When Worlds Collide
FCC vs. Coker Unheading Valve
ElectroHydraulic Actuator Systems

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The Issue

New Delayed Coker Unheading Device Projects

Inexperience with Hydraulic Actuators

Same refinery often has FCCU EH actuators

Communication between the FCC and Coker project teams limited
Agenda

- Comparisons
- History
- System Design
- Cases
<table>
<thead>
<tr>
<th><strong>FCC</strong></th>
<th><strong>Delayed Coker</strong></th>
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</thead>
<tbody>
<tr>
<td>• Continuously throttling for up to 6 yrs</td>
<td>• Cyclical on-off service</td>
</tr>
<tr>
<td>• Valve is process control, not pressure boundary</td>
<td>• Strokes every ~12-16 hrs</td>
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<td>• ESD function critical to process protection</td>
<td>• Valve is process pressure boundary</td>
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<tr>
<td>• Redundant and back-up systems required</td>
<td>• ESD function doesn’t exist</td>
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<td></td>
<td>• Redundant and back-up systems in spec</td>
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<td><strong>Delayed Coker</strong></td>
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<td>---------------------------------------------</td>
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<td>• 5 s throttling / 2 s ESD</td>
<td>• 4 minute stroke speed</td>
</tr>
<tr>
<td>• Failure to control properly causes process upset</td>
<td>• Failure to move properly</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>– lost profits</td>
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<td>• Spurious ESD</td>
<td>• Unintended opening while in service is worst case scenario</td>
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<td>– process upset</td>
<td>– loss of process containment</td>
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<td>– HSE consequences</td>
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<td>– lost profits</td>
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Lost profits can result from:
- Process upset due to failure to control or avoid ESD.
- Possible equipment damage due to failure to ESD.
- Delays in coking cycle due to slow movement.
- Loss of process containment due to unintended opening.

**HSE consequences** refer to health, safety, and environmental impacts.
5 s throttling / 2 s ESD
Failure to control properly causes process upset – lost profits
Spurious ESD – process upset – lost profits
Failure to ESD – possible equipment damage – lost profits
4 minute stroke speed
Failure to move properly – delays coking cycle – lost profits
Unintended opening while in service is worst case scenario – loss of process containment – HSE consequences
FCC Slide Valve Actuator History

- Sophisticated throttling control valve positioner
- Generally one HPCU per operated device
  - One PLC or analog position controller per valve
- Highly available with backup and redundant systems
  - Developed over many years of experience
FCC Slide Valve - Actuator History

- Some Pneumatic
- Central, low pressure (~250 psi) hydraulic – 1945
- Central, med. pressure (~1000 psi) hydraulic – 60’s & 70’s
- Self-contained electro-hydraulic (1500-2000 psi) – 1979
- Split architecture electro-hydraulic – early 80’s to now
FCC Reliability Improvements—80’s to today

- Shift away from central hydraulic systems
  - Single point of failure, large hydraulic fluid inventory
- HPU/HCU unit for each valve
- Use of manifolds to minimize tubing/pipe
  - Reduce leak paths
- Provided redundant components where practical
  - Redundant feedback devices
  - Added redundant ESD functions
  - Added redundant limit switches for ESD trip initiation
- Provided back-up systems where necessary
  - Back-up “jog” control to move valve when servo is unavailable
- Added fluid conditioning systems
- Mid 90’s begin use of PLC’s for monitoring / diagnostics and control
Coker Unheading Valves
Hydraulic Actuators History

- First Installations in 2001
- Relatively new to process (compared to FCC)
- Previously, refiners used manual and semi-manual unheading systems
- Personnel safety is biggest project driver
- Increased throughput and lower operational/maintenance costs are also drivers
Coker Unheading Valve
Hydraulic System Design
Once every 2 hours, a BUD and TUD is moved for 4 minutes each
<table>
<thead>
<tr>
<th>LEGEND</th>
<th>HOURS</th>
<th>ACTIVITY</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>COKING</td>
</tr>
<tr>
<td>SF</td>
<td>0.5</td>
<td>STEAMOUT TO FRACTIONATOR</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>STEAMOUT TO BLOWDOWN</td>
</tr>
<tr>
<td>D</td>
<td>4.5</td>
<td>QUENCH AND FILL</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>DRAINING</td>
</tr>
<tr>
<td>U</td>
<td>0.25</td>
<td>UNHEADING</td>
</tr>
<tr>
<td>K</td>
<td>2</td>
<td>DECOCKING</td>
</tr>
<tr>
<td>T</td>
<td>1</td>
<td>REHEADING AND TESTING</td>
</tr>
<tr>
<td>P</td>
<td>2.5</td>
<td>PREHEATING</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>TOTAL</td>
</tr>
</tbody>
</table>
Some questions…

• Which Hydraulic Power Unit design requires higher operational “availability” – FCC or Coker?
  – **FCC**: HPU requires 100% availability
  – **Coker**: Every 2 hours, a main pump runs for 8 minutes (96 minutes in 24 hrs – 6.7% required availability)

• Which Hydraulic Control Unit design requires higher operational “availability” – FCC or Coker
  – **FCC**: HCU requires 100% availability
  – **Coker**: In 24 hrs, each HCU operates for 8 minutes (0.56% required availability)
Some more questions…

- Which system operates in a harsher environment – FCC or Coker?
- What backup systems are needed?
- What redundant systems are needed?
  - Redundant PLC control processors?
  - Redundant I/O?
- Do these systems require “SIL” rated instrumentation?
  - What does SIL mean anyway?
- What spare parts do we need?
Why are we here?

- 35 yrs of FCCU electro-hydraulic system experience
- Coker unheading projects should leverage that experience
- Projects should recognize intermittent nature of Coker operation (vs. FCCU)
  - However, many project specs seem to ignore that fact
- Excessive design requirements and over-specification causes project costs to skyrocket
  - We wish to supply safe and optimum designs
  - We really don’t like wasting our customer’s money
Let’s Design a BUD/TUD Hydraulic System

- Move when commanded to move
- Prevent unintended movement of unheading valve!!
  - Prevent process energy from moving valve
  - Prevent external energy to actuator from moving valve
- A failure should not cause valve movement
- Inherent design of unheading device makes a difference
BUD/TUD Hydraulic Control Circuit

- Directional control valve design
  - One “open” solenoid, One “close” solenoid
  - Power off means hydraulic cylinder open to tank
  - Both sides of cylinder tied together

- Pressure isolation valve
  - Power off means no pressure to directional valve

- Permissive signal from refinery prevents unintended power to reach solenoid valves
  - Need permissive to permit power to solenoids

- Fail safe – no movement!
  - All solenoids are “energize to move”

- Pressure isolation valve plus directional control valve provides “double block and bleed”
Recent project issues
Recent Unheading Valve Project in US

HPU at FCC Unit

- Reservoir purged with nitrogen, operating at 50mm H₂O
- Relief valve on reservoir

HPU at Coker Unit, same refinery

- Reservoir purged with nitrogen, operating at 50mm H₂O
- Relief valve on reservoir

Project team decided that failure of the N₂ regulator was a hazard and could cause release of N₂ near people
- Removed relief valve, piped N₂ vent to atm over coke pit
- Allowed water to enter reservoir over time, causing problems in winter (freezing water in hydraulic lines)
Recent 2 Drum Unheading Valve Project

- For this project, HPU only runs for 16 minutes every 24 hours (1.1% availability)
- Specs required SIL 2 rated “safety PLC” to operate HPU and HCU
  - Honeywell Safety Manager
  - 2oo3 Voting for 3 level transmitters on reservoir
    - Individual transmitters rated SIL 3 (99.99% availability)
    - Low level only prevents pump from running
  - Required all electrical signal relays to be SIL 3 safety relays
    - SIL 3 relay to turn on lamps on local control panels
Some items in BUD/TUD Specs…

- **Spare hydraulic cylinder**
  - In 60+ yrs FCC experience, only one refiner keeps spare cylinder
  - But...FCC actuators have handwheels

- **Air operated portable HPCU cart**
  - in case HPU is down

- **Redundant PLC processors**
  - redundant I/O

- **“SIL rated” transmitters and electrical components**

- **Double block and bleed isolation valves for filter change**
  - Pumps **not** operating for 22 hours each day

- **Use of “process” specs for hydraulic equipment**
  - Systems built to ISO 4413 hydraulic standards, not API
Details Matter

Some specs require 2” 300RF minimum flanges on all vessels for instruments.

Reservoir fabricated from 3mm sheet 304SS.
In conclusion

- FCC systems require 100% availability
- Coker systems require only 7% availability
  - System design should take this into account
  - System must NOT operate in order to be safe

- FCC unit operators have many years of experience with hydraulic actuators
  - Ask them to share their experiences, good and bad

- Excessive specification for Coker unheading valve actuator systems is leading to higher costs compared to FCC
Thank You!