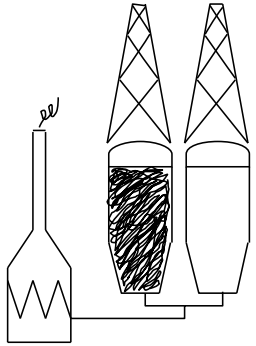
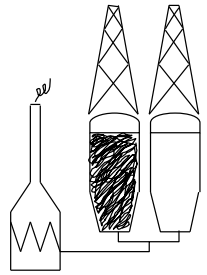
Delayed Coker
Automation & Interlocks



Presented by Mitch Moloney of **ExxonMobil**

@ coking.com April-2005

Delayed Coker Automation & Interlocks



Automation & Interlocks @ ExxonMobil - Background

We have 8 sites and 12 Delayed Cokers

3 sites (5 cokers) will be fully automated & interlocked by year end

+ Baton Rouge in response to a fire & fatality that resulted from opening feed to an open drum
  => They completed all three cokers prior to the 2000 merger

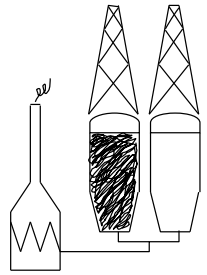
+ Baytown in 2001 because they knew it was the right thing to do

+ Jose Upgrader by YE2005

  => justified using financially-based risk review

  => Adding 4 additional MOV's and PLC interlocking all valves

Delayed Coker Automation & Interlocks



Automation & Interlocks @ ExxonMobil - Development

=> That leaves 5 sites (7 cokers) with manual LOTO operations in our circuit

Beaumont, Campana, Chalmette No 1 & 2, Joliet, Torrance North & South

=> Our Beaumont Coker is blazing the trail

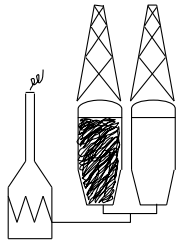
- 8 drums, 48 kB/D of Maya resid on 12-hr cycle
- Almost all valves are manually-operated
- Rely on procedures, 2-person checking and Lock-Out/Tag-Out protocol

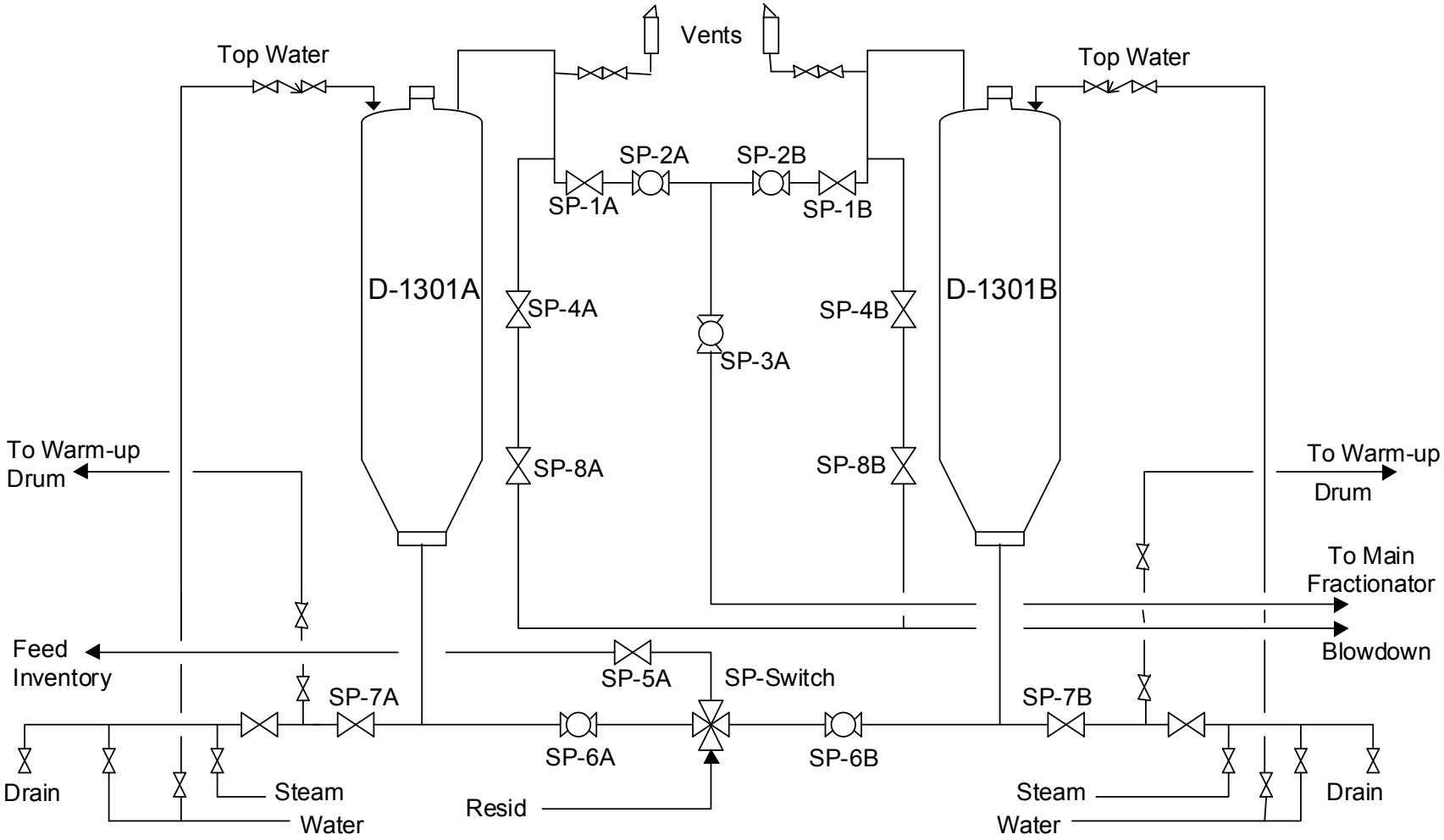
=> Automation & Interlock review is part of a large Safety Upgrade Project

- Risk-based review (Safety, Environmental, Financial & Public Disruption)
- Risk is converted to a quantified probability
- Severity & Probability yield Unacceptable, Gray Area or Acceptable

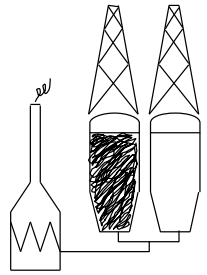
Delayed Coker Automation & Interlocks

Automation & Interlocks - Valve Risk Review





Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

=> Feed & Switch Valves => Switch & Recirculation Valves

=> Feed & Utility Header Valves

=> Drain & Warm-Up Condensate Valves

=> Overhead Vapor Valves

=> Blowdown Vapor Valves

=> Vent Valves

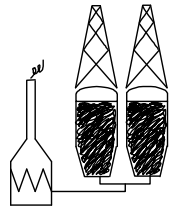
=> Antifoam Valves

=> PRV Block Valves

=> Top Water Valves

=> Water Over Valves

Delayed Coker Industry Safety Database



Assessing the Risk Probability

(1) Assessment of Industry Accidents

(2) Review of Plant Safety History

(3) Open discussion with operators to determine how often they have made mistakes in routine structure valve operations

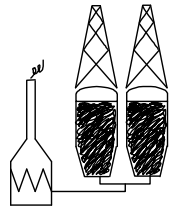
(4) Risk goes up with high turnover of operations force
=> need to consider the lowest common denominator

Human Error Potential (1)

Level of Stress	Complexity of Task			
	Simplest	**Routine and Simple**	**Routine, Require Care**	**Complicated, non-routine, other duties required**
Low	1 in 10,000	1 in 1,000	1 in 100	1 in 10
Moderate	1 in 1,000	1 in 100	5 in 100	3 in 10
Emergency, High Stress	1 in 100	1 in 10 to 1in 1	25 in 100 to 1 in 1	1 in 1

Note 1: Generic human error for various levels of stress and complexity of task.

Delayed Coker Industry Safety Database



Optimized Base Case

Manual or automatic valves that are controlled with LOTO procedures and two-person verification

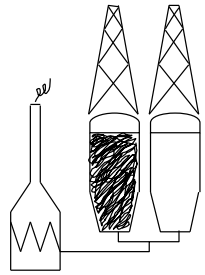
Double block valve arrangement on main hydrocarbon process flows
- isolating hydrocarbon from the atmosphere and an open coke drum

Proper barrier steam operation is a key element to a reliable double block:

- Feed & Switch Spool
- Overhead Vapor Spool
- Overhead Blowdown Vapor Spool
- Recirculation Valve & Switch Spool

Leaking valves are assumed to be open 10%, worst case, given coking service

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Feed & Switch Valves

Risk of Switching to Open Drum

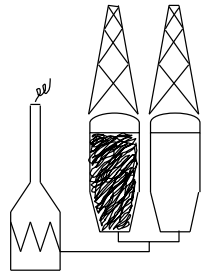
Risk of Switching against a Closed Block

Risk of Switching into a Leaking Block Valve

=> Severity & Base Probability are high enough (>1 in 10,000) to justify reducing the probability to less than 1 in 10,000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Recirculation & Switch Valves

Risk of Switching against a Closed Block

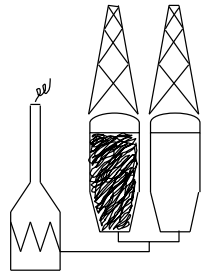
Risk of Coking/Plugging Recirculation Line

Risk of Unit Upset

=> Severity is medium to low; Base Probability is high (1 in 100); justifying reduction in probability to less than 1 in 1000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Feed & Utility Header Valves

Risk of Cracking Resid to:

- Open Drain
- Blowdown System, Cooling or Draining Drum

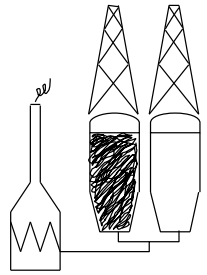
Risk of Resid to Utility Systems

Risk of Water to on-oil Drum

=> Severity & Base Probability are high enough (>1 in 10,000) to justify reducing the probability to less than 1 in 10,000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Drain & Warm-Up Condensate Valves

Risk of Coke Drum Vapors to Open Drain

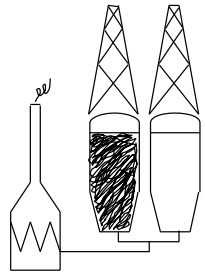
- Possibility of Fire & H_2S Exposure & Environmental Release

Risk of Leaking Coke Drum Vapors to Open Drain

=> Severity lower than feed valve event, but depends on drain disposition and activities near the drain line outlet; base probability is high (>1 in 10,000), justifying probability reduction to less than 1 in 10,000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Overhead Vapor Valves to Main Fractionator

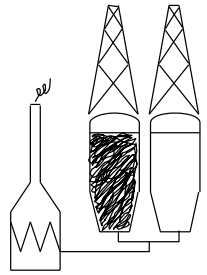
Risk of 800°F HC Vapors with high H_2S to Open Drum

Risk of Leaking Coke Drum Vapors to Open Drum

=> Severity is highest from safety, environmental and financial standpoints, but base probability is low (>1 in 10,000); however, the combination justifies probability reduction to less than 1 in 10,000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Blowdown Vapor Valves

Risk of Hot HC Vapors with high H_2S & Steam to Open Drum

Risk of Leaking Coke Drum HC & H_2S to Open Drum

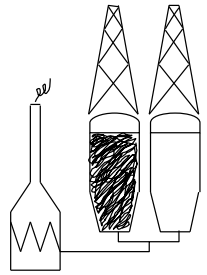
=> Severity is lower from safety and financial standpoints, base probability is still >1 in 10,000; which falls into the "gray area" and greatly depends on existing facilities in place and your assessment of their operation

If MOV's are already in place, no-brainer to interlock

If Manual, need to look at other advantages of automating
- eliminate single block, ergonomics & manpower

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Vent Valves

Risk of 800 °F HC and H_2S to the atmosphere
+ Fire, Injury & Environmental Incident

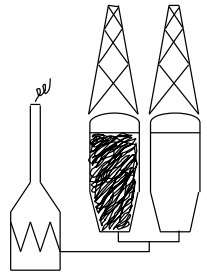
Risk of Coke Drum Damage, if closed during draining
+ Significant financial loss

=> Severity is highest; base probability is >1 in 10,000; however, the combination justifies probability reduction to less than 1 in 10,000

Note: Most new facilities are required to provide a reliable double block design from an environmental standpoint

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Antifoam Valves

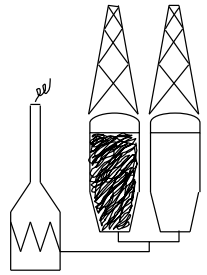
Risk of cold antifoam carrier (LCGO or HCGO) contacting 200°F coke in an open drum

=> Severity is low; base probability is greater than >1 in 10,000

Note: No automation or PLC interlocks provided

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Coke Drum PRV's

Risk of hydrocarbon vapors & H_2S leaking from the discharge side to the open coke drum

+ Fire, Injury & Environmental Incident

Safety Risk is a strong function of the discharge location

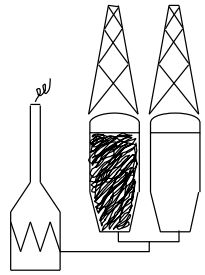
- Flare (1 - 3 psig)
- Blowdown System (1 - 30 psig)
- Main Fractionator (20 - 65 psig)

Mitigation Steps

- Industrial Hygiene vapor sniffing
- LOTO of discharge valve
- Discharge valve interlocking

Note: State Environmental agencies are starting to require closure of the discharge valve when the coke drum is open

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Top Water Valves

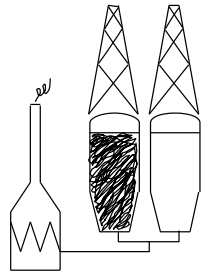
Risk of 200 - 400 gpm of water to live coke drum

=> results in severe unit upset and financial loss

=> Severity & Base Probability are high enough (> 1 in 10,000) to justify reducing the probability to less than 1 in 10,000

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks



Automation & Interlocks - Valve Risk Review

Water Over Valves

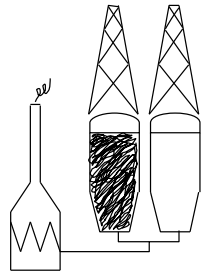
Risk of Blowdown or HC Vapors to Water Over Disposition, which is usually the coke pit or pad or maze

- Risk is very dependent on base valve arrangement and if there is a common valve for BD and water over

=> Severity is low from safety and financial standpoints, base probability is still >1 in 10,000; which falls into the "gray area" and greatly depends on existing facilities in place and your assessment of their operation

Base probability is defined as valves that are controlled with LOTO procedures and two-person verification

Delayed Coker Automation & Interlocks

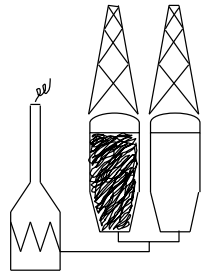


How do we Reduce the Probability of Incorrect Valve Movement to less than 1 in 10,000 ?

Based on ExxonMobil analysis:

- Use of automatically-controlled valves & a redundant Programmable Logic Computer (PLC) for most of the coke drum valves
- Why?
  => Because it is the only design which gives you a reliable shift in probability of one to two orders of magnitude (10 - 100) versus the optimized base case
- Acceptable valve automation:
  + Motor and/or hydraulic actuators
- Acceptable PLC's:
  + Triconics & Allen-Bradley Control Logix

Delayed Coker Automation & Interlocks



Valve Interlock System Availability

Based on ExxonMobil analysis:

- Delayed Coker Interlocks do NOT meet the definition of a Safety Instrumented System (SIS), consists of:

"the instrumentation or controls that are installed for the purpose of mitigating the hazard or bringing the process to a safe state in the event of a process upset."

"An SIS is used for any process in which the process hazards analysis has determined that the mechanical integrity of the process equipment, the process control, and other protective equipment are insufficient to mitigate the potential hazard.

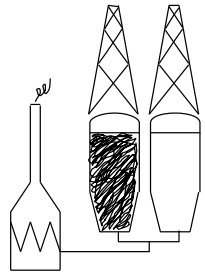
Heater Shutdown, Reactor Quench, HIPS, & Emergency Isolation are examples of SIS's

- They are passive systems waiting for a signal prior to acting

As a result SIL (Safety Integrity Level) is not applied

- We require a 97% availability factor

Delayed Coker Automation & Interlocks



Valve Interlock System Availability (cont'd)

Coker Interlock Systems are tested on an continual basis

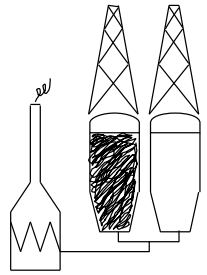
- Valve position indication consistency checking is needed (e.g., MOV's have position contacts for open & closed)

Basic PLC Requirements:

- Redundant Processors
- Redundant Power Supply (Primary on UPS)
- Environment conditioning system alarm
- Self-testing and systems diagnostics
- 1-0-0-2 redundant architecture for the PLC
- Failure of communications to Central Control building shall not affect PLC operations
- Input/output modules (the PLC) shall have redundant communications

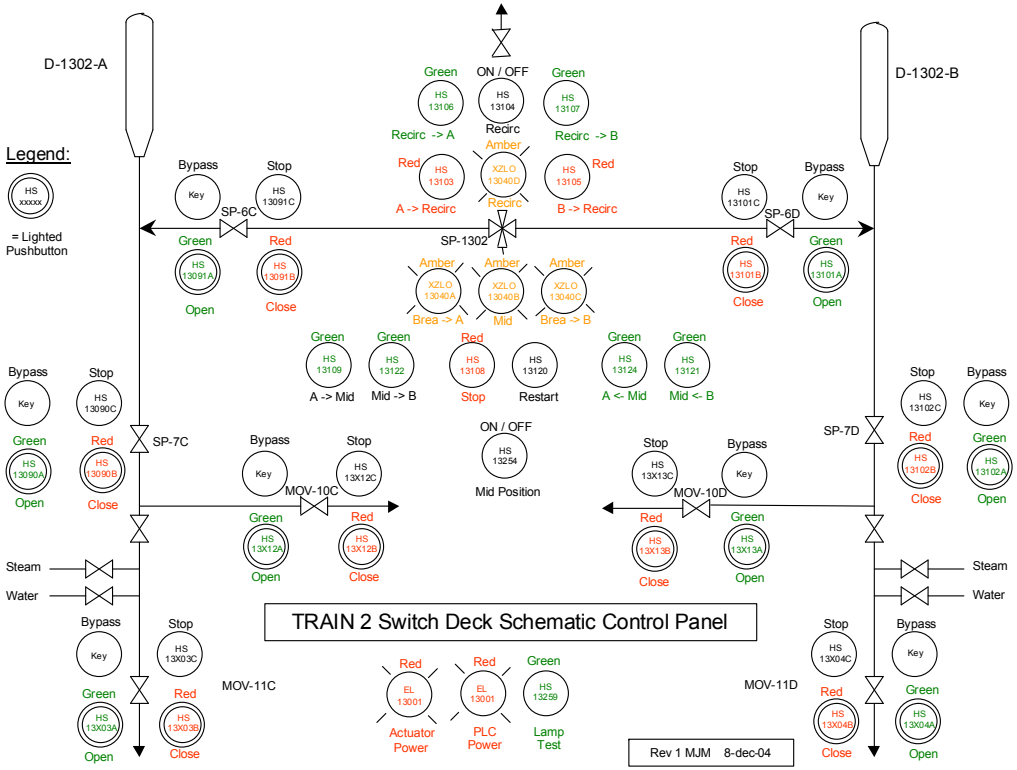
Delayed Coker Automation & Interlocks

Valve Interlock Systems - Miscellaneous



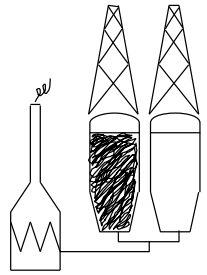
Bypassing of Interlocks

- Local Keyed Input with 5 minute reset
- Alarm in Central Control ensures 2-person communication
- Local Mimic Panels with view of valves help greatly



Delayed Coker Automation & Interlocks

Valve Interlock Systems - Manual Valve Applications



Quarter-Turn Valves with Factory-Installed Limit Switches

- Applicable to valve operations were incorrect opening or closing does not create a loss of containment
- Second vent valve or PRV discharge valve
- Wired to PLC with alarm function

Application of Smith Flow Control "Keyed Lock" design

- Requires use of specific keys to open or close a manual valve
- Makes sense for applications where valve movements are not frequent
  => PRV blocks, Pipe Pigging, Emergency System Lockouts
- Not practical for multiple coker valves

Guiding light system is an improvement (factor of 2 - 4) over LOTO

- However, does not yield an order of magnitude improvement since the human factor is still a big part