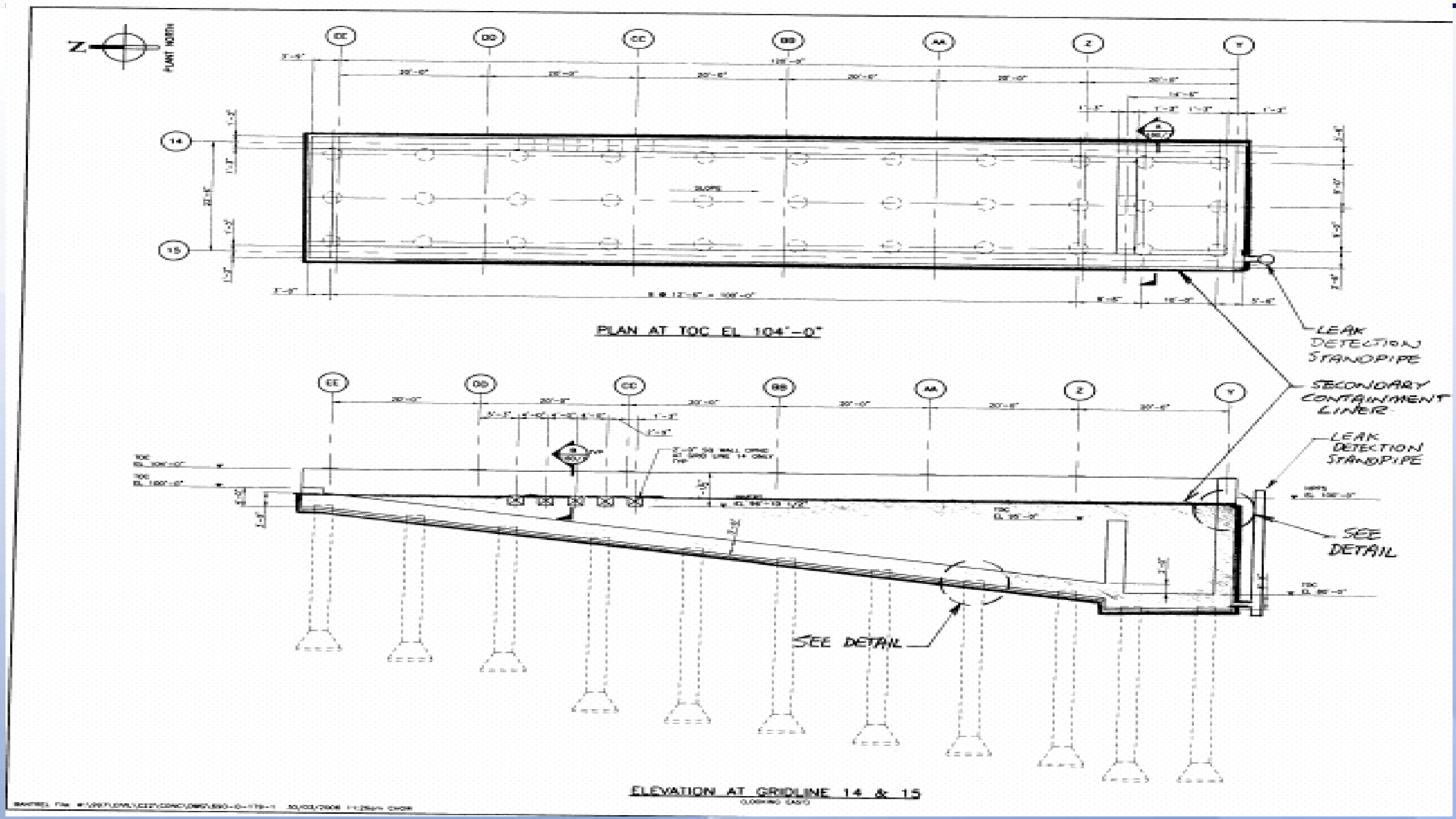
- Environmental issue: following environmental review with facility owner, the coke water basin was considered a permanent underground water storage facility as supposed to flow through – secondary containment was required for the coke fines settling basin.

Secondary Containment

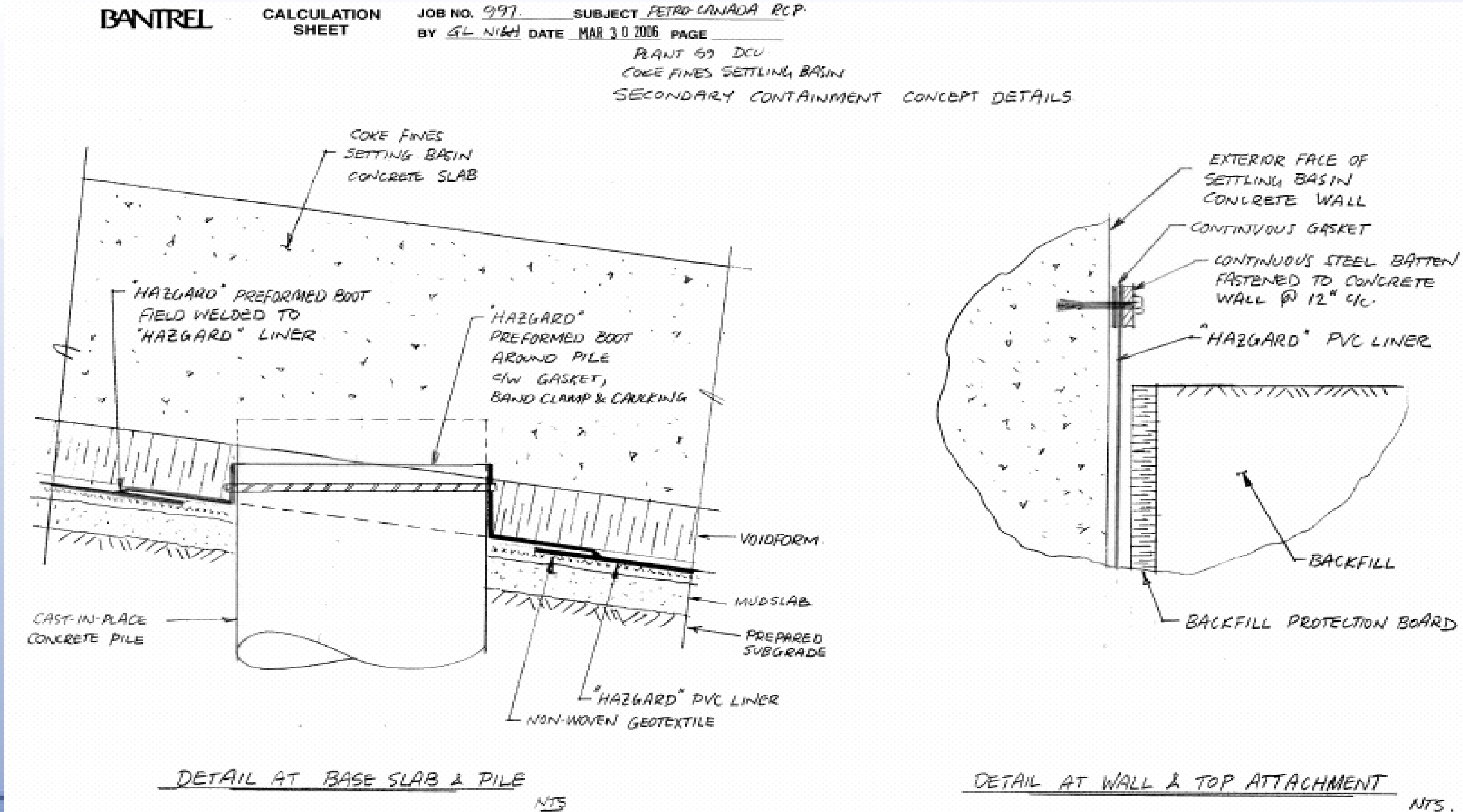
- Coke fines settling basin:
  - Located just off coke pad
  - All coke water drained to settling basin
  - Settling basin is sloped to pump out low point
  - Dimensions 60ft long x 20ft wide x 30ft deep
  - Leak detection stand pipe required

Coke Fines Settling Basin

Secondary Containment



Secondary Containment



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

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Dust suppression – delayed coking

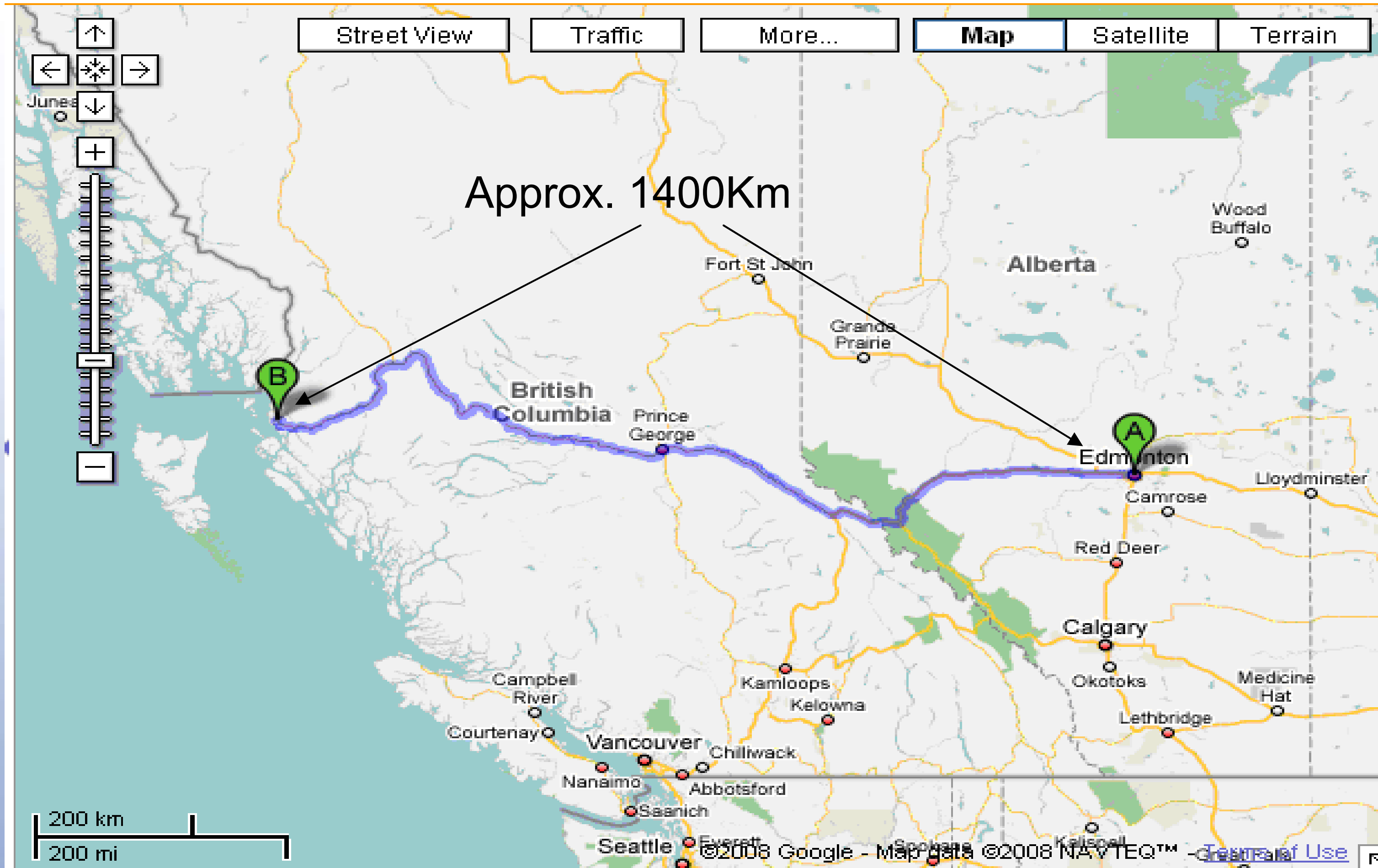
Dust Suppression – Environmental issue

- 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



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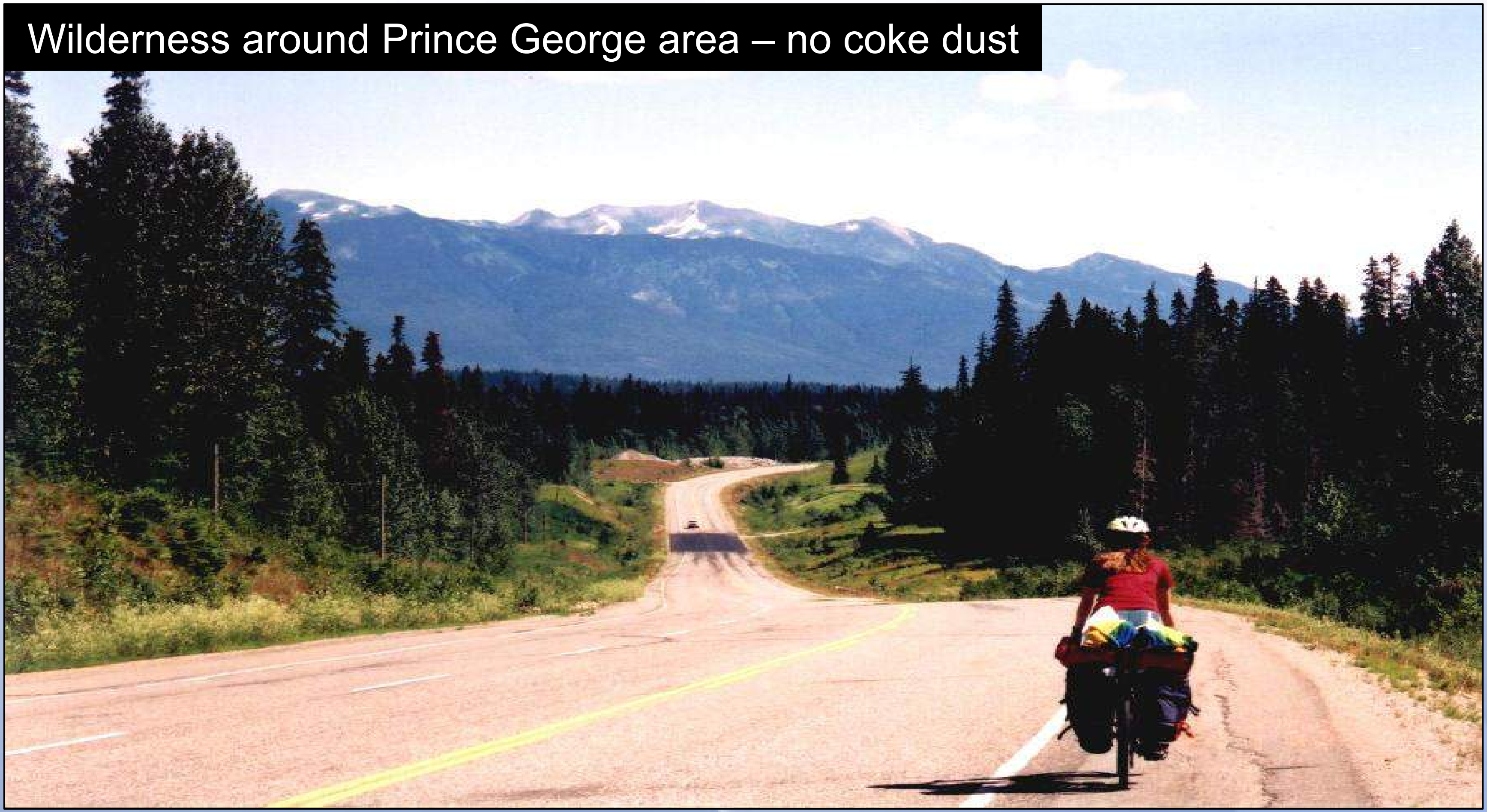
Dust Suppression

Wilderness around Prince George area – no coke dust



Dust Suppression

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

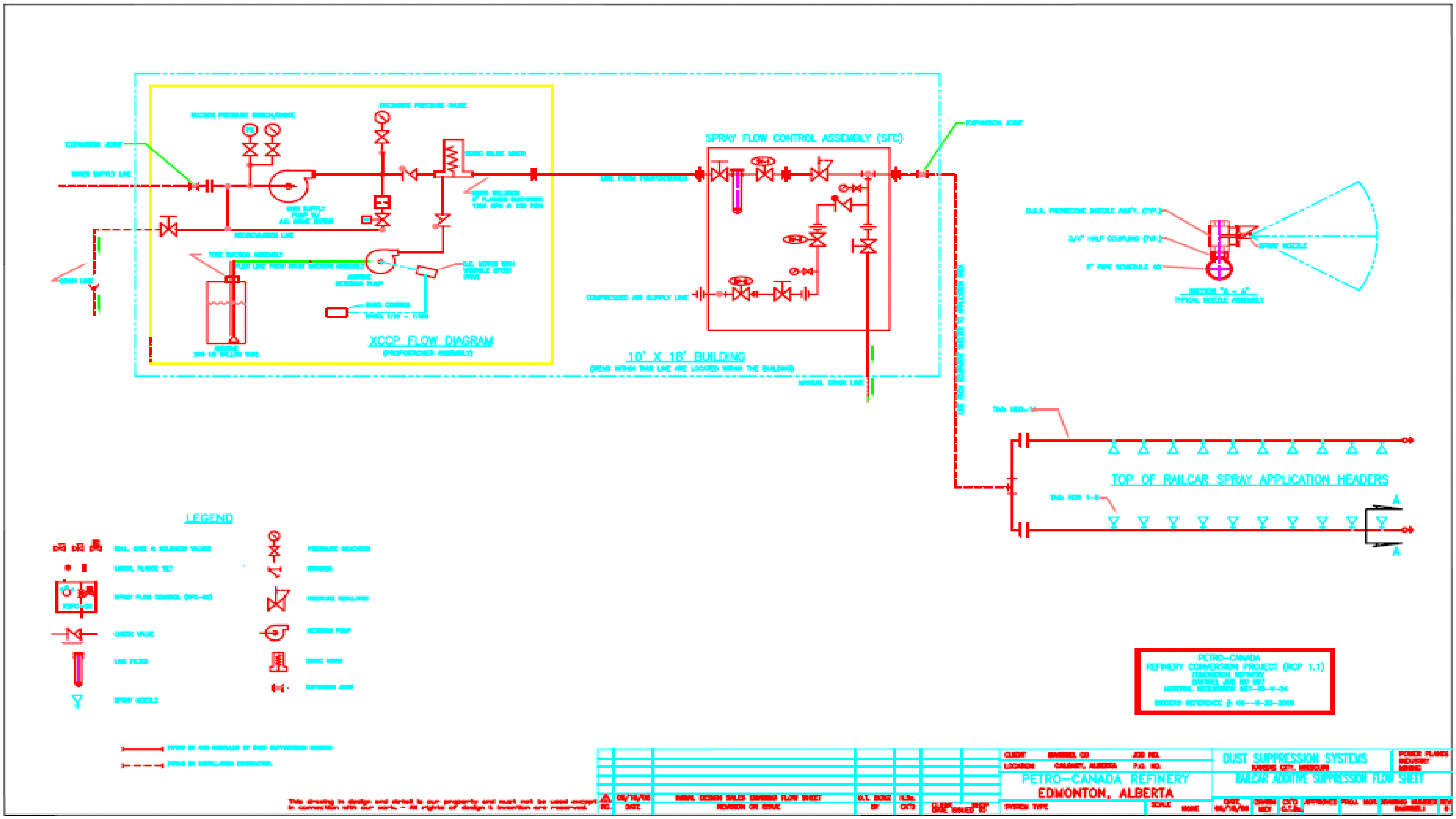
Dust Suppression

- 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



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