COKER
Safety and Reliability Lessons Learned

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Coking.com

COKER SAFETY & RELIABILITY

Current Situation

The Delayed Coker industry has had many incidents with severe consequences, including numerous fatalities. There has been great progress in the last 10 years to improve Coker design to reduce personal exposure and improve safety.

Even with all the improvement, Chevron has experienced some near miss, operational reliability , and safety incidents.

Near miss, Incidents and Lessons Learned

- **FURNACES**
  - Charge pump - seal failure
  - Outlet Flange - small fire re-introducing oil after online spall
  - Outlet piping metallurgy – carbon steel fitting
  - Furnace u-bend erosion
  - Blocked in severe coking incident
- **Coker Structure**
  - Top and Bottom Unheading
  - Drilling
  - Coke drums
  - Motor Operated Valves
- **WET GAS**
  - Power trip during normal operation
  - Power over speed incident on start-up

Desired Outcome

- Provide "lessons learned " to allow fewer Coker safety and reliability incidents.
- Highlight areas where additional safety and reliability improvements are needed.

COKER FURNACE INCIDENTS

Salt Lake Furnace Charge Pump

- 2012: Installed discharge Emergency Block Valves (EBV's).
- 11/2013: Catastrophic seal failure
  - Field operator observed spraying hydrocarbon from pump seal.
  - Remote start of spare pump
  - Shutdown primary
  - Closed suction and discharge EBV's

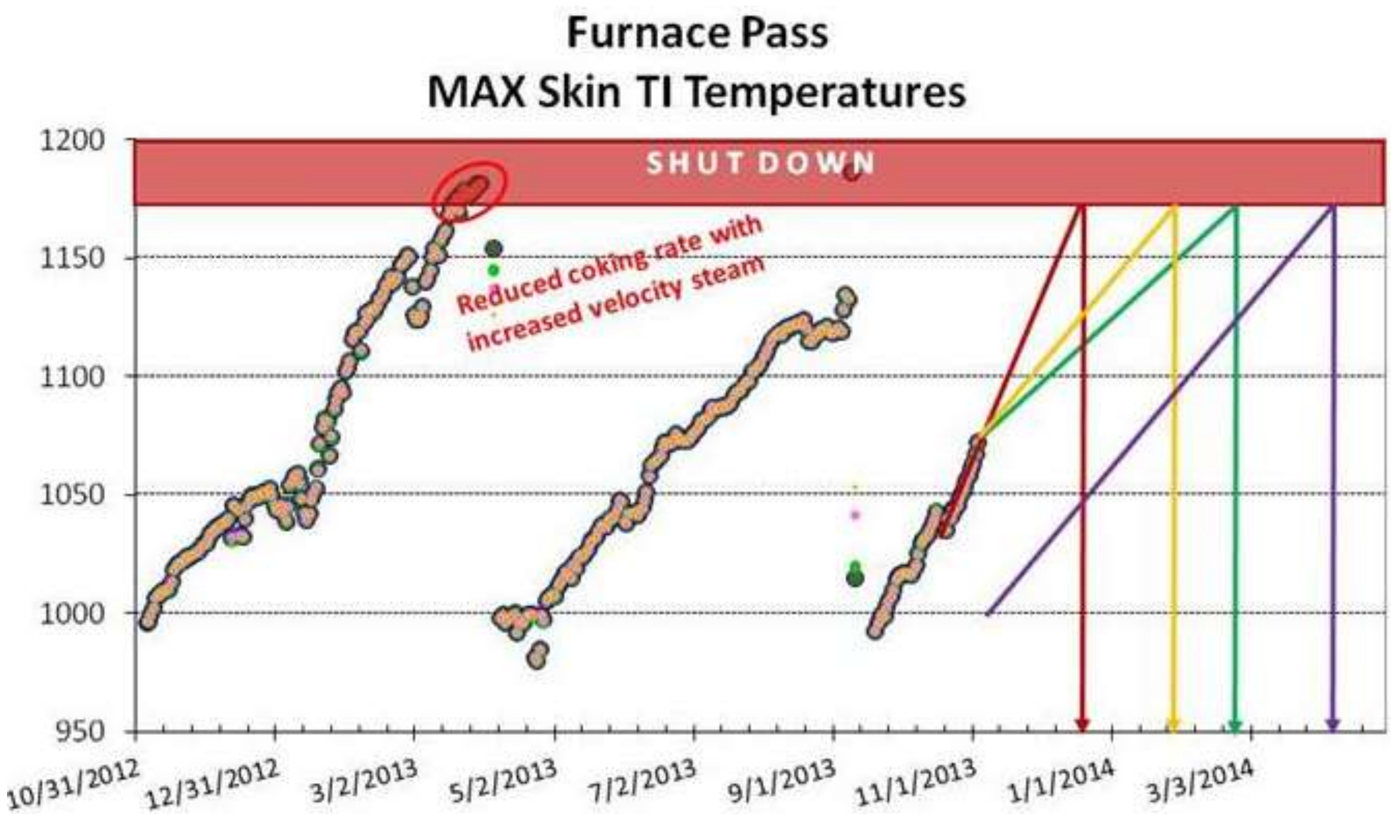
Lesson Learned:
Equipment design with process safety consideration for seal failure allowed remote operator action.

Coker – Salt Lake

Suction EBV

DISCHARGE EBV

Coker – Salt Lake



- Increased furnace fouling rate with paraffinic resid.
- Steam: air decoke typical for coke removal.
- Developed “on-line spall” procedure.

Coker – Salt Lake

- Completed on-line spall.
- Re-introduced resid to furnace pass
- Outlet piping flange leak, small fire.
- Removed resid, stopped fire.
- Tightened nuts, able to achieve about ½ turn.

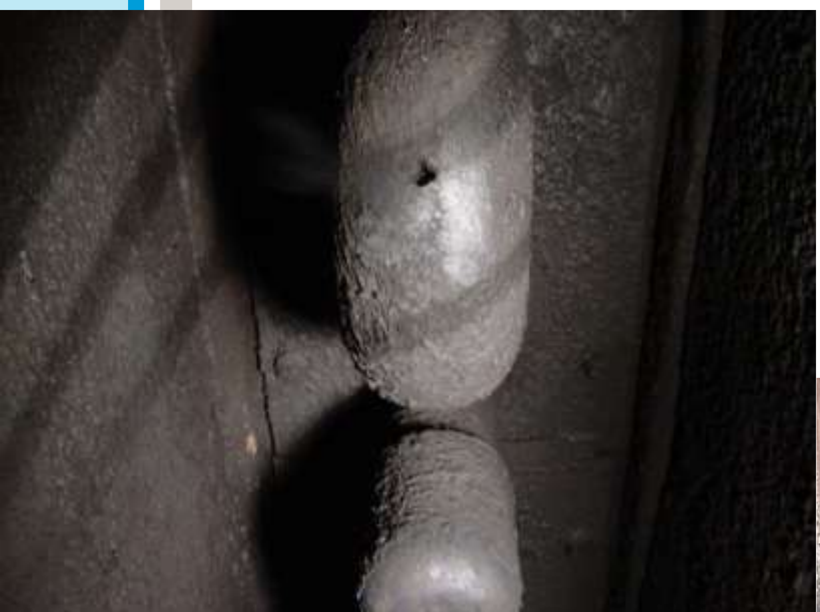
- Lesson Learned: Furnace outlet flange has severe thermal cycles. May need to tighten after spall / de-coke procedures.

Coker Furnace Tube Damage Mechanisms

Flame Impingement, Overheating

Erosion (during decoke)

Rupture– Over pressure from blocked in incident(s)



Coker Furnace – Tubes and U-bends

Lessons Learned

1. Must monitor flame patterns and tube skin temperatures.

2. Recommend tube pressure test after steam air decoke prior to introducing oil.

3. If erosion occurs, a different u-bend geometry can improve safety.

4. Need to inspect u-bends periodically to determine erosion rates, insure adequate wall thickness.

Coker Furnace - Blocked In Incident

9/2013 ELS Sequence of events:

1. Resid isolation MOV returned from maintenance; bad signal into SIS.
2. Operations bypassing SIS to rotate switch valve ~ 10 days.
3. Connect laptop computer to SIS PLC, intend to bypass position signal for resid isolation valve on feeding drum.
4. The bypass command became a close command because of incorrect wiring
5. Blocks flow, unable to open for ~ 20 MINUTES due to Interlock permissive.

Coker Furnace - Blocked In Incident

6. Operations chops fuel gas. Pressure reaches ~ 920# but tubes do not rupture (600 # design).

CONSEQUENCE Severe coking. Radiant section required cutting u-bends, Aqua-Drill to bore out coke, then pig.

Lessons Learned

* Do not do any type of work on a feeding coke drum.

* Need to improve SIS system training, make information more visible on DCS, validate all repairs.

COKER STRUCTURE INCIDENTS

Top Unheading System

Delta Valve, fully automated, remote operation, no manual labor.

Auto-switch cutting tool

Top Unheading System

Cutting water isolation valve leaking, allowing water to drain from drill stem to top of slide gate valve.

Auto-switch cutting tool not functioning, required manual rotation.

Driller decided to climb up and rotate drill position while the drum was hot, still feeding.

12/2012 – slip into condensate, burn to foot.

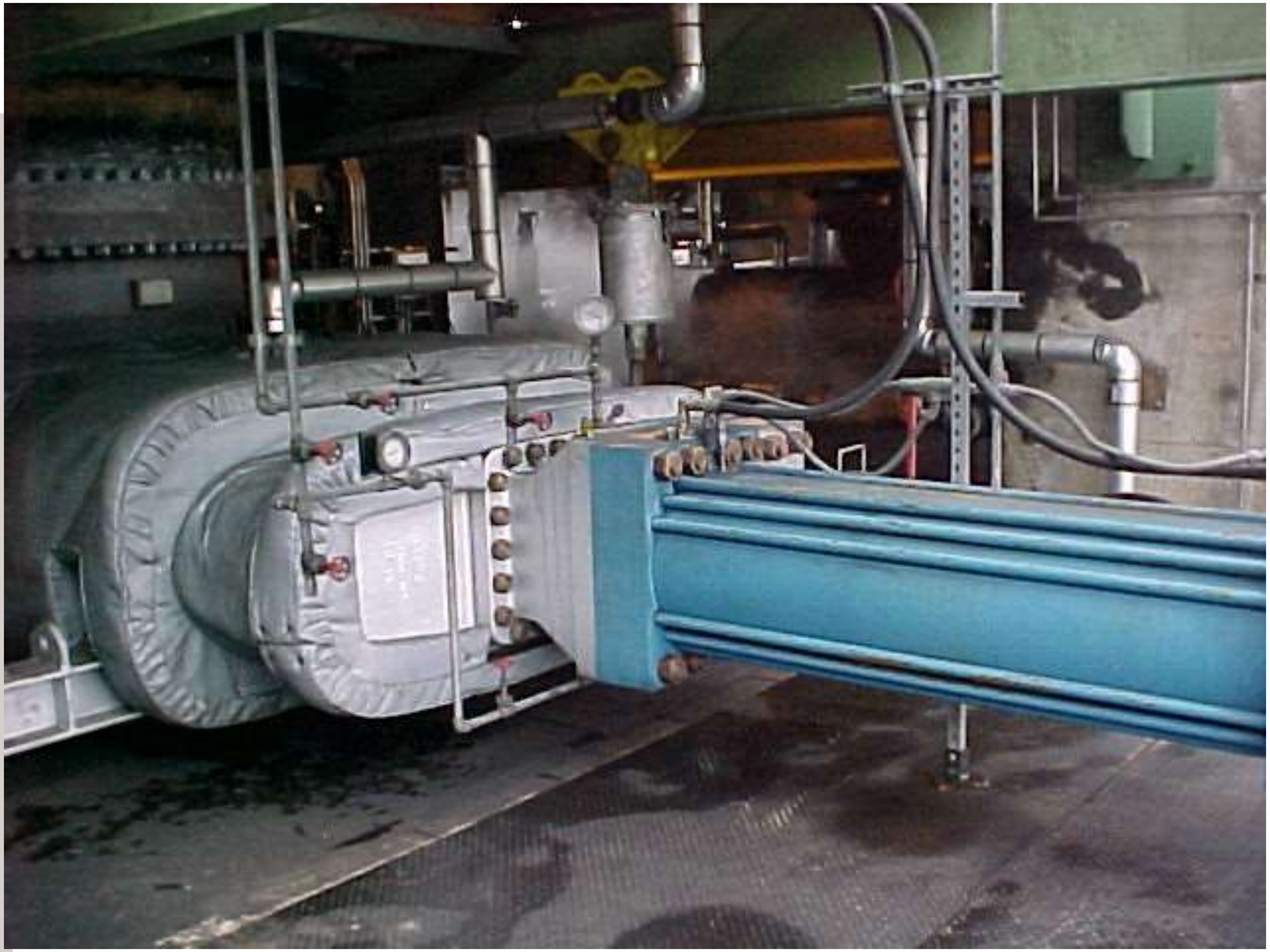
LESSON LEARNED Be sure procedures are clear to only perform manual function after drum has been cooled.

Bottom Unheading – The Old Method

Coke drum unheading involved manual unbolting of a coke drum bottom head and physical separation, exposing ~850 tons of coke to the atmosphere.

Chute attachment and bottom head cleaning required manual steps with high exposure, partially mitigated with extra PPE.

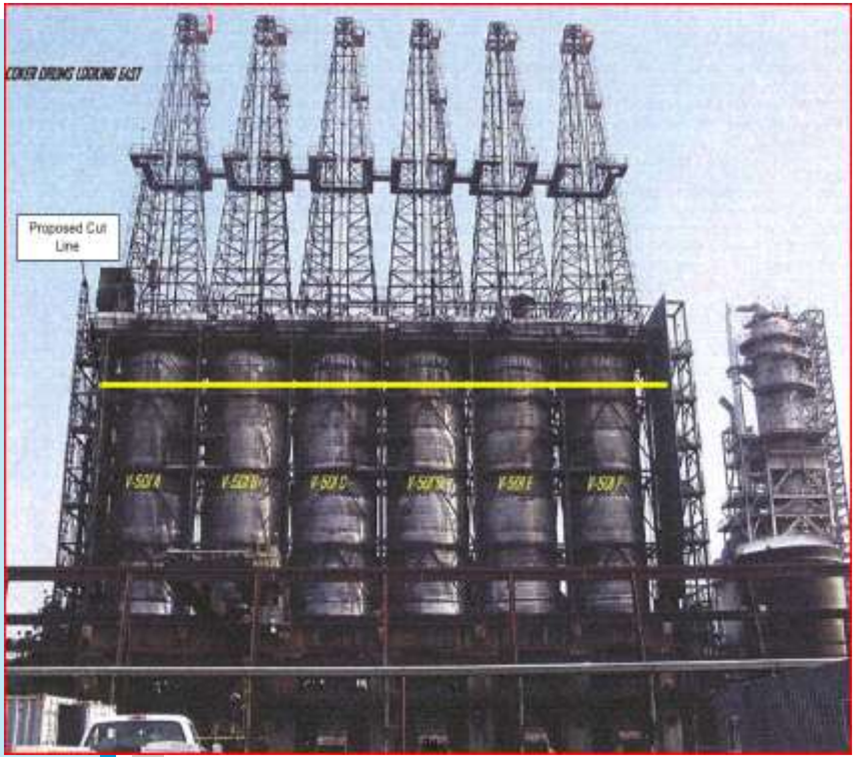
Bottom Unheading With Slide Gate Valve



Bottom unheading Delta Valve's have eliminated manual labor and exposure. 14 valves have been in-service for 10+ years in SL, PAS, ELS.

Opportunity: Identify maintenance interval and shutdown work scope to sustain long term operation (minimize steam use).

Coke Drums - El Segundo



Original 1968 drums – replacement in 2014

Jan 2014 night shift - Drum crack at 4th circumferential weld on feeding drum

Coke Drums – El Segundo

NIGHT SHIFT RESPONSE TO CRACK

Aim fire monitors at the leaking vapors.

Reduce furnace feed rate and outlet temperature.

Drain and pressure test module bypass line.

Bypass module; begin steam strip of coke drum.

DAY SHIFT

POTENTIAL TARRY DRUM – feeding time only 75 minutes.

Tarry drum guideline developed primarily for loss of furnace fires.

OPS and Engineering developed furnace procedure to remove resid, superheat velocity steam and re-introduce to coke drum. Executed procedure, heating to 1050 F for 4+ hours, not letting skin TI's exceed 1175 F.

Quench, depressure, vent, drain through Delta Valve to pit.

Clean Delta Valve condensate lines and traps.

No issues cutting or loading coke to belts.

Coker Structure MOV Valves

Goals:
*Allow structure interlocks program to prevent out of sequence valve movement.

•Prevent INCIDENTS , no loss of containment from exposing hydrocarbons to atmosphere.

Preventative Maintenance: Must maintain steam purges to prevent coke in valves which leads to over torque incidents.

Opportunity: Improve MOV RELIABILITY ; reduce bad signal, valve jammed, and data highway communication errors to the Interlocks Programmable Logic Computer (PLC).

COKER WET GAS COMPRESSOR INCIDENTS

El Segundo Wet Gas Compressor

Incident: 1/11/ 2014

- Non-PLC shutdown

Root Cause

- Oil ingress into electrical wiring for speed measurement.
- Speed probe failure, shutdown compressor.

Opportunity:

Eliminate oil ingress.

Evaluate if one of one speed voting logic for shutdown is the appropriate design for motor protection.

Wet Gas Compressor K-8320 - Pascagoula

Sequence of Events

No planned work for compressor during 2013 planned shutdown, no operational issues.

Startup per normal procedures – using nitrogen to displace air from system

About 60 seconds after the motor was started, catastrophic gear box coupling failure.

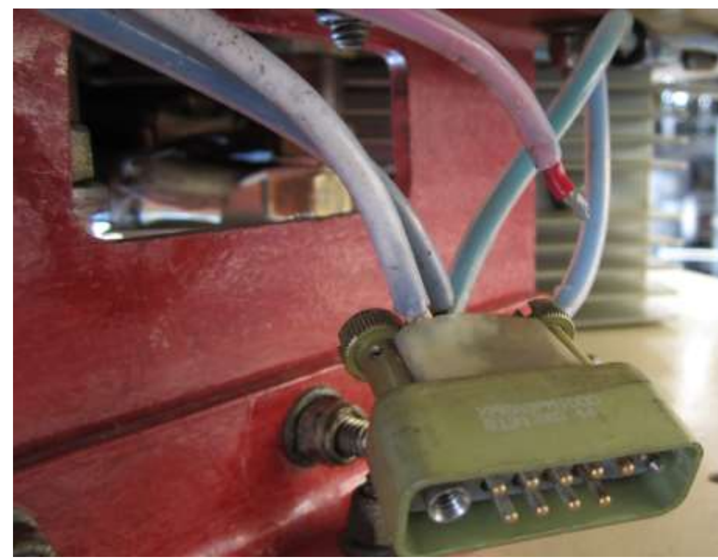
Wet Gas Compressor K-8320 - Pascagoula

Root Cause

Motor speed synchronization did not occur. Sheared coupling, shattered coupling guard. Found loose exciter wire that prevented proper speed control.

Lessons Learned

- Develop shutdown motor preventative maintenance procedures.
- Consider running motor un-coupled prior to start-up.
- Review proximity of people to rotating equipment during start-up.



APPENDIX

SAFETY: Damage Mechanisms

Coking

Furnace radiant tube coking occurs regularly as seen by increase in skin temperatures, typically 1 -3 Deg F per day. Skin temperature and IR camera monitoring are used to determine de-coke timing to prevent over-heating which causes severe "creep" tube damage. Strapping and visual inspection are the primary evaluation methods. Tube samples and destructive testing is the best technique to understand internal tube metal condition. Note: Tarry drum is the opposite problem, too cold into drum and causing a tarry mess.

Thermal Cyclic Stress

Coke drum skirt attachment (42' deck) is the most severe thermal cyclic stress area. Other areas include coke drum vapor line, furnace outlet line, and the preheat system.

Erosion

High velocity in conjunction with coke fines causes erosion. The radiant furnace u-bends are highest area of vulnerability for erosion. Rate of furnace coke build-up and removal frequency impact u-bend life. Blowdown lines to V-509, V-509 bottoms, and coke preheat V-508 bottoms are also susceptible to erosion.

SAFETY: Damage Mechanisms

High Temperature Sulfidation

Corrosion of Carbon Steel and other alloys due to reaction with sulfur compounds in high temperature environment (> 500 F). Thermal decomposition of sulfur compounds to H2S & reaction with steel is the mechanism. Most vulnerable piping has been upgraded to 5 chrome.

Naphthenic Acid Corrosion

High temperature corrosion that occurs primarily in crude and vacuum units. Naphthenic acids remove protective iron sulfide scales on surfaces of metals. Molybdenum % in steel improves resistance.

Ammonium Chloride / Ammonium Sulfate Corrosion

Ammonium chloride salts precipitate from high temperature streams as they are cooled and are absorbed by water. These salts form an acidic solution that is highly corrosive. Ammonium sulfate forms when Coker flue gas is cooled.

Ammonium Bisulfide Corrosion (High pH Sour Water)

Nitrogen in feed is converted to NH3 and reacts with H2S to form NH4HS, which precipitates out of the gas stream below 150 F. NH4HS deposits lead to corrosion and fouling. Water injection and circulation is used to prevent deposits.
Cyanide Attack: Presence of cyanides increases rate of corrosion by destroying protective iron sulfide film. Ammonium polysulfide is used to remove CN-.