Coking.com

Important References -

2001 CSB

Safety Bulletin

U.S. Chemical Safety and Hazard Investigation Board

MANAGEMENT OF CHANGE

No. 2001-04-SB | August 2001

2003 OSHA & CEPPO

United States Environmental Protection Agency

EPA 550-F-03-001
August 2003
www.epa.gov/ceppo

Chemical Emergency Preparedness and Prevention Office (5104A)

Occupational Safety and Health Administration
Directorate of Science, Technology and Medicine
Office of Science and Technology Assessment

CEPPO **OSHA**

Hazards of Delayed Coker Unit (DCU) Operations

United States Department of Labor

SHIB 03-08-29(C)
www.osha.gov

Seattle Times

SEATTLE - Houston-based Equilon has agreed to pay $45 million to settle a lawsuit filed over the deaths of six workers in a 1998 Anacortes refinery explosion.

Coking.com

Thomas Meek & Brent Sattler

Improvements since the 1998 Equilon Puget Sound Refinery Coke Drum Incident

DCU Safety & Reliability

Equilon Puget Sound -1998 DCU Fire

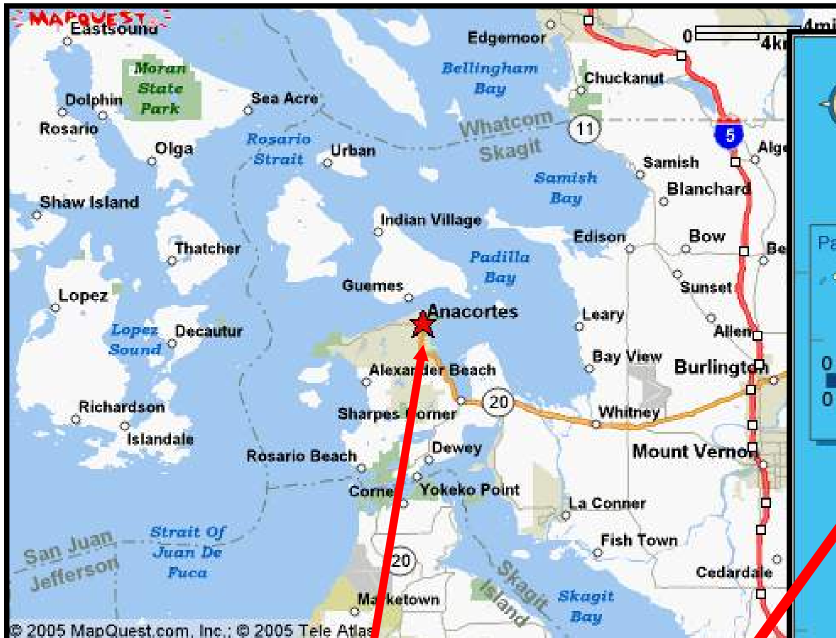
Komo News 4 Reporting

Ongoing Video by local media during the event.

1998 Equilon DCU Fire Fight….

- Figure 2. Fire control efforts at Equilon refinery.

Matt Wallis, Skagit Valley Herald


MAPQUEST
Eastsound
Edgemoor
Moran State Park
Dolphin
Sea Acre
Bellingham Bay
Chuckanut
Rosario
Olga
Rosario Strait
Urban
Whatcom
Skagit
Samish
Samish Bay
Blanchard
Shaw Island
Indian Village
Edison
Bow
Thatcher
Padilla Bay
Guemes
Sunset
Lopez
Anacortes
Leary
Lopez Sound
Decatur
Allen
Bay View
Burlington
Alexander Beach
Richardson
Sharpes Corner
Whitney
Islandale
Dewey
Mount Vernon
Rosario Beach
Yokeko Point
La Conner
Strait Of Juan De Fuca
Fish Town
San Juan
Jefferson
Cedardale
Marketown
Skagit Island
Skagit Bay
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United States
YAHOO! Travel
Hudson Bay
CANADA
RUS.
AK
CAN.
60°
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150°
Pacific Ocean
HI
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Ottawa
45°
Washington, D.C.
Pacific Ocean
Atlantic Ocean
Northern Mariana
MEXICO
Gulf of Mexico
FL
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100°
0 250 500 mi
0 250 500 km
U.S. Virgin Islands
Puerto Rico
80°


Vancouver Island
BRITISH COLUMBIA
CANADA
Ferndale
Lynden
Bellingham
North Cascades
Sedro Woolley
N.P.
Strait of Juan de Fuca
Cape Flattery
Anacortes
Mount Vernon
Omak
Okanogan
Colville
Oak Harbor
Port Townsend
Everett
Port Angeles
48° N
Forks
Olympic N.P.
Olympic Mts.
Snohomish
Edmonds
Kirkland
Seattle
Bellevue
Renton
Bremerton
Kent
Chelan
Spokane
Cheney
Opportunity
Wenatchee
Ephrata
Tacoma
Auburn
Puyallup
Shelton
Quincy
Moses Lake
Hoquiam
Aberdeen
Tumwater
Olympia
Mount Rainier N.P.
Ellensburg
Othello
Mt. Rainier 14,410 ft. (4,392 m)
PACIFIC
OCEAN
Centralia
Chehalis
Raymond
Pullman
Selah
Yakima
Toppenish
Sunnyside
Richland
Clarkston
Cape Disappointment
Grandview
Pasco
Kennewick
Longview
Kelso
Prosser
Walla Walla
46° N
IDAHO
0 50 Miles
0 50 Kilometers
Vancouver
Camas
OREGON
118° W
122° W
120° W
Washington
MAPQUEST.COM

Shell Delayed Coking in the US

Shell Puget Sound Refinery - DCU

26.9 MBPD Heater Feed, 2 Drums - 26', 15 Hr. Cycles
Typical Gas Plant and Blowdown vapor recovery

Equilon Puget Sound Refinery Incident

- **Incident Description**
- **Contributing Factors**
- **Investigation: Summary of what happened**
- **Findings**
- **Recommendations**
- **Learning's**

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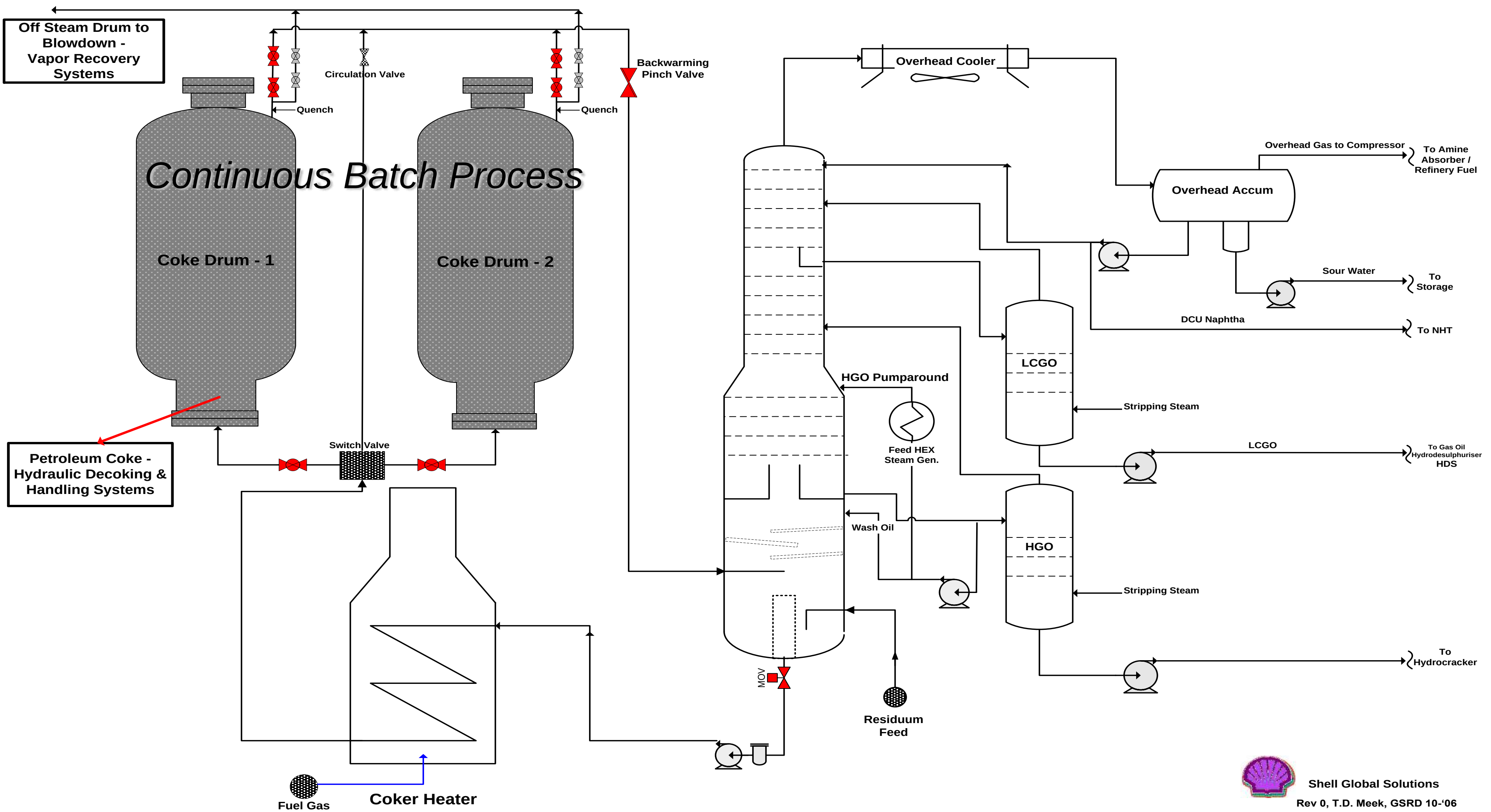
Coking – Process Overview

Simplified Process Flow Diagram of a Delayed Coker



Shell Global Solutions

Rev 0, T.D. Meek, GSRD 10-'06

Description of Equilon Incident

Unit Overview

- This Two Drum DCU is situated along the shores of Puget Sound in Anacortes, Washington.
- In 1998 this refinery was owned & Operated by Equilon and was a legacy Texaco Refinery. Presently it is owned and Operated by Shell Oil Products.
- Unit Safe Guarded Capacity is 26,880 BPD DCU Heater Feed
- Unit was Operating on 15 Hour Cycles on 11-25-1998
- Normal DCU configuration.
- Crude Processing Department staffing for the DCU
- Operators rotate between two units – Crude and Coker
- Contractor WPSI did Coke Drum Un-heading, Cutting, Coke Handling, Drum Re-heading, Maint. – all done by the CHD Dept

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15 Hour Drum Cycle - November1998

Time & Date	Cycle Step	Drum
11/24/98 8:00 PM	Steam Test - earlier if drum is ready	
11/24/98 8:30 PM	Warm Up - earlier if drum is ready	
11/24/98 10:00 PM	Warm Up Transfer Line	
11/24/98 11:00 PM	**Switch Drums**	**B to A**
11/24/98 11:01 PM	Steam to C1 @3.5 Lines	
11/24/98 11:30 PM	Steam to C-104 @9.5 Lines	
11/25/98 12:30 AM	Start Cooling Water	
11/25/98 5:00 AM	Shutoff Blowdown Blocking and PRV Steams	
11/25/98 6:00 AM	Unhead	
11/25/98 8:00 AM	Steam E106's and G-16 Strainers	
11/25/98 11:00 AM	Steam Test - earlier if drum is ready	
11/25/98 11:30 AM	Warm Up - earlier if drum is ready	
11/25/98 1:00 PM	Warm Up Transfer Line	

Cycle Interrupted by Major Utility Failure ~1 Hr after Switch

Description of Equilon DCU Incident

Tuesday, November 24th 1998

- **Drum A- Approx. 1100 Bbls of Charge in 1 Hour**
- **Power Outage - 12:01am**
- **Loss of steam following power outage**
- **Power Restored - 2:00am**
- **Unit on Circulation - 4:00am, Drum A Isolated**
- **Steam Restored - 12:30pm**
- **Attempted to Steam Into Transfer Line to Drum A**
  - 16 hours after loss of flow –
- **No Work Overnight – Drum allowed to cool on its own**

Description of Equilon DCU Incident

Wednesday, November 25th 1998

- Drum Temperature Data Reviewed in Morning
- Discussions Held - approx 10:30am
- Two Additional Steaming Attempts are Made
- Permit is Issued to Unhead with Fresh Air !!!
- Top Head Removed - 12:50pm
- Deheading Cart Positioned
- Bolts Removed and Head Lowered - 1:23pm
- Fire with Six Worker Fatalities

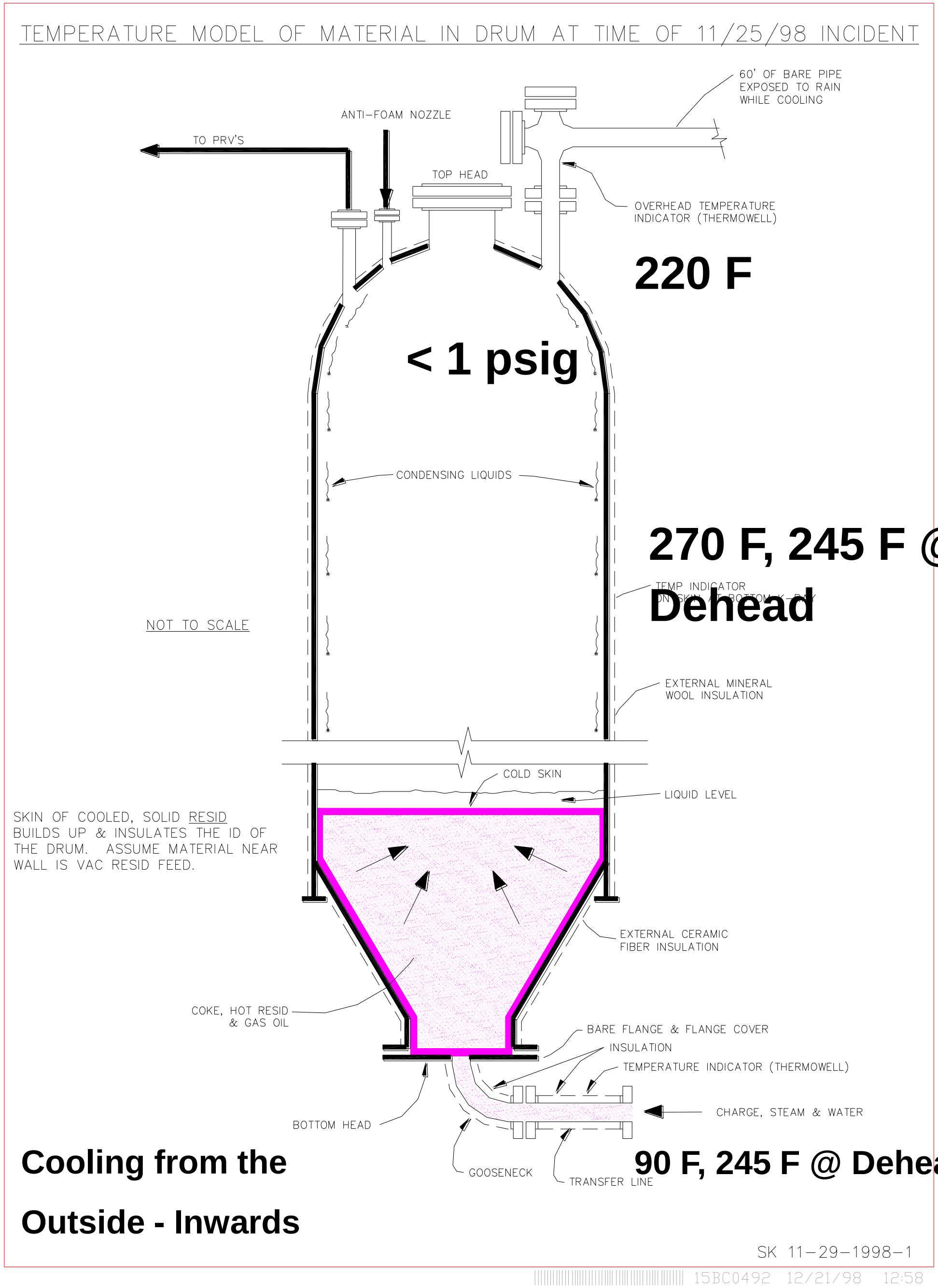
Summary of Equilon DCU Incident

Contributing Factors – Process Only

- **Total Loss of Power Steam with Transfer Line Plugging.**
  - CoGen down due to loss of main power line to west side of refinery,
- **Bottom Flange, Cone, Feed Piping Cool To Touch**
  - Insulating Crust – "R" factor same as mineral wool & TI's do not measure bulk thermal mass
- **1996 Water Incident on a Partial Drum**
  - Drum would not Drain & Difficulty in Removing Head
- **Cooled "Gooey Tar Balls" Removed in the Past**
  - Much less Feed and Drums Steamed & Cooled

Investigation: Summary – What Happened?

Morning of Incident –
All temperatures appeared to be decreasing, indicating" that the drum was cooling.



220 F

< 1 psig

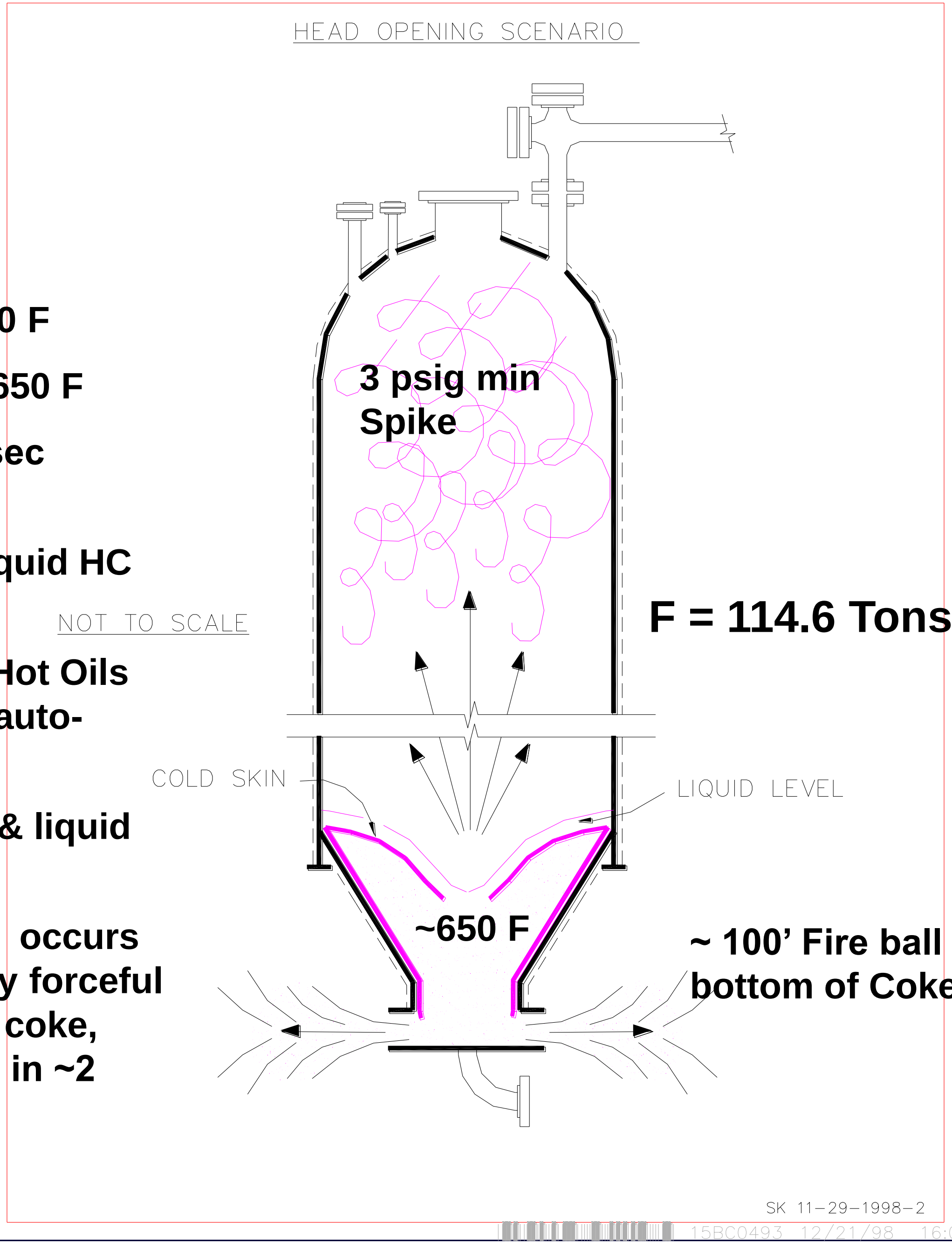
270 F, 245 F @ Dehead

90 F, 245 F @ Dehead due to steaming attempt

Cooling from the Outside - Inwards

Investigation: Summary - What Happened?

- ~4”
- 1,100 BBLS - center at ~650 F
- VISC = similar to water @ 650 F
- Head = 20’ or 8.5 psig = 6 sec gravity flow of total amount.
- Min ~300 gals of H_2O + Liquid HC was pooled on top of Crust
- Lowered Head – Tar, then Hot Oils begin Flowing out drum and auto-ignite.
- Crust on top of mass fails & liquid on crust falls to hot center.
- Rapid Expansion of Liquid occurs with ensuing fire ball and very forceful expulsion of partially formed coke, residuum, & gas oils - out 75’ in ~2 secs, in all directions.



F = 114.6 Tons

~ 100’ Fire ball emitted from bottom of Coke Drum.

Investigation: Summary

- What happened - What went wrong -

- **~4" thick Crust**
- **1,100 BBLS - Center of Mass at ~650 F**
- **Viscosity = similar to Water, since Mass was at 650 F**
- **Head = 20 Ft or 8.5 psig = 6 Sec Gravity Flow of Total Amount.**
- **Min ~300 gals of H_2O + Liquid HC was pooled on top of Crust**
- **Lowered Head– Tar, then Hot Oils begin Flowing out Drum and auto-ignited.**
- **Crust on top of mass fails & liquid on crust falls to hot center.**
- **Rapid Expansion of Liquid occurs with ensuing fire ball and very forceful expulsion of partially formed coke, residuum, & gas oils - out 75 to 100' in ~2 Seconds, in all directions.**

Investigation Findings

- There were no pressure vessel or piping integrity failures found.
- Procedures were in place for normal, routine operations of Coke Drums.
- There was a loss of steam and subsequent plugging of the coke drum charge line. No ability to steam strip and cool the drum normally.
- The effective insulating layer of cooled residuum and coke on the wall and bottom head did not provide operators with indications of the hot liquid center
- The temperature indicators on the coke drums would not indicate temperature in the central mass of the drum. They do not measure bulk temperature
- In cases where a partially charged drum has occurred, along with the loss of steam, care must be taken relative to water addition to the coke drum. <u>Rapid flashing of steam can be extremely hazardous</u>
- The fire resulted from auto-ignition of the hot drum contents emptying from the bottom head during Deheading.
- The team's opinion was that egress was probably not an issue in this particular incident because of the rapid nature of the release.

Investigation Findings (cont)

- \- In the case of significant DCU events, review by both Operations and Technical Personnel is necessary. If normal procedures do not apply, specific written plans and procedures are required. Call for help! Involve Everyone.
- Conduct a study of options such as alternate steam sources, other purge media, to keep the transfer lines clear in the event of power or steam outages!
  - We reviewed and selected the most reliable utility in the Plant – Natural Gas. Works great and has been used many times at our locations since 1999.
- Revise drum Deheading and cart Tugger controls to a more remote location.
- Develop tools such as a predictive model for coke drum internal temperature that operators can use in the case of changes from normal drum cycles.
- Continue to involve WPSI (Coke Contractor) personnel in significant events involving drum Deheading. Communications: MOC's
- Review all DCU Operating procedures and compete a pre-start up safety review prior to re-starting the unit. Review the existing Hazop study and address any open items.

Summary of Equilon Incident
- Learning and Training -

- Fundamental – Heat Transfer
- Fundamental – Force, F = psig X Area (Sq In)
- Fundamental – “Roll Over” Phenomena rapid vaporization 1,020 Gal = 75 PSIG; Drum damage
- Coking Fundamental Review – Coke Formation
- Procedure Development – Technical Reviews proper Tech Expertise, Warnings/Cautions
- Changing Existing Procedures
- Incident Database to Support the above

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Learnings

Fundamentals:

- **Heat Transfer: Steaming and cooling the drum is the practice and teaching in the Industry, however, the fundamental knowledge of the heat transfer during Drum cooling may not be well understood by all operators**

- **Heat loss from a hot Coke Drum allowed to just sit and cool by thermal and surface conductivity would take months due to the insulating properties of residuum and coke. (Per WA State L&I – 236 Days)**

- **If it is a short drum with a concern about draining, then it can be pumped out the top. Drums must be cooled!**

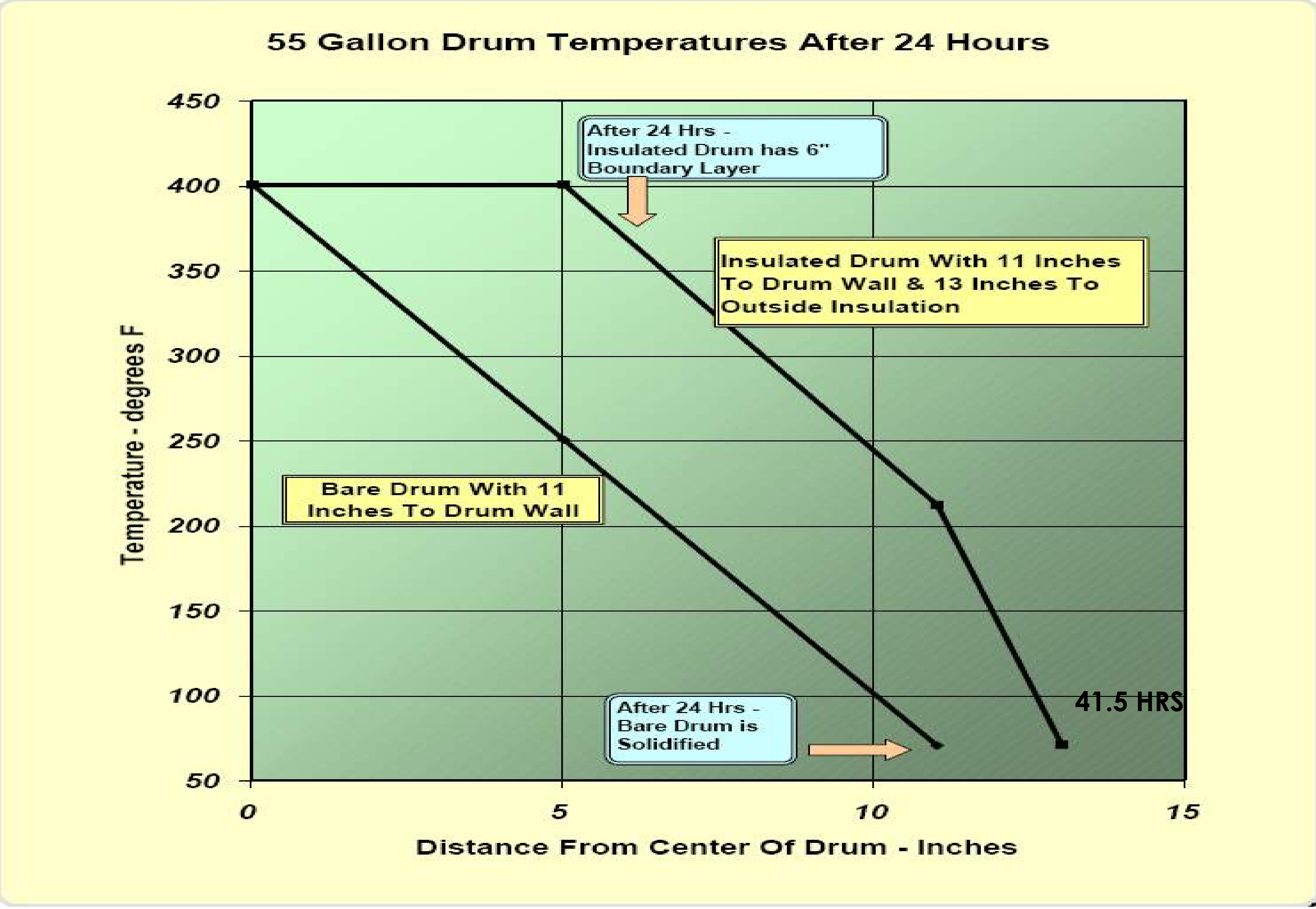
- **Past Unit Examples: Normal Coke Drum hot spots; Heater Tube Coking; Residuum Shell & Tube Coolers and Cooling Box buttering.**

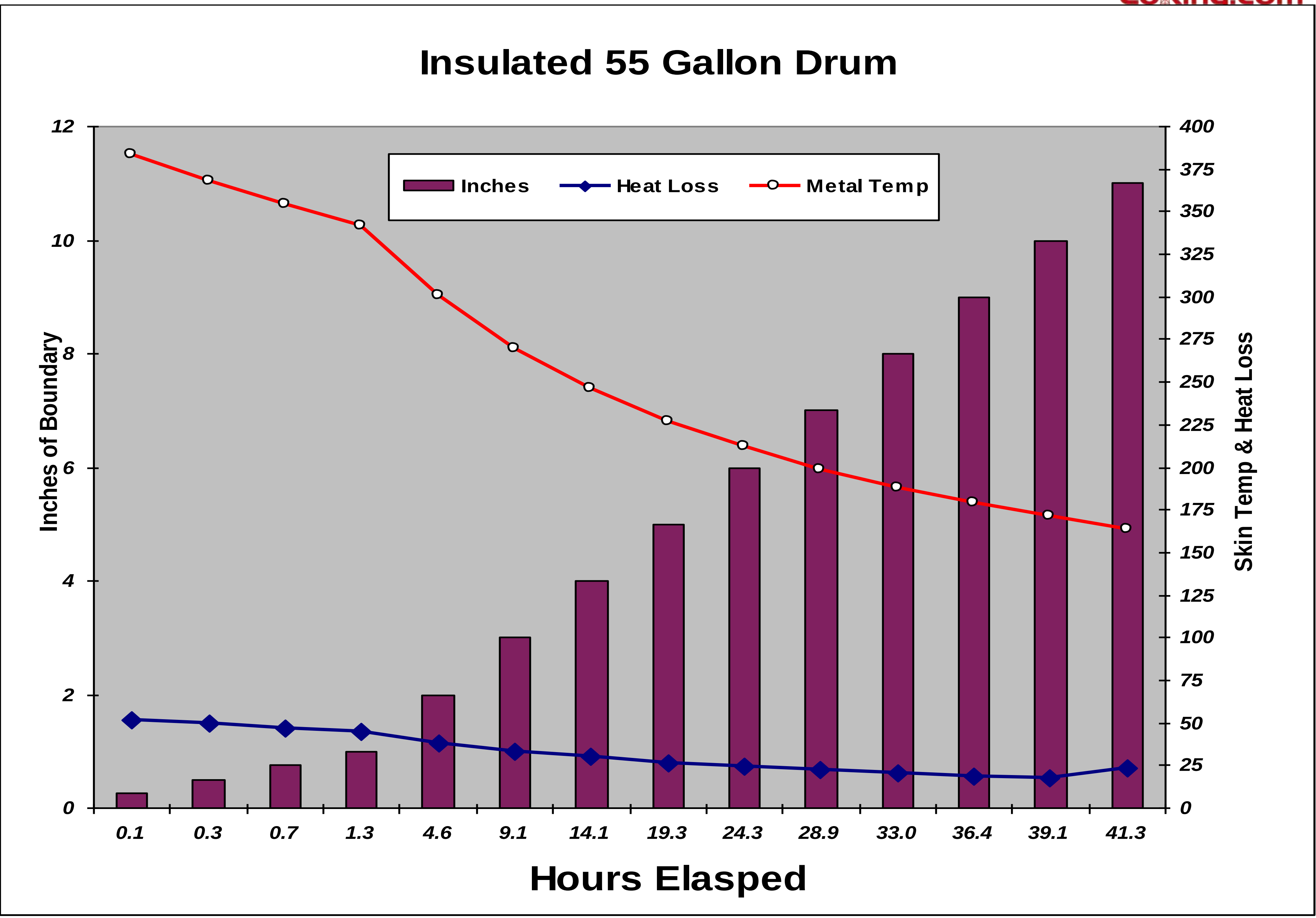
- **Past Plant Examples: FCCU Spent Cat Hopper, SRU Sulfur Beds, HTU & CRU Rx's – all very hot, take long to cool - same heat transfer principles**

- **Coker Fundamental Review of Coke Bed formation and Quench Water flow in to the Drum – review "channeling"**

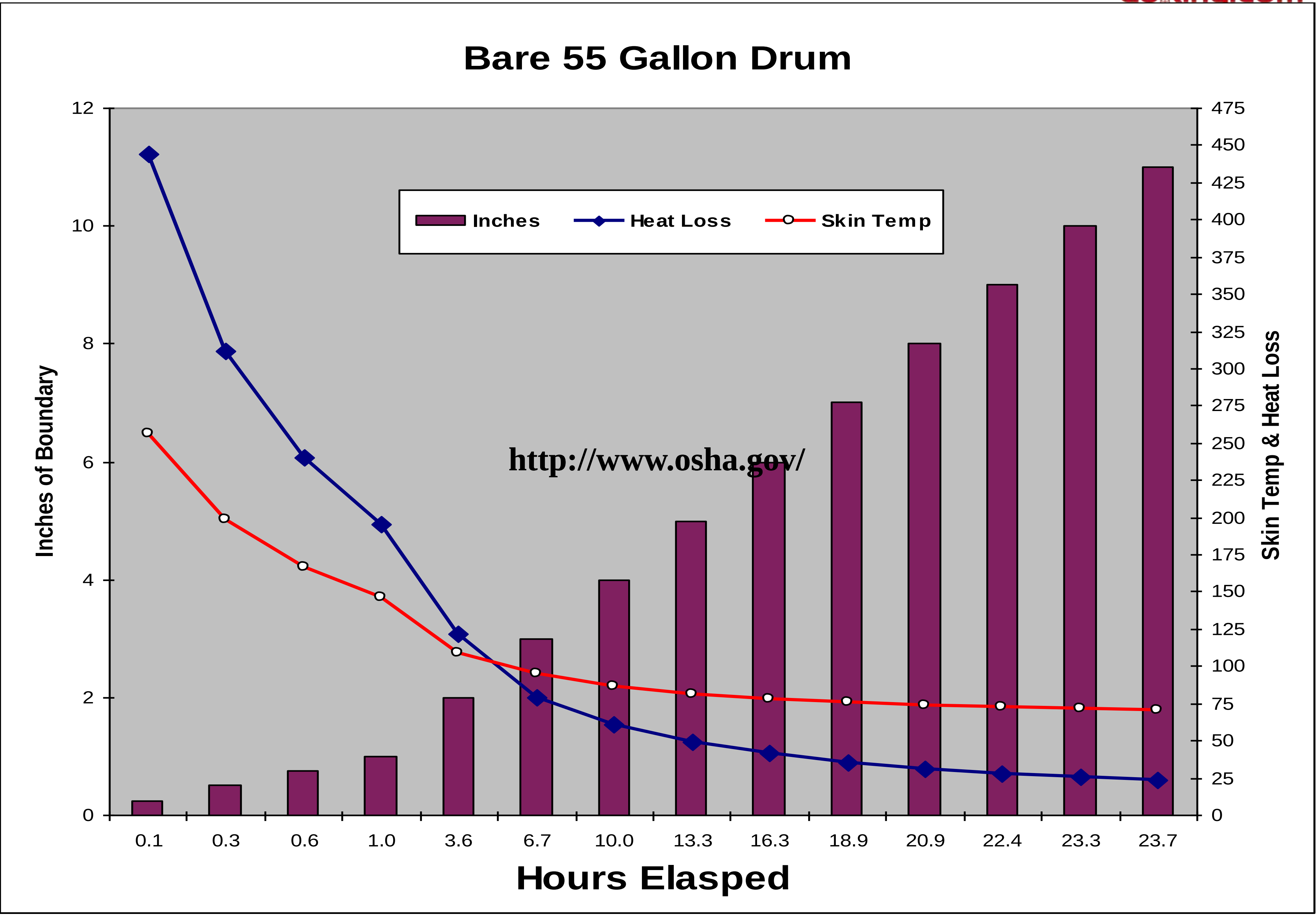
- **"Roll-Over" Phenomenon During Tar Drum Cooling is a big concern review mitigations when quenching from the Top.**

Heat Transfer Problem





Insulated 55 Gallon Drum
Inches
Heat Loss
Metal Temp
Inches of Boundary
Skin Temp & Heat Loss
12
10
8
6
4
2
0
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
0.1
0.3
0.7
1.3
4.6
9.1
14.1
19.3
24.3
28.9
33.0
36.4
39.1
41.3
Hours Elasped


Bare 55 Gallon Drum
Inches
Heat Loss
Skin Temp
http://www.osha.gov/
Inches of Boundary
Skin Temp & Heat Loss
0
2
4
6
8
10
12
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
0.1
0.3
0.6
1.0
3.6
6.7
10.0
13.3
16.3
18.9
20.9
22.4
23.3
23.7
Hours Elasped

Next Step: Coker Safety Technology

Equilon 1999 DCU Safety & Reliability Study

Study included 8 units - **PSR, MR, LAR, BKR, EDR, DPR, PAR, NR. BAR in 2006**
The Study Team = 3 Technologists/Managers from Shell WTC, 4 Ops from Operating Units including Brent & Tom!

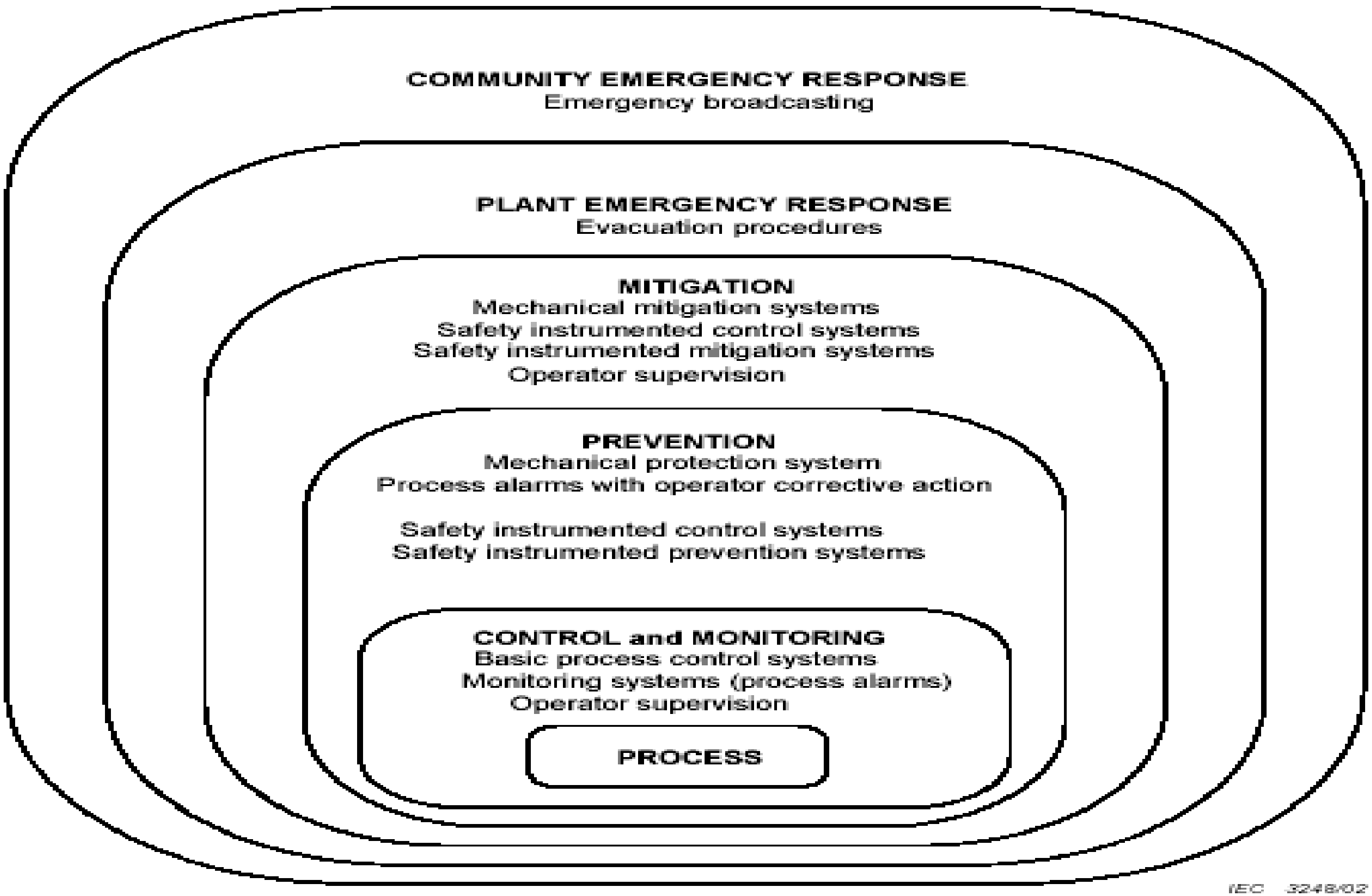
-Typical Study Recommendations for implementation

- **Facilities (23)**
- **Base Level Practices (50)**
- **Written Procedures for Normal Operation (20)**
- **Written Procedures for Emergency Situations (20)**
- **Successful Practices (40)**
- **Site Specific Recommendations (50-100)**

**** Note- numbers are average recommendations made for each plant.***

Coker DCU Safety Study Methodology

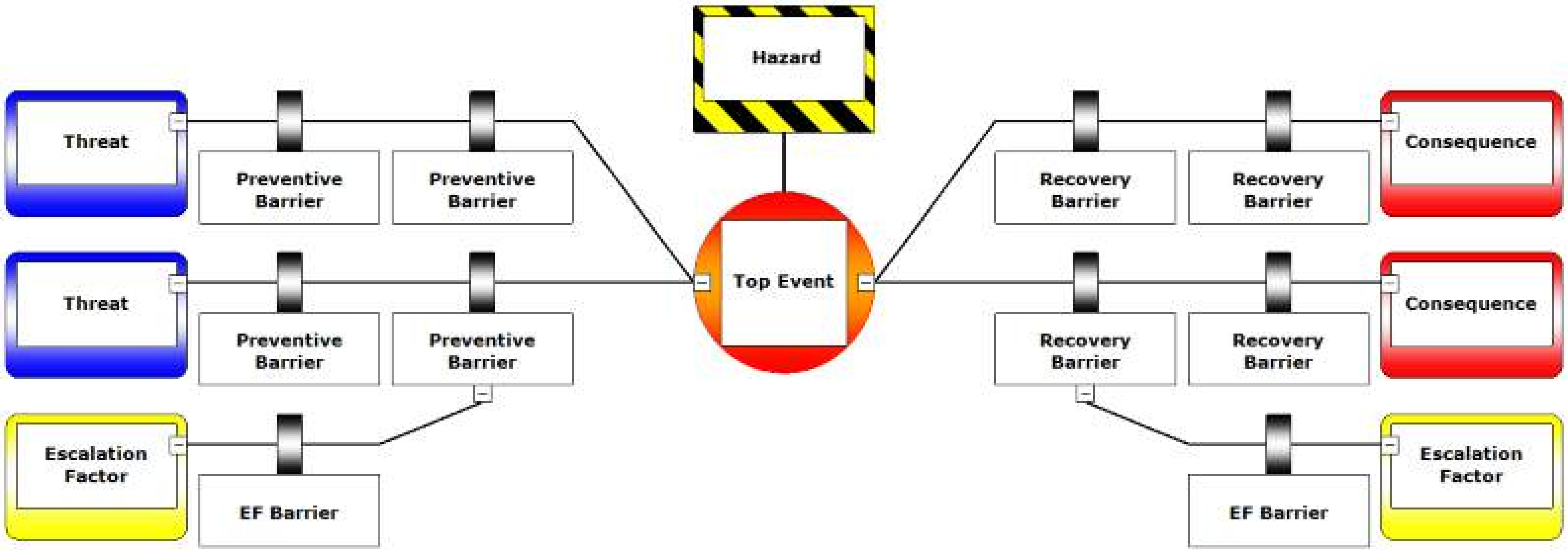
LOPA (Layers of Protection Analysis)



Developed by Shell's Arthur Woltman in 1993 with the AIChE Center for Chemical Process Safety

Coker DCU Safety Study Methodology

Model Bowtie done for units Pre-implementation after 2006



PSR DCU 2011 Safety Project Training

Delayed Coking Model Bowtie

- ❑ Original Model Bowtie was developed in 2009 at WTC
- ❑ Several Reviews done in US and AMS.
- ❑ Used for several large projects – BAR, PSR
- ❑ Did a verification at each DCU Location
  - Martinez review was done May 2011
  - Norco review was done in August 2011
  - Deer Park started needs to be completed as of 2012
  - Puget review of Project MBT completed in 2012
  - Buenos Aries MBT review to be completed in 2013
  - Port Arthur DCU-1 completed in 2012

Delayed Coking TDN Safety Score

23 Layers of Protection

- Vision –
No Person on the Structure!

Delayed Coker Safety Facilities

Refinery Locations

Coker Safety - Layer of Protection Item	Deer Park	Port Arthur	Norco	Los Angeles	Puget Sound	Martinez	Buenos Aires
Furnace PRV's	No, Risk Assessment completed.	yes	Yes.	yes	yes	yes	Yes
Alternate Emergency Egress Means	ramps	ramps	Chutes and ramp	Phase II - 2006	ramps	Chutes	Lateral staircase (apart from lift)
Fire Suppression	yes	yes	Yes.	Phase IV - 2009 T/A Project	yes	yes	Yes (FFW automatic system)
Deluge System	yes	yes	Yes.	Phase IV- 2009 T/A Project	yes	yes	No
Remote Bottom Unheading System	yes	yes	Planned Delta Valves in 2006	Yes, Delta	yes	yes	No
Remote Feed Line Opening (Grayloc Flanges or equivalent)	yes	yes	Planned Delta 2006- no need for Grayloc	Delta - no need for Grayloc	yes	yes	No
Automated Top Head Handler	Toilet seat, Electric motor	Toilet seat, pneumatic system	Toilet seat, hydraulic system	Phase III - Scheduled During Decoke	Toilet seat - hydraulic system	Toilet seat, electric motor	Yes (not fully automated)
Auto-centering device for top cover or/and drill bit and drill stem	yes	yes	Yes.	Phase III - Scheduled During Decoke	yes	yes	Manual centering device for drill bit and stem
Interlocks	yes	Yes - PRV's will be input in 2007	Yes.	Phase III - Scheduled During Decoke, & IV - 2009 T/A Project	Yes	yes	Partial
Feed line purge in case of steam failure	Risk Assessment Complete - Project for 2007 T/A	Yes(Natural Gas)	Yes (Nitrogen)	Phase IV - 2009 T/A Project	Yes (natural gas)	Yes (Secure steam supply)	No (only MPS as emergency fluid at furnace coils inlet)
All double blocked Isolation Valves	yes	Upgrade - 2007 T/A Project	yes	Yes	yes	yes	Double blocks only in quench line to drums
Blowdown Flow Meters	Yes	Yes	Kicked out of 2006 T/A	Yes	Yes	Yes	No
Blowdown Vapor Recovery	yes	yes	NO	Yes	yes	yes	Only on coker
Coke Cutting Shelters & Instrumentation	yes	yes	yes	Phase III - Scheduled During Decoke	yes	yes	On top, not totally enclosed
Combination tools	yes	yes	yes	yes	yes	yes	No
High pressure cutting hose chains	yes	yes	yes	yes	yes	yes	No
Drilling Stem Free-fall arrestors	yes	yes	NO	Phase IV - 2009 T/A Project	Yes	yes	No
Compressor Anti-surge system	yes	yes	yes	Yes	yes	yes	No compressor
Re-route vent discharges	yes	yes	yes	Yes	yes	yes	???
Programmed Antifoam Injection	yes	yes	No	Phase IV - 2009 T/A Project	yes	Manual	Manual
Add Coke Drum Vacuum Indicatior or dual range PI w/alarm.	Yes - Completed in 2005	yes	No - not big concern since we pressure out	Yes	Yes	Yes	Two PR's on top and bottom w/alarms
Programmed, Independent Quench System	yes	yes	yes	Phase IV - 2009 T/A Project	yes	yes	No
Isolate Power Distribution and Supply for MOV's (or equivalent means to prevent spontaneous movement of MOV's).	yes	Yes - MOV Buttons are pinned.Upgrade	No	Yes	Yes	yes	Yes, manual

Delayed Coking TDN Safety Score Card

DCU Incidents –

1.) Site and company Incidents – Analyze, RCA, 5-Why, etc.
Document and Train.

2.) Keeping Up with the Industry Incidents – Sharing as allowable.
Coking.com, CSB, OSHA, CCCP

Documenting and Benchmarking is Essential –

Coker Incidents (Worldwide)

Coking.com

➢ ***Observation*:**

- **Roughly 2 significant Coker incidents reported per year**
  - **List of incidents – Next**

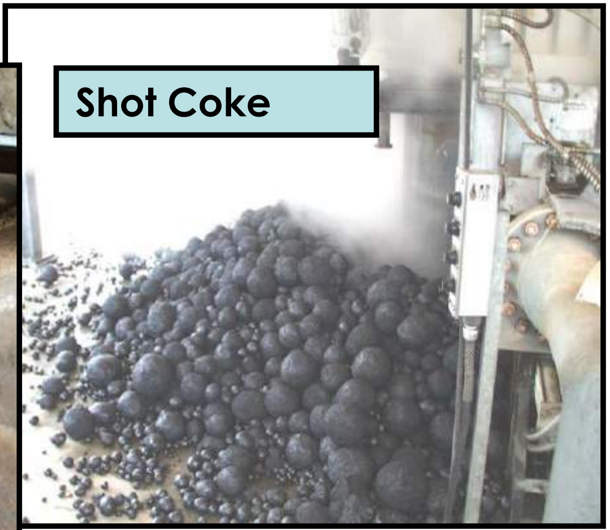
Delayed Coking Incidents

Improper Drum Isolation

PMI Failure

Tarry Drums

Coke Drum Cracking



Shot Coke

Drilling Incidents

Coking.com

Incident Photos

Hovensa, St Croix - 2004

Shell BKR - 2005

Exxon Baton Rouge - 1993

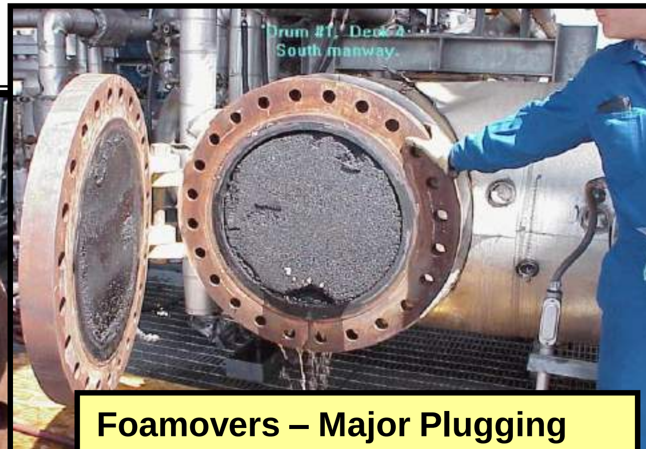
Tosco Carson - 2001

LCR Pasadena - 1999

Fundamental Process Challenges for Delayed Coking

- Coker Heater Outlet Lines
- Coke Drum Vapor Lines
- Coker Fractionator Coking

24" Coke Drum Vapor Line



Foamovers – Major Plugging

HCGO Draw Manway

Wash Oil Spray Header


PSR 2011 Delta Valve
2007 Safety Study Revisit at PSR
– Post 2005 Upgrade Project
Head lowered remotely - Since 2011
there are Slide Valves

2012 Delayed Coking Meeting at Motiva Port Arthur

Known Major DCU Incidents in past 19 Years (as of 2012)

- **Exxon Baton Rouge – 1993 – Three Fatalities - Six inch Heater Inlet elbow, Carbon Steel in 5 Chrome line. Loss of life and unit destroyed > $150 MM. PMI failure**
- **Citgo Corpus Cristi – 1994 - One Fatality - when In-Service Coke Drum was accidentally Deheaded. Loss of life and major unit damage.**
- **Chicago Area Refinery – 1995 – One Fatality - from resulting fire when contractor pulled out thermowell on heater outlet. Loss of life destroyed Heater.**
- **US Refinery - 1997 – One Fatality - when In-Service Coke Drum was accidentally deheaded. Loss of life and major equipment damage.**
- **Equilon Puget Sound - 1998 - Six Fatalities - Opened Bottom Head on Uncoked Hot Tarry drum. Loss of life with Major Fire >$100 MM Training, Procedures, Tech Support.**
- **Conoco Lake Charles - 1999 – One Fatality - resulted from welding on top of Coke Drum when vapor released caused flash fire. Improper Drum Isolation,valve leakage. Loss of life and equipment damage.**
- **Amoco Whiting - 2000 – One Fatality - caused by Drill stem retraction from the Coke Drum during cutting- interlocks bypassed. Loss of Life and Major damage to unit.**

Known Major DCU Incidents in past 19 Years (as of 2012) (cont.)

- **VEBA (BP) Gelsenkirchen, Germany - 2001 – One Fatality - when Operator was fatally scalded following the removal of the Top Head. Coke Drum eruption of scalding Hot Water and Coke. Close proximity of employees to Coke Drum. Loss of Life.**
- **Chevron Pascougoula – 2002 - One Fatality - resulted from a Contractor being severely scalded with hot water and coke while working near the coke pit during the Coke Drum Cut. Loss of Life.**
- **Coffeyville Resources – 2004 - One Fatality - when Operator was fatally scalded at the Top Cutting Deck during the drum cut. Coke Drum eruption of scalding Hot Water and Coke. Close proximity of employees to Coke Drum. Loss of Life.**

Turnaround Incidents

- **Motiva Port Arthur – 1998 – One Fatality - resulted from a contractor fall during Turnaround in the DCU Cooling Tower. Loss of Life.**
- **Chevron Pascougoula – 2003 Two Fatalities – during DCU Turnaround Construction, Coke Drum change out, from a Contractor fall from extreme height and a dropped Crane load. Loss of Life, equipment damage.**

Continued Running Incidents

- **Repsol Argentina – 2007 - Two Fatalities – during Bottom Deheading.**
- **Mexico City Pemex – 2008 - One Fatality – during Deheading.**
- **ExxonMobil Torrance – 2009 One Fatality – during Bottom Deheading. Operator Supervisor hit with Hot water when Bottom Head was dropped. 80% burns.**

Known Major DCU Incidents in past 19 Years (as of 2012) (cont.)

- **Resol La Coruna Spain – 2010 – <u>One Fatality</u> - Flash Fire, two seriously burned with one fatality – Drill Stem welding above Open Coke Drum which still had partial Coke Bed. Gas evolved from Coke Bed - investigation revealed all valves were holding.**
- **Holly Tulsa – 2010 - <u>One Very Serious Injury</u> - Hot water out of bottom head hit Coke crew with one sustaining burns over 70%.**

- **25 Total Lives Lost**

Keeping up with Technology Changes - Training Personnel at Sites – Staff, Engineering, Process and Operations.

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Impacts of the Incident and Safety Study

Huge impact on the Industry - led to the development of the Slide Valve Deheading system

Slide Valve Deheading Systems

- ❑ **Chevron and Delta Valve installed first one on the bottom of a coke drum in 2001 at Chevron Salt Lake**

1st Installation of Delta Valves at Shell Los Angeles in 2004 – 4 drums - Bottom
2nd at Motiva Norco – 2006 – 2 Drums, Bottom installed in 2006
3rd at Shell Deer Park – 2007 all 6 Drums – Bottom; Top installed in 2014
4th at Shell Martinez – 2009 – 2 Drums – Bottom, then Top in 2014
5th at Buenos Aries – 2010 – 2 Drums – Top and Bottom
6th at Shell Puget Sound – 2011 – 2 Drums – Top and Bottom
7th at Motiva Port Arthur – 2012 – 6 Drums – Top and Bottom – Zimmerman & Jansen

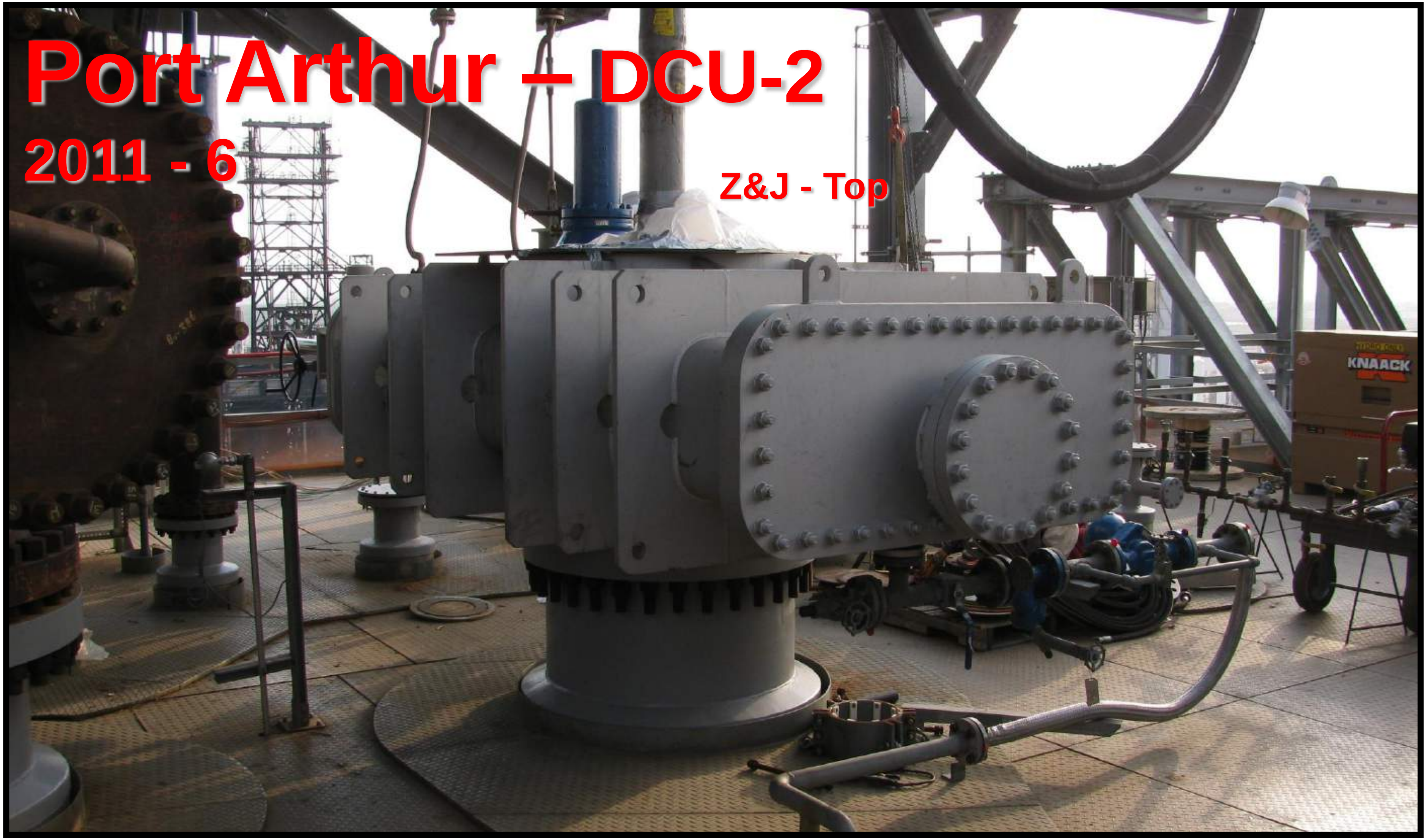
Remote Coke Cutting -
1st Shell Buenos Aries 2010
2nd Shell Puget Sound 2011
3rd Motiva Port Arthur 2012

What about Process/Ops Changes to mitigate?

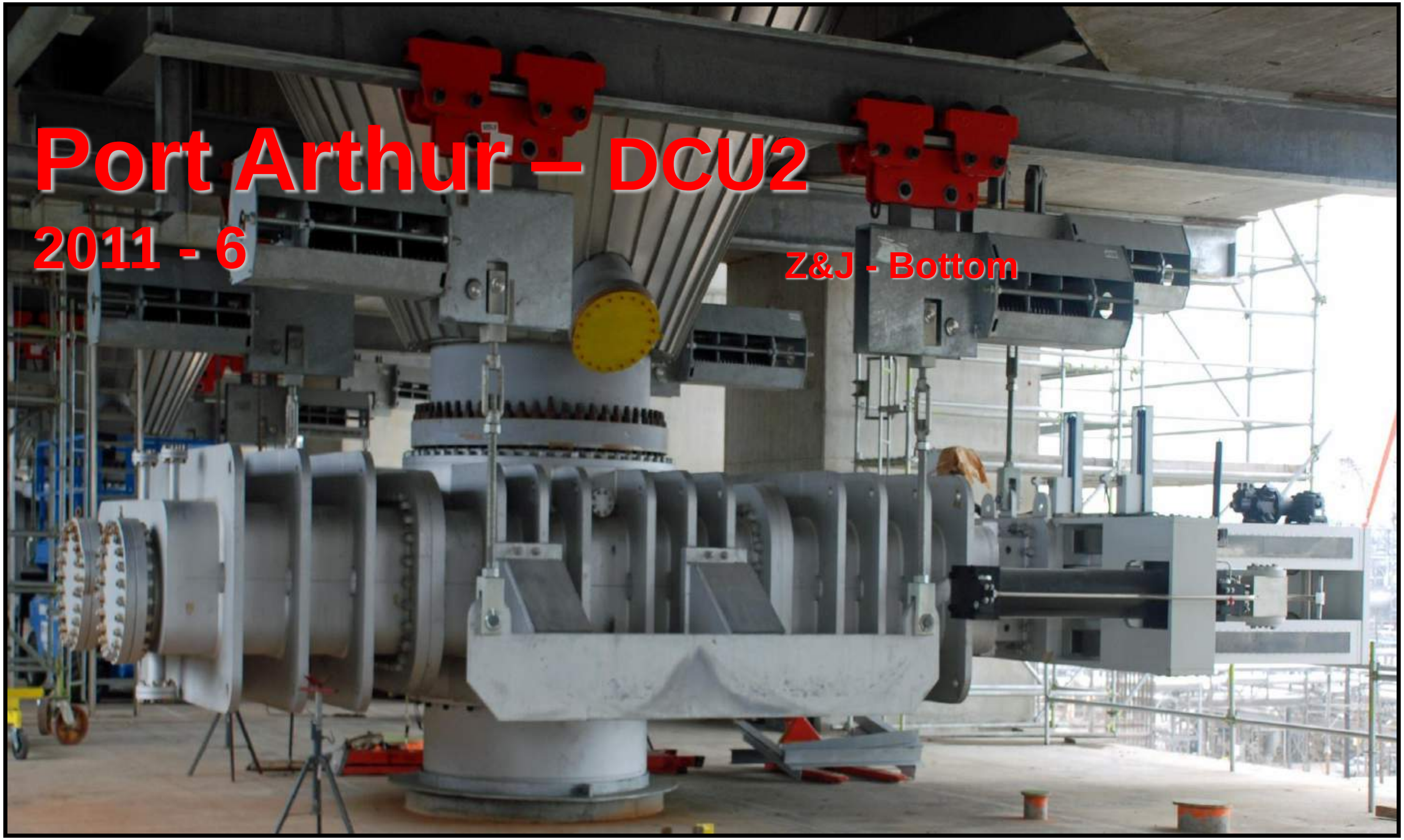
Procedures have been Developed in the Industry and within Shell to help mitigate Tarry Drums -

- Water Quench using BTU Balance method – Issues can be Rollover from Water Flashing. Tar in the Chute and Pit and even Crusher – one location asphalted their Pit losing ½ the volume! Also – results in high VCM
  Coke so must be sold as Fuel or if very high must be disposed of.
- Superheated Baking or "Cooking" of the Bed - requires the use of the Heater so unit is taken out of Circulation – 900 F steam injected into the Coke Drum until top temp lines out. PAR did this in late 2012 and has done so since – produces on-test coke. Also used procedure for Whole Heater Spalling. Possible Option - run DCU Superheated steam to Steam/Water manifold if available.
- Cutter Dilution Method - Put LCGO in the Top, antifoam carrier, and then mix with
  Steam. Drain to Coke Drum Warm Up Drum pump to Blowdown and recycle or to slop
- Decision Trees – decision what to do with a Tarry Drum and if you should Switch Back in
- or Proceed to Baking or other methods.
- Communications – Technical Operations Network with routine Telecoms and Annual Meetings.
- Training – Have routine DCU Training for all operators an Process

PSR DCU 2011 Safety Project Training

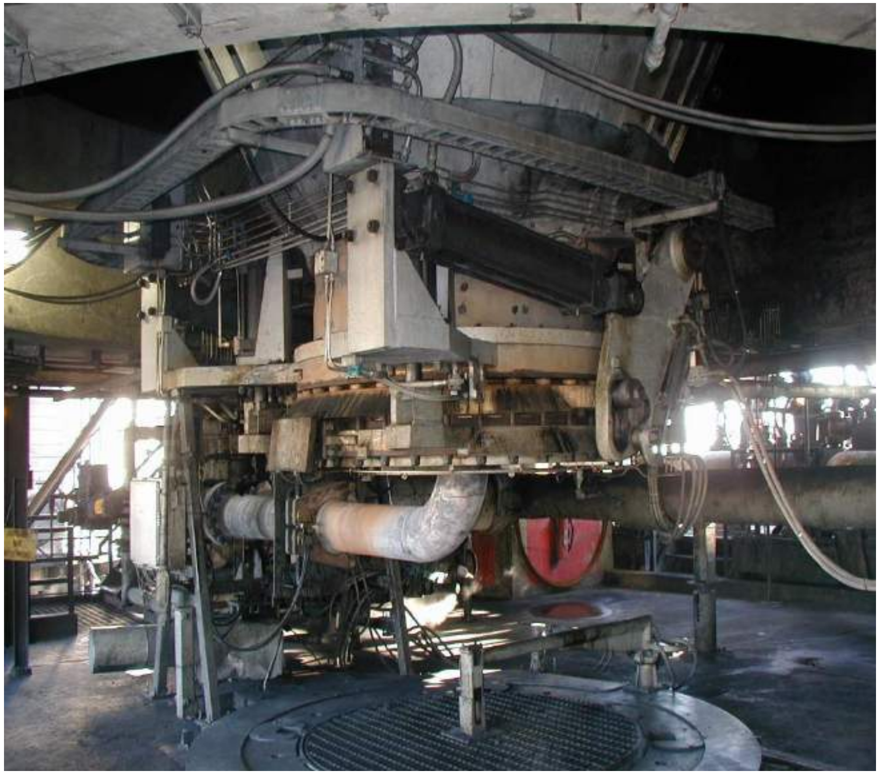


PSR DCU 2011 Safety Project Training



Installed Safety Facilities – Coke Drum Auto Deheading

"What we are doing to make it safe!"



Hahn & Clay with Grayloc

Delta Valves

Installed Safety Facilities – Coke Drum Remote Deheading

"What we are doing to make it safe!"

Remote Deheading at Grade

- Future -
Top Deheading
& Cutting from Remote Shelters

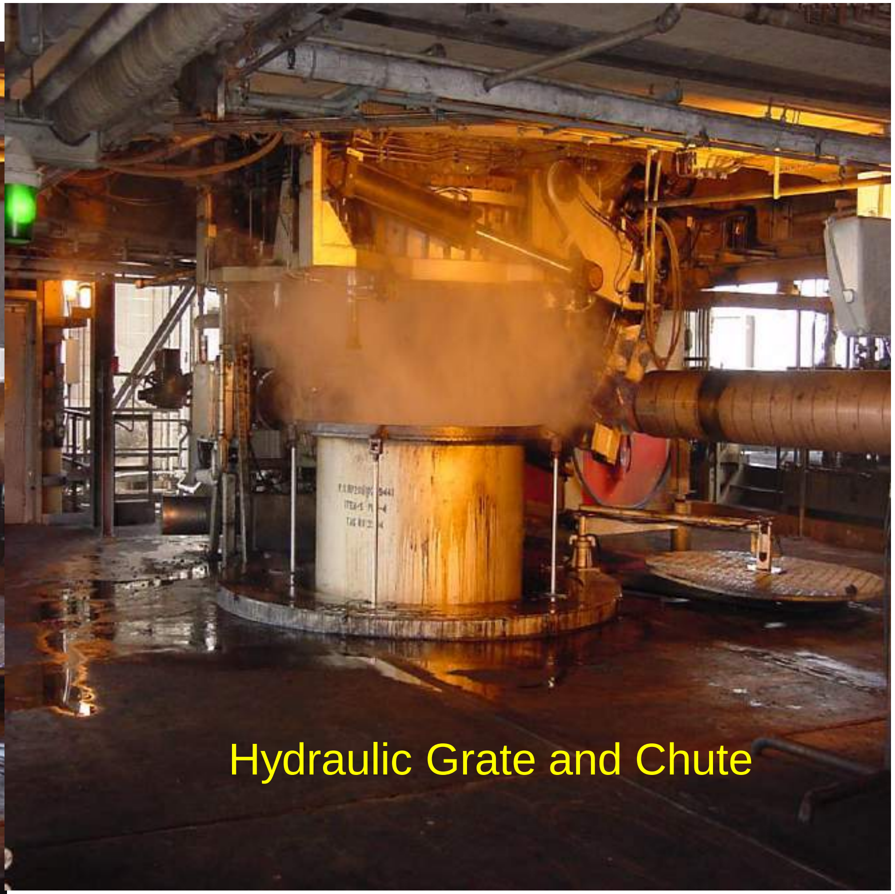
Installed Safety Facilities – Coke Drum Egress

"What we are doing to make it safe!"

Chute Entrance

Stairway Fire Shields

Implementation - Auto Bottom Deheading



Locations with the Hahn & Clay Swing Away System

Implementation - Auto Bottom Deheading

cont.

Two Locations had Hahn & Clay-Foster Wheeler Systems

These have been replaced with Delta Valves Bottom and Top

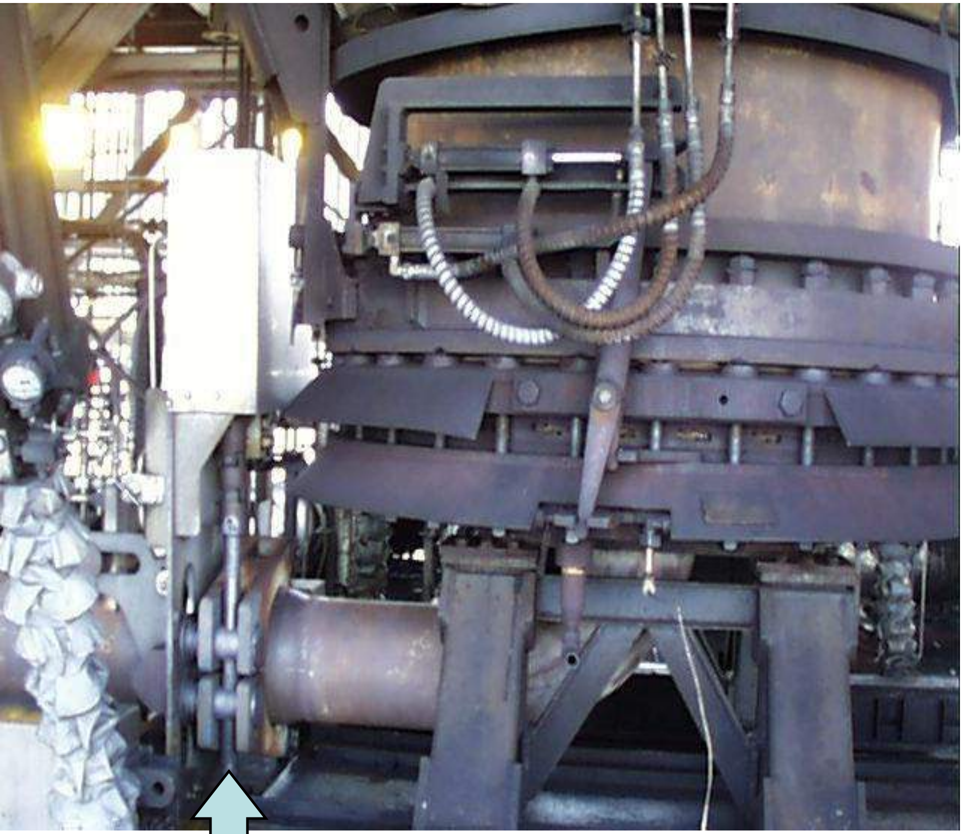
Implementation - Auto Bottom Deheading

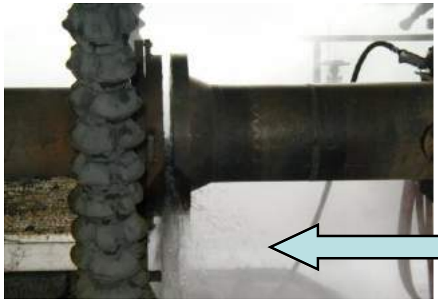
cont.

Our 1st Location to install Bottom Slide Valves in 2004

Others Followed

Implementation – Remote Feed Line



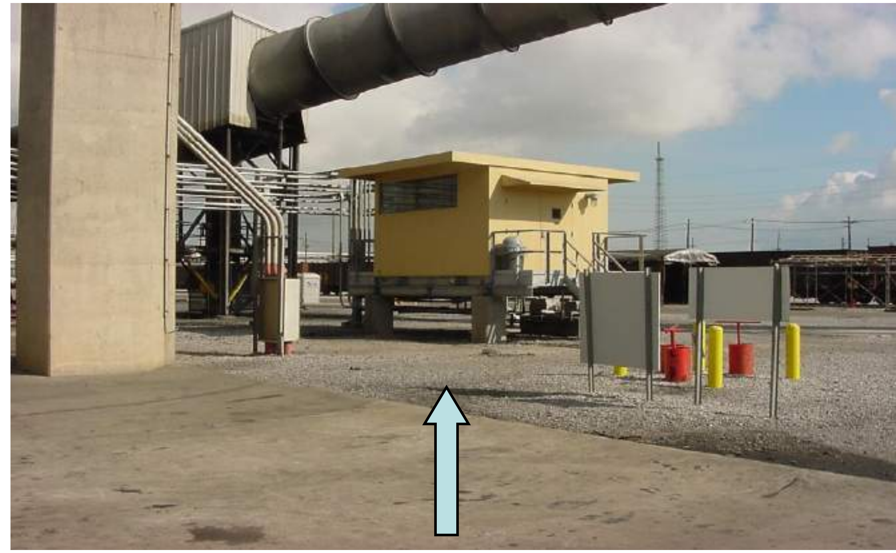


Why you need it!

Most Locations have Grayloc Flanges

Implementation - Remote Deheading

Remote On-Structure Location



Remote Off-Structure Locations

Structure Cameras – 2 Per Drum

Implementation - Remote Deheading cont.

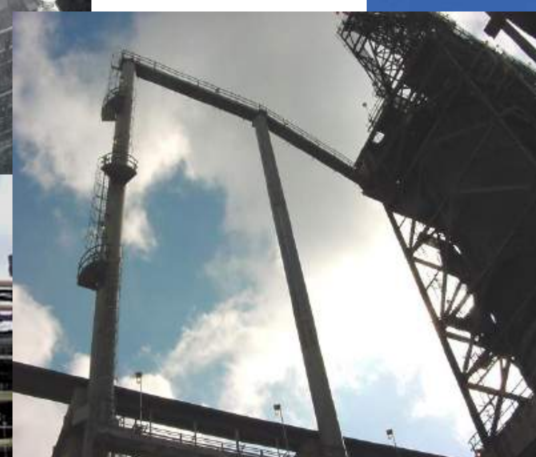
Remote Deheading Controls

Every Location has Remote Bottom Deheading

The Overall Structure must be Visible from Remote Shelter

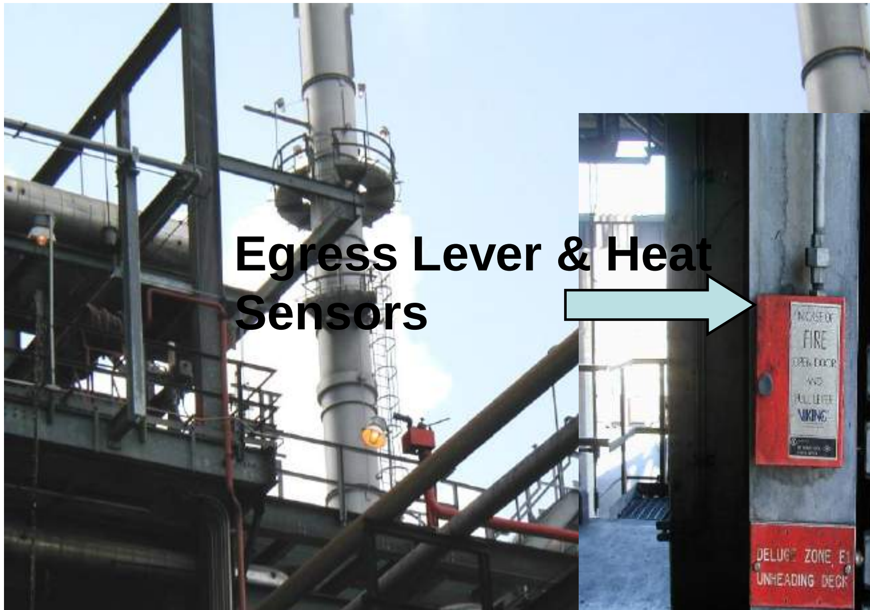
Implementation - Emergency Egress

- Baker Life-Chute™ with steel cable
- Egress "ramps" to self standing Stairway Towers or Ladder Cages
- Fire Shielded Stairways to Grade
- Egress Water Deluge to assist personnel at egress pathways
- Egress "runways" over crane rails

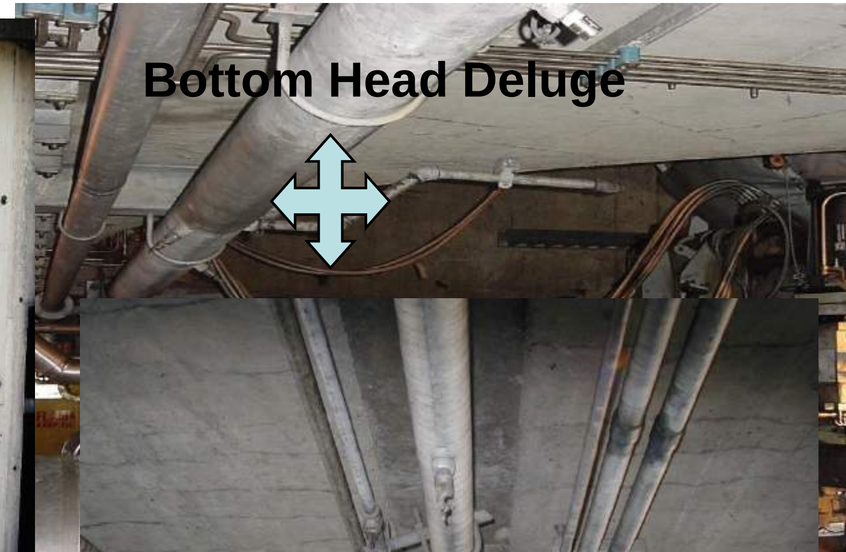


Fire Walls

Implementation - Fire Protection & Deluge



Egress Lever & Heat Sensors



Bottom Head Deluge

Extra Reciprocating Monitors

Entire Structure Deluge - Testing

Shelter must have Safety Equipment including Several SCBA's or 5 min Escape Packs

Monitoring of Pit from Within

Camera Monitoring Pit

Moving Away from This – No Shelter!

Looking at Fresh Air Supply to Shelter & Remote Top Deheading and Cutting

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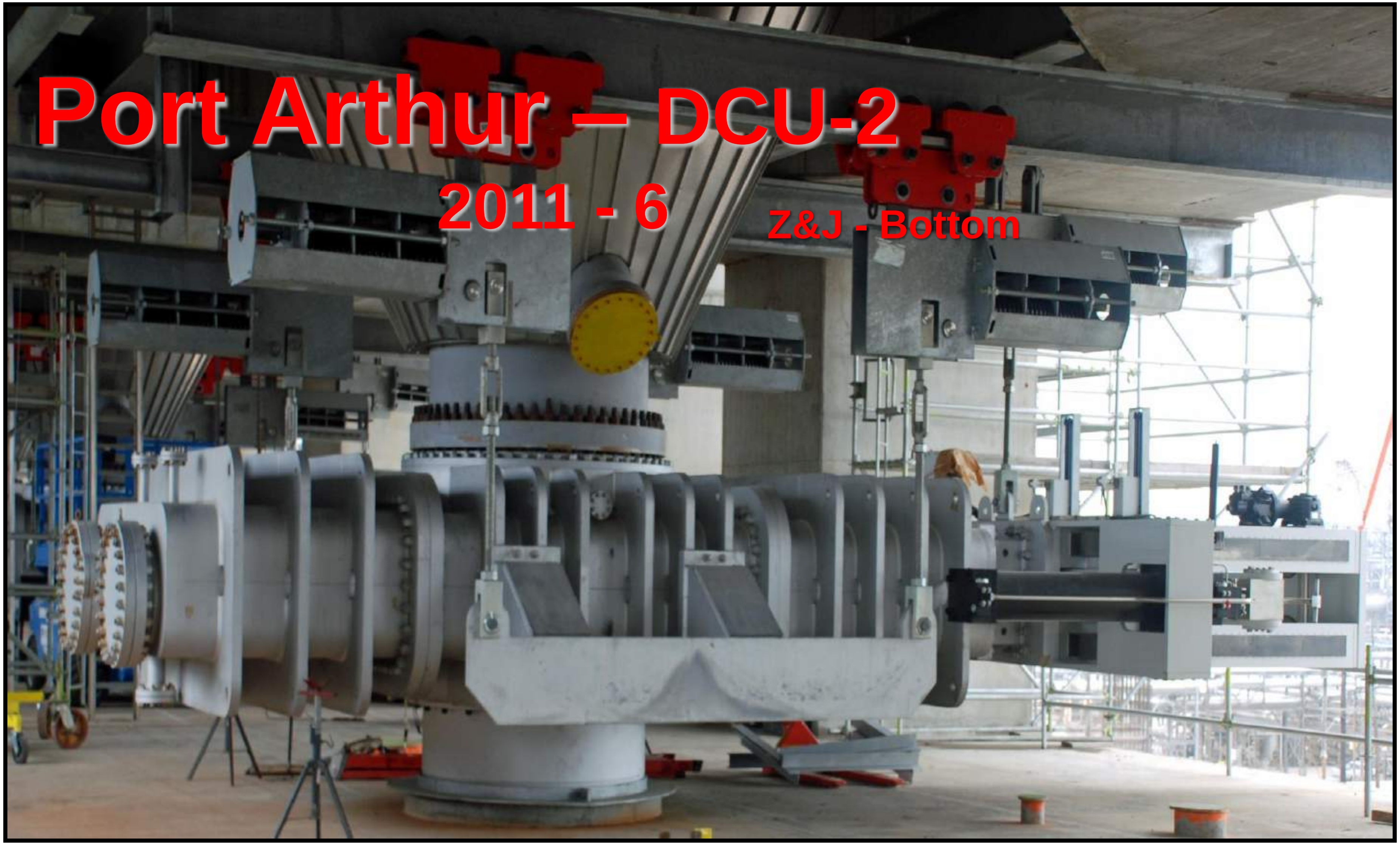
Implementation – Coke Drilling Safety – Drill Stem Interlocks & Free Fall Arrestors

Moving Away from Structure Incidents!

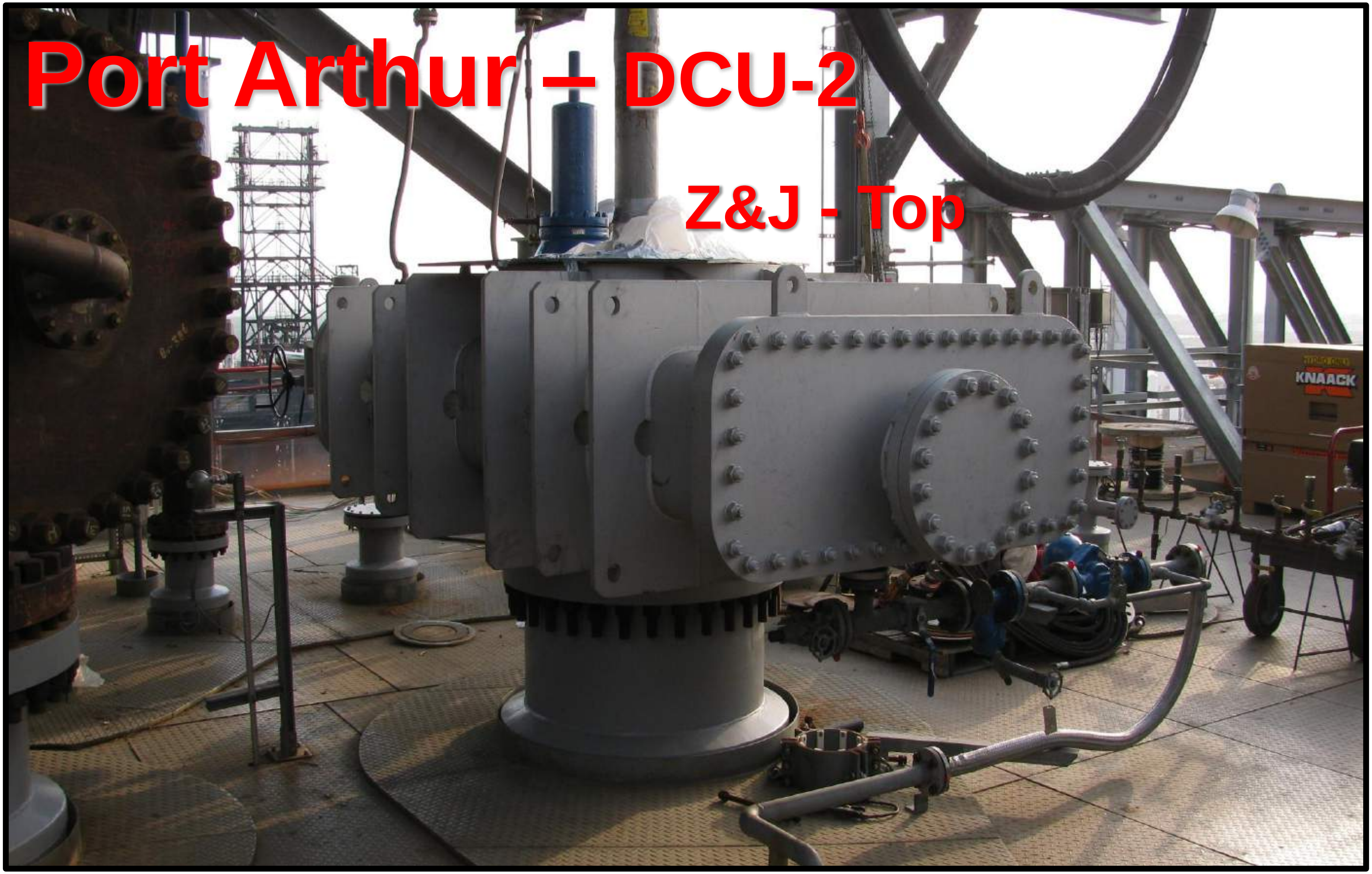
Free Fall Arrestors and Proper Inspection & Maintenance

Shell DCU 2011 Safety Project Training

Shell DCU Safety Project Training



Shell DCU 2011 Safety Project Training



Shell DCU 2011 Safety Project Training

Shell DCU Safety Project Training

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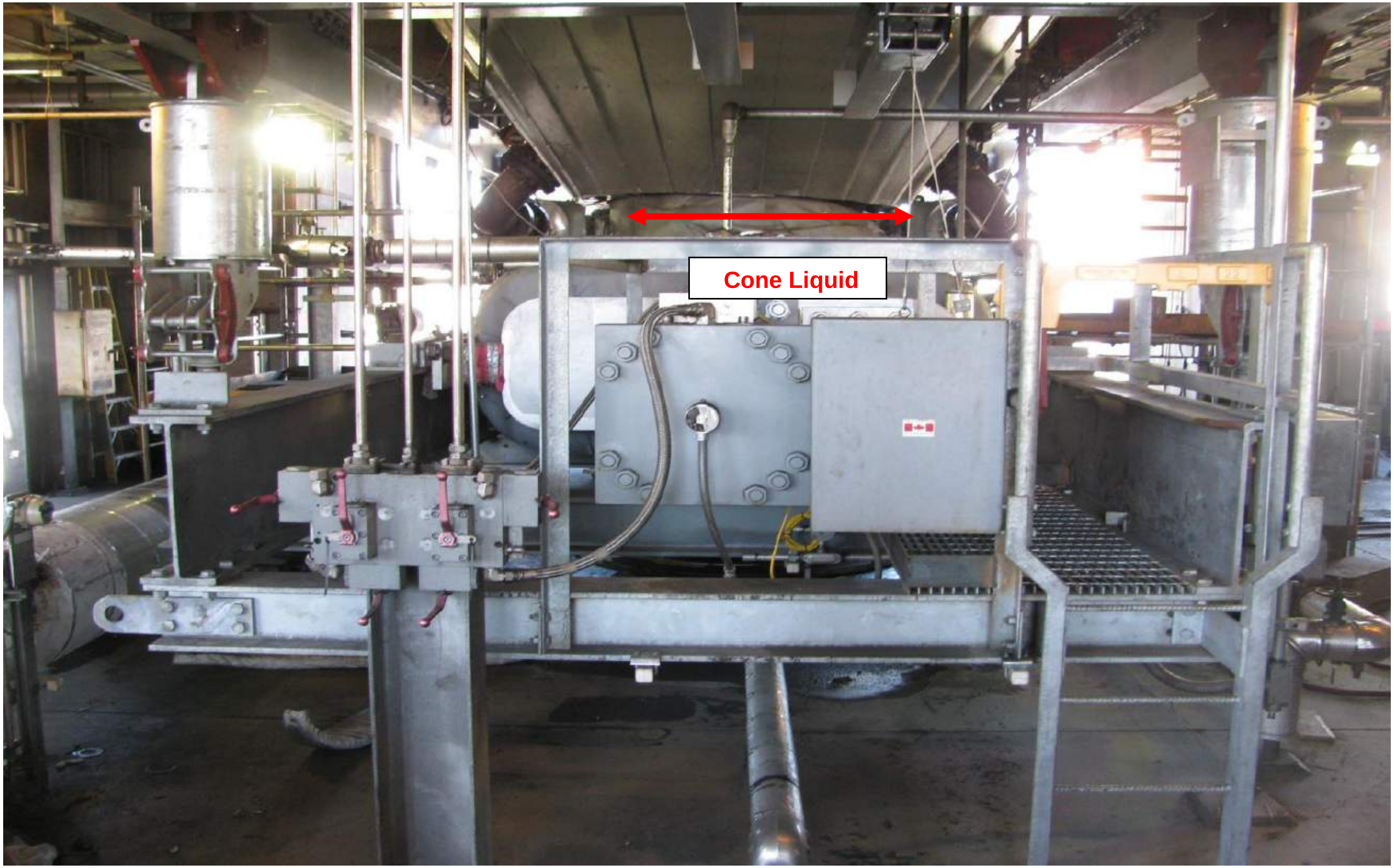

Shell Martinez – Martinez Dual Feed

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Implementation - Remote Top Deheading & Cutting

- The Vision -

- Out of Harms way during Dehead
- Out of Harms way during Cutting
- ✓ No Blowout & Boil Over Injuries - No Exposure

➢ **Project: Complete Remote Top Deheading & Cutting**

- **Camera's on Top Deck**
  - **Run Controls to Grade to Remote Bottom Deheading Shelter - BRM**
    - **Completed in 2011**

Coker Safety Conclusions

- Coker Safety First!

- Safety is a continuous process – 'Stay Up with the Evolving Technology!'

- Keep Pushing and Following Up

Coker Safety Technology

1. Data Collection and Benchmarking
2. On Site Visit:
   - Interviews, Incident Discussions, and Field Observations, with Immediate Feedback on Areas of Concern and after action evaluation
   - Evaluation of Safety in Coker areas
   - Risk Assessment for each event/facility
   - Identification of Issues
   - Recommendations
3. Follow up on implementation

)

Delayed Coking Safety Facilities – 23 Original

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PSR has completed 22. The last item, Coke Cutting Instrumentation, will be completed during 2011 DCU Safety Project.

Delayed Coker Safety Facilities

1 To 23

Refinery Locations

	Coker Safety - Layer of Protection Item	Deer Park	Port Arthur - DCU-1	Norco	Puget Sound	Martinez	Buenos Aires	Port Arthur - DCU-2
1	Furnace PRV's	No, Risk Assesment completed.	Yes	Yes	Yes	Yes	Yes	Not required per design
2	Alternate Emergency Egress Means	Ramps	Ramps	Baker Life Chutes and Ramp	Ramps, Deluge Egress	Baker Life Chutes	Yes - RA Done	Ramps
3	Fire Suppression	Yes	Yes	Yes	Yes	Yes	Yes (FFW automatic system)	Yes Structure Fire Water System
4	Alternate Top Quench (Top Deluge, unheading & Cooling)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	Remote Bottom Unheading System	Yes: Upgrade to Delta Valves 2007	Yes - Hahn & Clay; Planned Upgrade to Delta Valve in 2017	Yes: Upgrade to Delta Valve in 2006	Yes: Upgrade to Delta Valve in 2011	Yes: Upgrade to Delta Valves in 2009	Yes: Upgrade to Delta Valve in 2010	Yes - Z&J Valves - 2011
	Remote Feed Line Opening		Yes - Grayloc Bottom		Yes 3-D Alignment -			

23 Safety Facilities from the original 1999 DCU Safety & Reliability Study. Tracked by the DCU TechNet TDN and TIN, as well as the HSSE Americas and Project Management at Sites and in Houston.

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Delayed Coking Best Practices - *Includes Updated Facilities*

PSR has completed 22 out of 27- 5 more under review or done as small projects

Delayed Coking Best Practices – 17 are additional Facilities

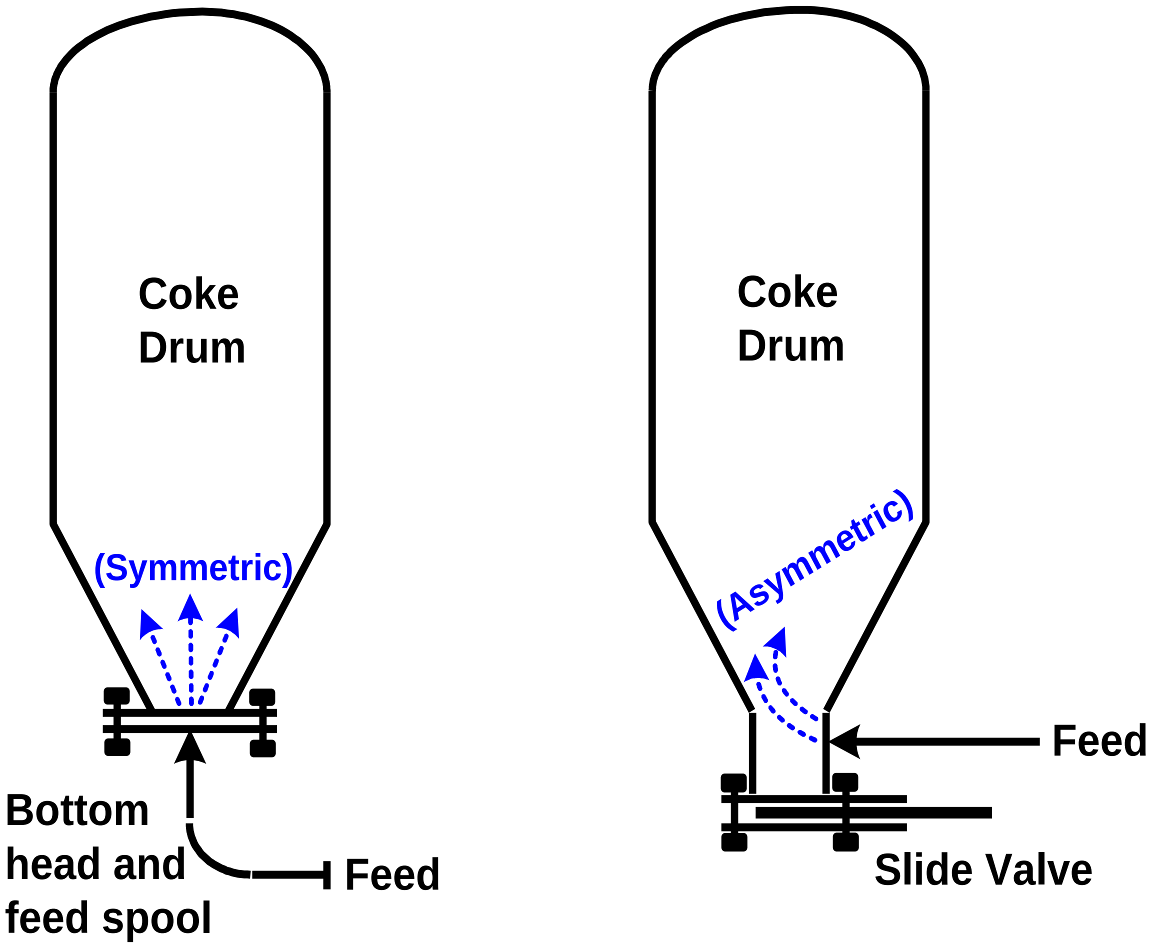
Coker Safety - Layer of Protection Item	Deer Park	Port Arthur DCU-1	Norco	Puget Sound	Martinez	Buenos Aires	Port Arthur DCU-2
1. Running lights at all decks (2nd, Vapor and top) to indicate the coke drum is in service.	NO	Indicating lights on switch and top deck.	2nd floor only	Yes, since mid 1990's	No	NO	Remote Operated Control Panels with Lights
2. Blowdown system sour water flow meters and totalizers.	Yes	Yes	total flow for SW, but not strictly for blowdown. However it is calculatable. OSE to provided procedure to	Project using Sonic Meters (Flexim)	Yes	Yes	Yes
3. Tack-welding of coke cutting nozzles. Flowserve Tools only.	Yes - Getting Delta Valve Auto Switch	Yes	Yes	Not Required on RP tools -Yes on Flowserve tools.	Yes, but we have had some break off.	Not Required on RP tools	Reviewing requirement for new Flowserve Tools
4. Monitor and plot delta P between drum and fractionator flash zone.	Yes, quarterly report and Radical	Yes	Yes	Yes - A DCU KPI	Yes	Yes	Proposed- a part of Proactive Process Monitoring
5. Antifoam certificate							Proposed - assume

27 Delayed Coking Best Practices developed from 2004 - 2011. Developed and tracked by the DCU TechNet, TDN and TIN, as well as Project Management at Sites and in Houston

Shell Delayed Coking Safety Meeting

Photograph of dust plume from a Hot Coke Drum within refinery limits. Study done; facilities installed and these no longer occur.

Shell Delayed Coking Safety Project Meeting



Prior design practice

Slide Valve + Single Point Side Feed

PSR DCU 2011 Safety Project Training

Safety Project Focus

Bottom Slide Valves – LAR, NR, DPR, MR, BAR, PSR, PAR CEP DCU2 PAR DCU-1 remaining

Top Slide Valves – BAR, PSR, PAR CEP DCU2. DPR and NR both have Projects >>> DCU Model Bowties DCU-1 and MR remaining

Dual Feed Inlet – MR, Buenos Aries, PSR, PAR CEP DCU-2 Dual Feed and Retractable Feed Inlet under review by others.

Interlocks – new or Upgrades, PSR, BAR, PAR-DCU1, others reviewing Basis Model Bow Tie.

Remote Coke Cutting – BAR, PSR, PAR CEP DCU-2

DCU IPF – New or Upgrades PAR, PSR, NR, BAR

Safety Facilities and Best Practice Facilities – all locations

Example – Coke Drum Levels: NBS plus Continuous Gamma at Top

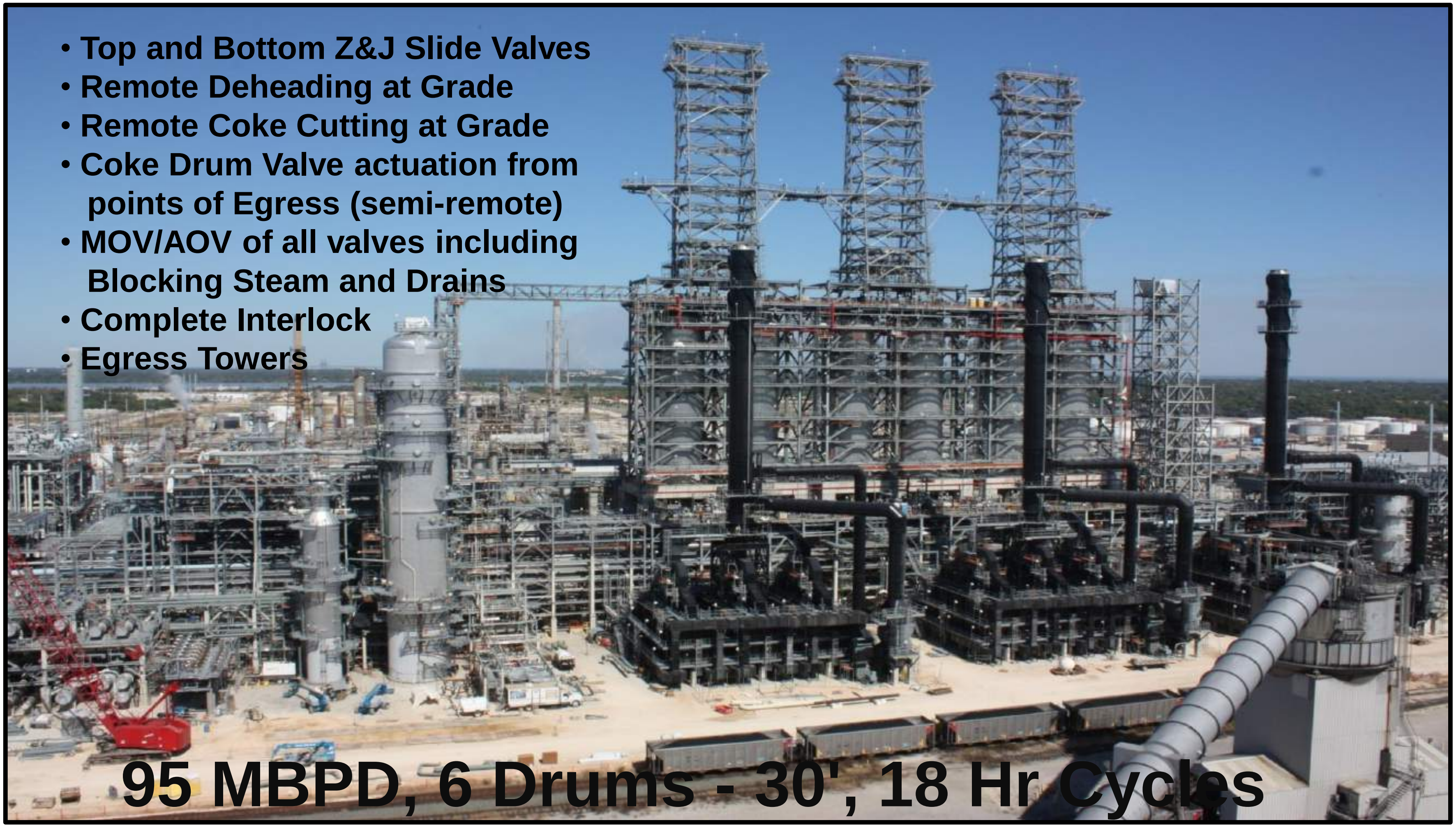
Other - Coflexip Decoking Hose – PAR, MR

Delta Valve Retractable Center Feed Device

Implementation – Other

Auto-Shift
Combo Tool

Motiva Port Arthur DCU2



Video Camera Views

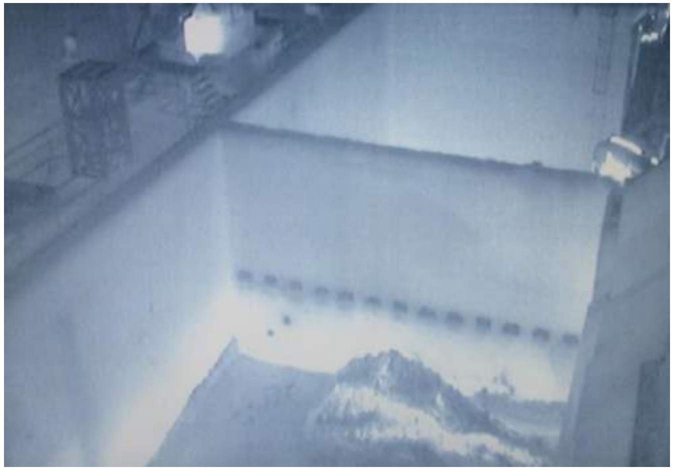
Coking.com

- September 2012

4-Square View

Chutes

Top Head View



IR / Thermal Camera – Pit and Maze

Key learnings & successful practices at PSR

Video is essential 'kit' for a coke handler. PSR requires a system which is reliable and will provide at least four views simultaneously.
(Open head, winch drum, chute, and crane location.)

The coke handling experience becomes increasingly visual because of the loss of proximity. Instrumentation provides valuable feedback but is too indirect to portray some of the nuanced events that require prompt response.

Audio is near-essential. PSR has tried to provide a system which is reliable and low-noise. Multiple locations is helpful, particularly near the cone and mid-to-upper drum.

Audio provides information which is not offered by any other instrument, including verification of clean drum, proximity to drum wall during cut, coke bed condition, etc.

Panel ergonomics should be a key deliverable because of the attention and static body posture required. Consider working with a coke cutting operator to design the panel.

Avoid replacing physical controls with HMI touch screen controls. Prevent requiring continuous pressure on a joystick, as this may invite 'creative solutions' by the user.

Key successful practices at psr - 2

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Consider "serious controls" on human presence on the cutting deck during unheading and decoking. Routine human presence may come to be viewed as necessary, and reduce the benefit of the effort.

There are multiple examples of sites which have installed remote decoking only to use it with people on the deck and/or not to use it at all. Its clear that making this transition requires resolve; use it.

HMI graphics need to be simple to use, consistent, and well understood by the coke handler.

Agree on design and dynamic behaviour well ahead of the FAT, so that FAT testing can include complete graphics.

Consider hydraulic or electric winches.

Puget retained pneumatic winches because we had been successful with them and were already undertaking a substantial change. Other technologies may be more suitable for remote operation.

PAR DCU2 CEP

- This unit has all of the 1999 recommendations and more!
- World Class Delayed Coking Unit.

Delayed Coking Unit 2

Port Arthur Refinery

Safety – Remote Unheading

Bottom Z&J Unheading Valve – During Construction

Dual Cylinder Drive Rams

Safety – Remote Unheading

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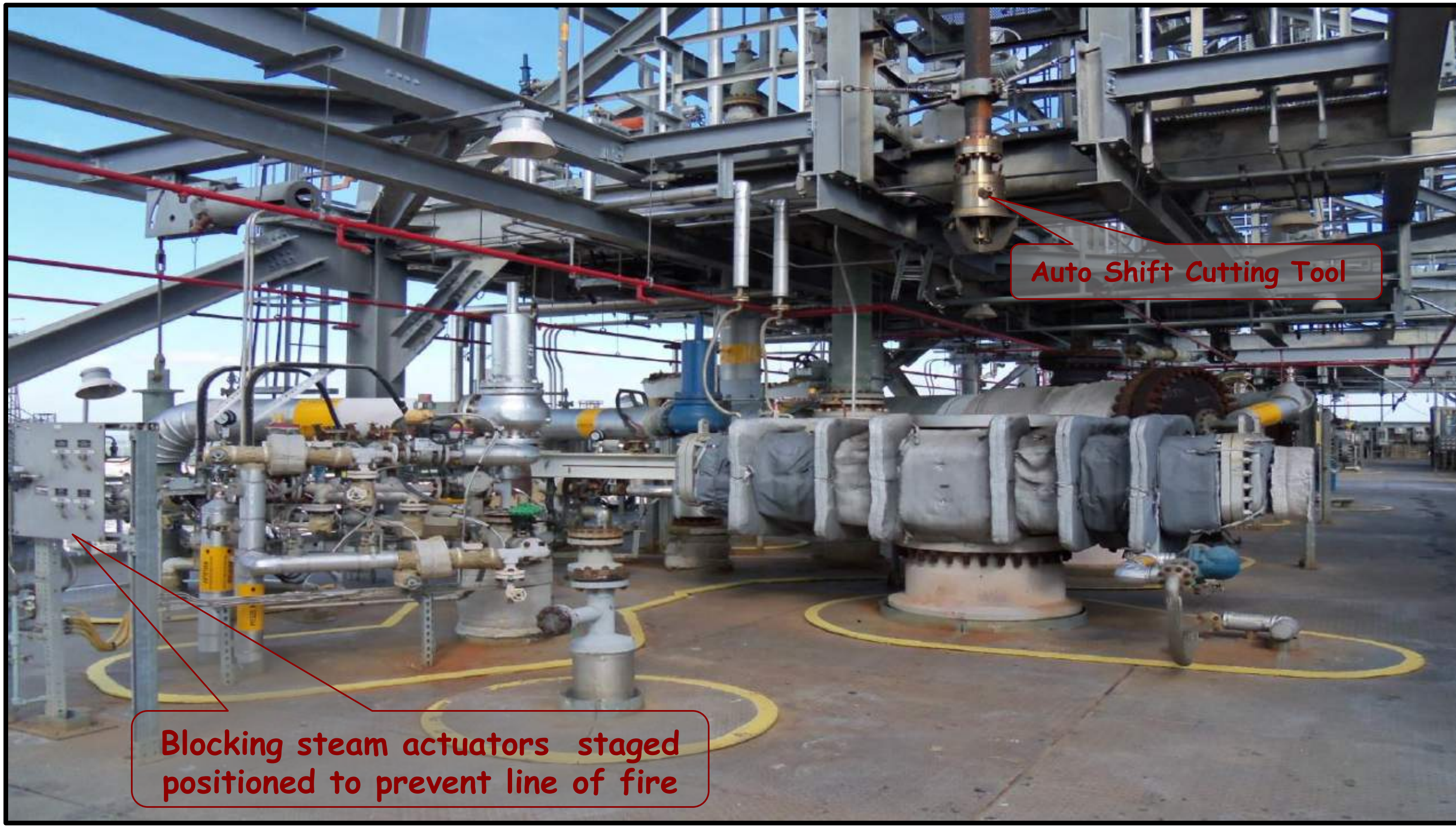
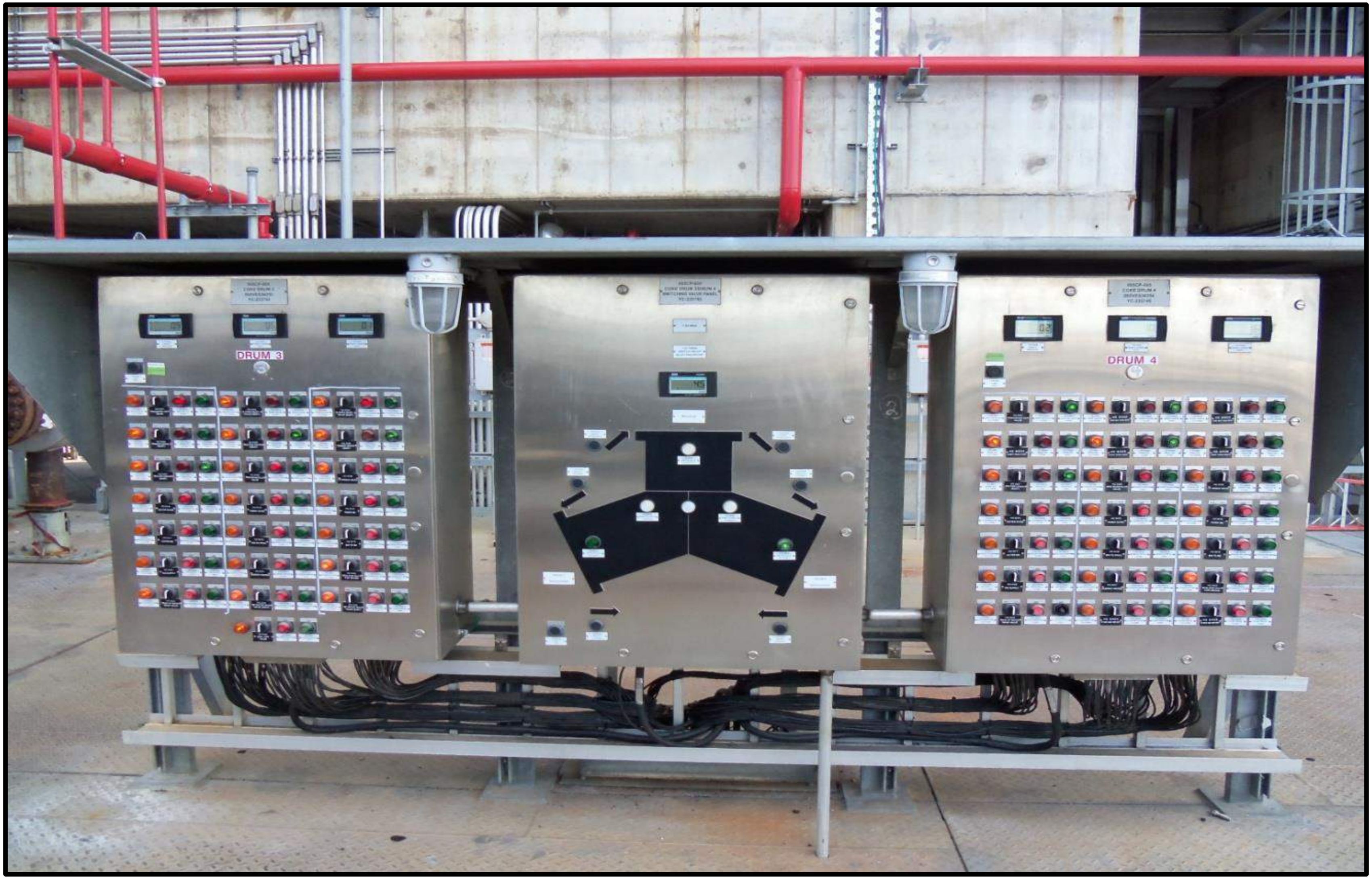
Top Z&J Unheading Valve – Post Construction



Safety – Drum Switching



Safety – Drum Switching

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Safety – Remote Coke Cutting

MOV Operating Panel located to reduce line of fire and unnecessary climbing.

Maintenance Podium only allows raising and lowering of drill stem.

Safety – Remote Unheading & Coke Cutting Shelter (RUCCS)

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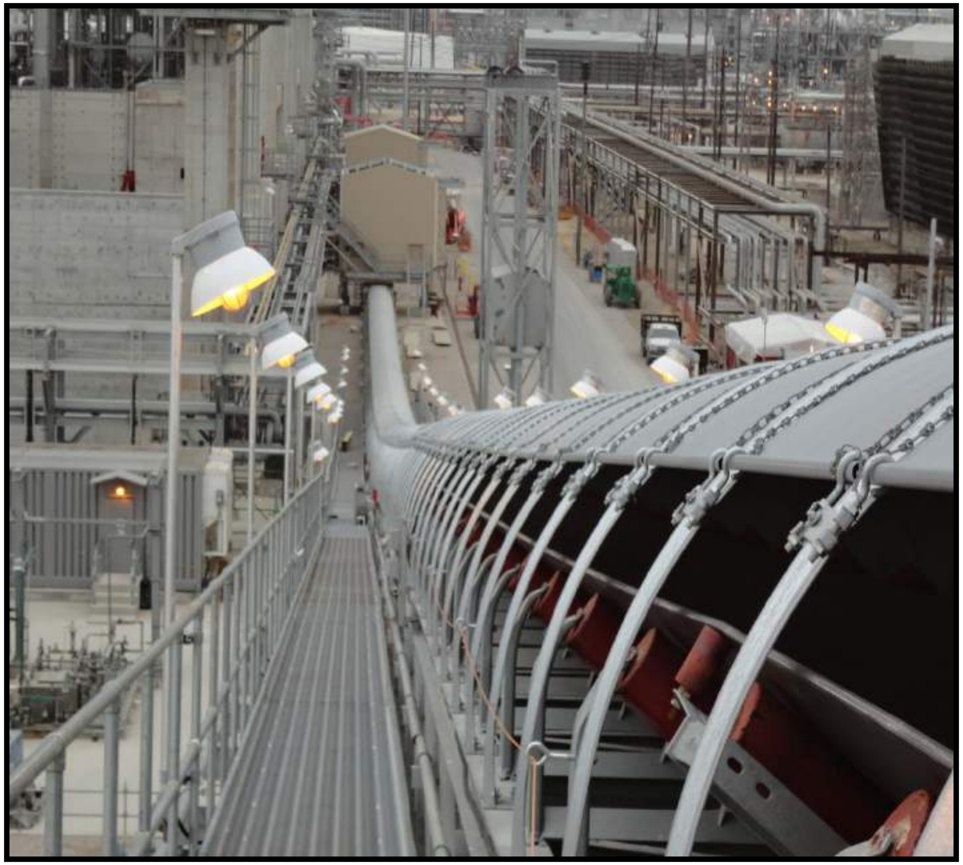
Safety – RUCCS User Interfaces

Safety – Coke Handling

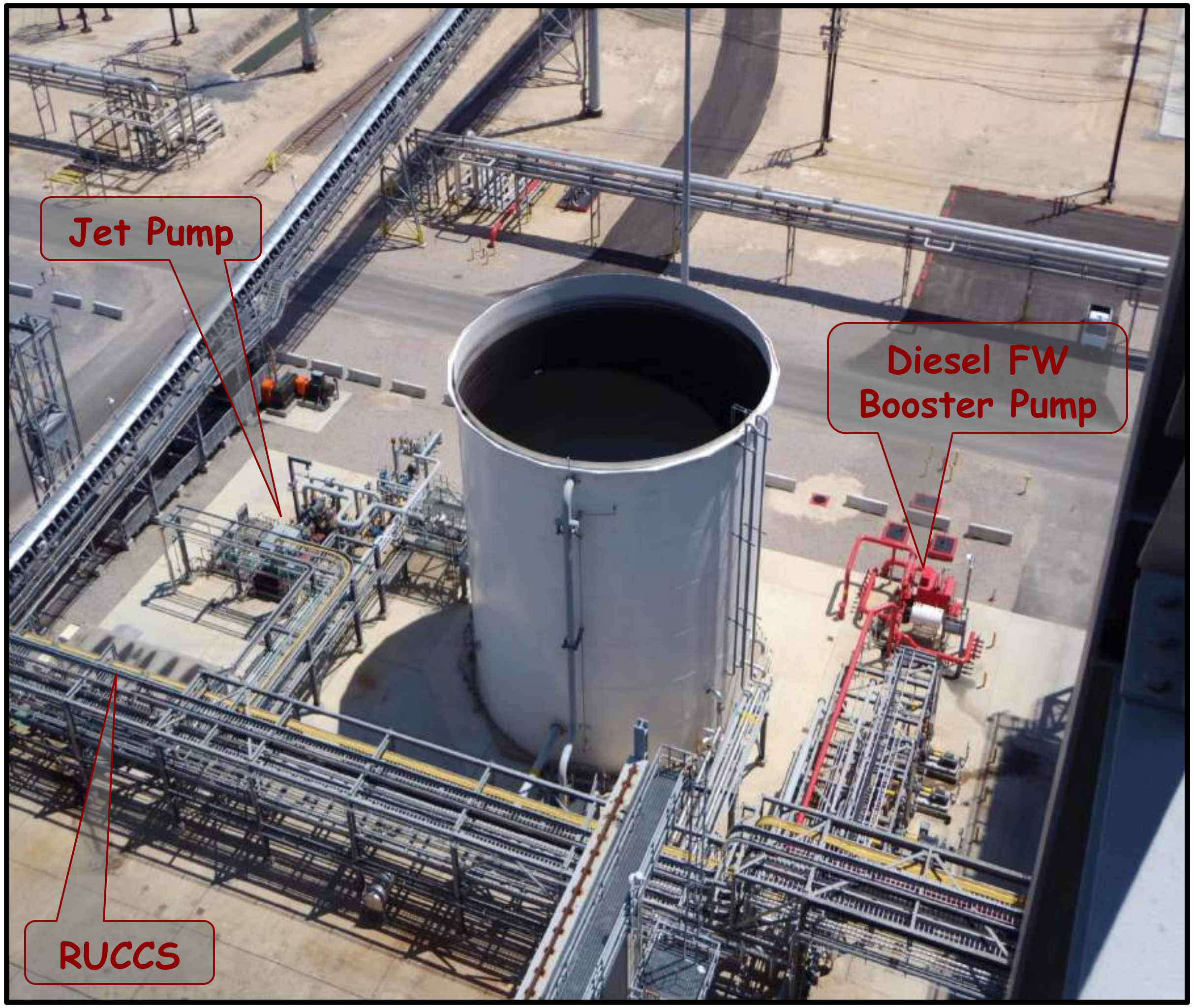
Silos and Load Out Shelters

Silo's Eye View



Design Improvements – Quench Water Storage Tank

- Drum overhead vapor is quenched using quench tower bottoms
- HHGO used as quench tower make up
  - Reduced natural recycle
  - More stable quench tower operation (due in part to quench water spray)
- Conical Bottom Quench Tank
- Four Mixing Nozzles



Motiva Port Arthur DCU2