Delayed Coker Innovation to Improve Safety

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CHEVRON INSULATED TRANSITION SPOOL

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2. Lessons Learned – Inspection, Operation, Surprises, Benefits

3. Most Recent Design Enhancements – 2018 Pascagoula Installation on 4 of 6 Coke Drums

The coke drum bottom head was a 72” flange, original 1968 Foster Wheeler design.


Chute attachment and bottom head cleaning required manual steps with high exposure, partially mitigated with extra PPE.
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- Chevron installed industry’s first Transition Spool and Bottom Unheading Device (BUD) in Salt Lake September 2001. BUD manufactured by Delta Valve.

The BUD met all SAFETY expectations – remote actuation, no manual labor, interlocked.
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- The original Salt Lake transition spool did not meet all expectations – the top flange routinely leaked.

- Note: Inlet nozzle pointed up

Chevron chose to install a bolted transition spool which was viewed as “replaceable part” vs. entry into cone section of coke drum. Anticipated cyclic stress issues with spool or drum.
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THERMOGRAPHIC IMAGE T-8300

Notice hot drum wall opposite inlet line

ORIGINAL SPOOL

Thermal scan shows radial temperature gradient of ~ 400 F that resulted in uneven bolt clamping force at the transition spool to coke drum flange. This allowed resid leakage. Major nuisance with a safety risk (no fires).
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2003 Insulated Transition Spool

Goal: Even radial temperature, even bolt load at the transition spool to drum flange connection.

- Item 1 – New 72” Coke Drum Bottom Flange, refractory filled
- Item 2 - Top Transition Spool Flange
- Item 3 - Bottom Transition Spool 60” Flange to mate to BUD
- Item 4 - Transition Spool plates
- Item 5 - Internal Barrel, refractory filled gap
DESIGN: Thermal Scan shows how the resid heats the Spool and Cone evenly.
Insulated TS Design – El Segundo 2003

Changes from Original un-insulated to patented TS
1. Straight in feed line into inner barrel
2. Inner barrel with refractory, allow more even radial temperatures.
3. Larger diameter studs for increased bolt loading for top (TS to drum) and bottom (TS to BUD) flanges.

Installed on all 6 ELS drums in 2003.
Developed special gasket & bolt tensioning procedures. Needs to be tensioned cold, hot, after ~ 5 cycles, and then checked in 3 months. **Following procedure, no leaks**

COKE DRUM - Coke Removal Process

SWITCH VALVE – rotate feed

Steam Strip

Depressure to blowdown

Quench (cool) to blowdown. Use maximum time available.

Vent to atmosphere (< 2 psig)

Drain

Unhead / remove coke

Rehead / Steam O2 free

Preheat using adjacent drum vapors

SWITCH VALVE – rotate feed
El Segundo
OVERVIEW – INLET TEMP and Radial Skin Temperatures on coke drum just above cone

Medium Diameter
E PREHEAT - Vapors from F Drum

Blue is inlet line temperature, the marker for cycle step.

Relatively even skin delta temp, within 50 F throughout preheat

Feed into drum, high rate of change
Inlet line temperature above coke drum skin temperature due to endothermic reaction.

Very close radial temperature during feeding, a little variation late in cycle when coke is above this section of coke drum. Depends on coke drum insulation.
E DRUM Strip and QUENCH

Steam strip shows dramatic drum inlet temperature change.
Radial skin TI’s do not cool very much because steam is already vapor, low mass flow vs. coke mass.

Inlet temperature drop at start of quench. Takes some time to cool above cone. Quench water distribution is based on flow path. Flow path depends on coke type, VCM, quench water rate, etc.
ELS QUENCH: Relatively Even Cooling

Advanced coke drum quench technique – Patent US 9,809,753 B2. Reduce potential for hot spots, reduce drum vent emissions. Besides drum inlet design, quench profile is VERY important in order to minimize coke drum stress from metal temperature rate of change.
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This cool is more uneven, has greater variation due to coke morphology, ie shot coke.
Insert 1st B drum laser scan when available

Number of Cycles: B drum, approximately 1625 cycles ~ 4/10/2019
HISTORY: Pascagoula New Coke Drums

Pascagoula experienced coke drum banana in 1st 5 years with new drums and ORIGINAL (non-insulated) transition spool.

The uneven water flow experienced from the un-insulated transition spool resulted in long term coke drum deformation (i.e. banana) in Pascagoula between 2003 – 2008.

Operations had to have the top deck plate cut to accommodate the different coke drum vaporline position.
Further banana has been minimal since 2008 when the insulated spool replaced the original. The laser scan of D-8300B in 2015 shows the drum to be out of plumb from tangent line to tangent line ~8”.

B drum – 1st weld seam crack in 2016
Pascagoula Laser Scan

“E” bulges and out of roundness increased in 2018 vs 2015 baseline. Tilting remained the same at ~8.5”.

Goal: Long coke drum life. No loss of containment – no through wall cracks
Operation: Large coke drum diameter, short cycle time
Installed new coke drums 2003, un-insulated spool. Banana from first 5 years.
Installed insulated transition spool in 2008 with new drum flange.
Inspection Results: Two through wall cracks on B drum, 2\textsuperscript{nd} circ weld above skirt attachment weld. Lowered initial quench rate to minimize future crack likelihood. Still experienced some bulges, addressed with weld overlay.
Small diameter coke drums
Long cycle time, excellent preheat since there is lots of time
Sponge coke
Middle and bottom TI’s track. Next slide shows variation of bottom TI’s when zoomed in
SALT LAKE – Radial TI Data Above Cone

Quench – stair step profile

Feeding Steam Strip Quench
Middle of drum TI’s
Less TI alignment
higher up in the drum

Bottom of drum TI’s
Reasonable alignment
above cone

Proving the open flow path, not recommended
Salt Lake Coke Drum Laser Scan

- A drum laser scan was performed, showing an outward deviation of 0.384" discovered on the east/north side at approx. 30’ elevation measured from the bottom of the drum.

- SUMMARY: EXCELLENT CONDITION, NO ISSUES.
  (smaller diameter, long cycle times)

- 2008 baseline laser scan shows about 0.75” bulge length

- Used a different laser scan company for logistics. Recommend same company for future scans.

- Approximately 1730 cycles.
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1. History of Transition Spool – purpose, performance from 2001 - 2018

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4. The Future - Marketing the Chevron Transition Spool through Chevron – Lummus-Global (CLG), a Chevron 50/50 Joint Venture
2003-2018 – LESSONS LEARNED

- Inner barrel – reinforced internal liner at nozzle inlet ~ 2005

- The inner barrel with refractory is not a pressure containing boundary. Some thermal cyclic stress damage is expected. 2011 pictures ~ 6 years in service on “short” cycles
El Segundo: 2009 E transition spool to BUD flange roll. ELS corrective action was to machine flat the flange.

NOTE: The “flat face flange” is not the desired long term design because it requires a custom gasket to load BUD dynamic seat.
Nozzle crack, minor loss of containment.

Temporary chain falls used to support inlet line during deck concrete replacement.

Lesson Learned: MUST ALLOW DOWNWARD GROWTH OF DRUM DURING FEEDING CYCLE. Must use spring can hanger for inlet line support.
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Pascagoula 2018: Bottom flange
• Thicker bottom flange is needed to prevent permanent deformation (excessive strain) from operating temperature and expansion / contraction of the spool wall.
2018 PAS Design Changes

- Bottom flange
  - Thicker to prevent flange roll and plastic deformation
  - Bolt pattern changed to (56) 1-3/4” diameter studs to match ELS
  - Flange changed back to original raised face design
    - Gasket – special CMG custom design
Transition Spool: 2018 Pascagoula

Old Spool

Original 2003 BUD with fabricated (welded) body. End of life due to maximum number of center body crack repairs.

New Spool

New BUD, cast body – much longer expected life based on finite element analysis (FEA).
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Coke Drum Resid Inlet

Goal: Extend coke drum life. No loss of containment – no through wall cracks

Evaluation criteria: Skirt inspection, keyhole slots, visual & surface eddy current
Drum circumferential weld inspection, penetrant test (PT), dye
Coke drum laser scan for bulge and tilt (banana) monitoring

PREMISE: More even radial temperatures throughout the cycle will result in slower rate of coke drum damage. Some variation is expected since water flow through coke is not controlled (Not all cycles are the same, greater rate of change = more damage).

CONCLUSION: Insulated transition spool in Chevron facilities, in conjunction with coke drum design and operating procedures, has slowed (PAS) or avoided (SL) coke drum damage. ELS status is pending laser scan data (Skirt inspection was good).
Future: Transition Spool

Delayed Coker feed inlet line configuration is important to minimize negative coke drum thermal cyclic stress consequences (banana, bulging, weld cracks).

The insulated “Chevron Transition Spool” is easy to maintain and replace compared to the coke drum. The TS is the simplest design that provides protection to the coke drum from the severe thermal cyclic stress associated with feed in (rapid temperature increase) and quench water (temperature decrease).

The TS has no moving parts, no permissive’s, no steam purge, and no operator requirements.

Special Bolting and Tensioning technique is required to avoid leaks. The bolt size and flange design enhancements have allowed near leak free operation.

The “lessons learned” from operating experience since 2003 has allowed design enhancements to improve TS reliability.
Future: Transition Spool (continued)

The transition spool is now commercially available through CLG. Chevron experience over last 16 years has allowed design enhancement. Coker operators can examine radial TI data and drum laser scans to see if this technology would be beneficial for your site.

Material Cost: TS Rough Order of Magnitude ~ $400,000 - $500,000 (Coke drum flange & installation is an additional cost for a retrofit)

Inlet line size and available vertical height are important considerations for determining feasibility for a retrofit.

New construction with specially designed insulated 72” coke drum flange to mate to new transition spool and proper 3D modeling to achieve required inlet line piping flexibility is recommended.

For more information, contact
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