LOOKING BACK:
PHILLIPS 66 EXPLOSION
PASADENA, TX

North Jersey Section AIChE

Virtual Dinner Meeting

May 27, 2020

YOUR PRESENTER:

- Peter Sibilski, P.E., CEM, FAIChE
- Plant Manager, Pharmetic Manufacturing Co., LLC
- B.S., Chemical Engineering - NJIT
- MBA, Technology Management - University of Phoenix
- Member, Industrial Advisory Board, NJIT Otto York Dept. of Chemical and Materials Engineering
- Work experience includes:
  - Diamond Shamrock – specialty chemicals
  - Occidental Chemical – specialty chemicals
  - Henkel Chemical – specialty chemicals
  - Olin Hunt – microelectronics chemicals
  - EI Associates – A/E consulting
  - BOC Gases – industrial gases
  - Schering-Plough - pharmaceuticals
  - ALZO International, Inc. – specialty chemicals

ATTRIBUTIONS

Some information presented on these slides was obtained from:

- **Looking Back at the Phillips 66 explosion in Pasadena, Texas: 30 years later** – K. Bloch, contributing writer, and B.K. Vaughen, Lead Process Safety Subject Matter Expert, Center for Chemical Process Safety, AIChE; Hydrocarbon Processing, October 2018
- **The Phillips Explosion: Pasadena Texas, 1989** – The Pop History Dig; https://www.pophistorydig.com/topics/phillips-petroleum-explosion-1989/
- **30 years ago: The Phillips Petroleum explosion in Pasadena and 'RoboCop 2' films in Houston** – Chron.com; https://www.chron.com/local/bayou-city-history/article/30-years-ago-The-Phillips-Petroleum-explosion-in-14563155.php

Incident Summary

- The Phillips disaster was a devastating series of explosions and fires on October 23, 1989, occurring at approximately 1:05 PM local time, at Phillips Petroleum Company's Houston Chemical Complex (HCC) at 1400 Jefferson Road, Pasadena, TX
- The initial blast registered 3.5 on the Richter scale, and the conflagration took 10 hours to bring under control
- The explosions killed 23 employees and injured 314
  - *(185 Phillips employees and 129 contract employees)*
- The HCC produced approximately 15 billion pounds per year of High-density polyethylene (HDPE)

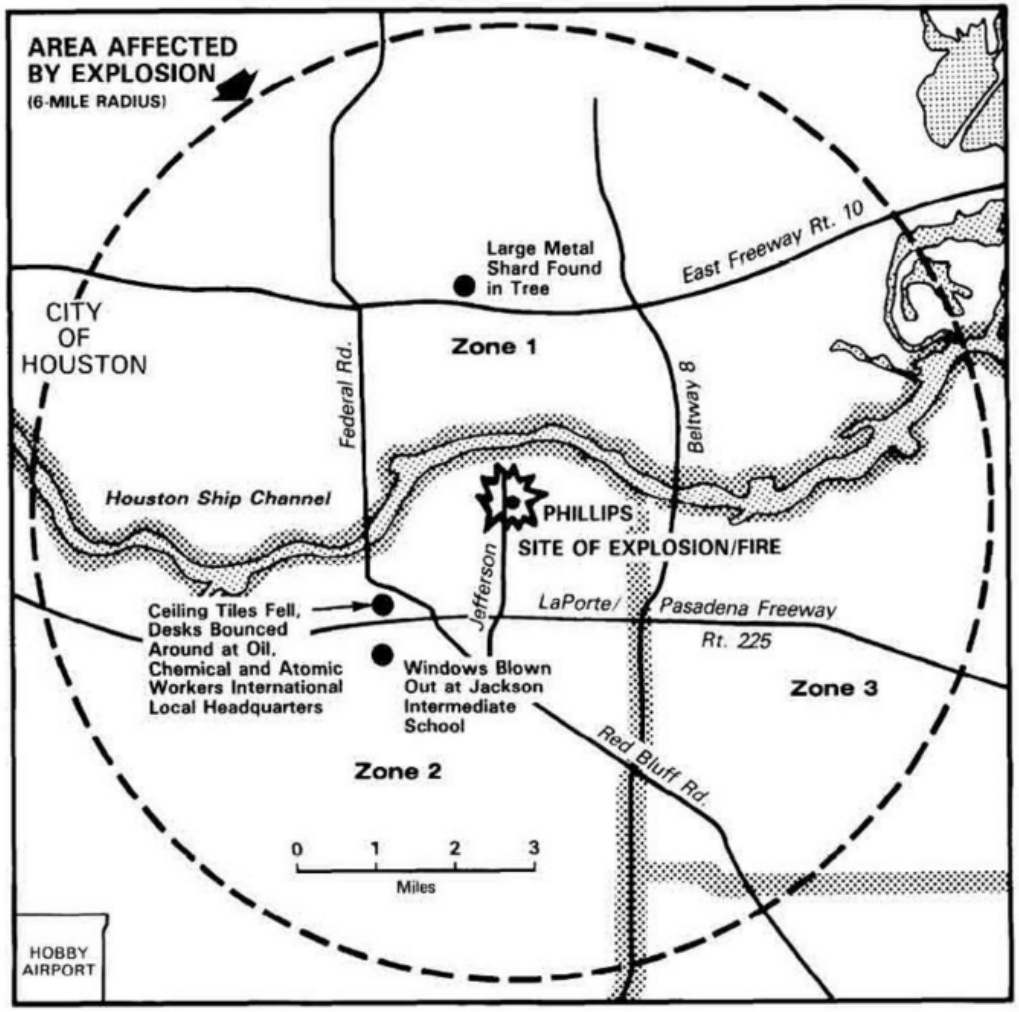
Incident Summary Cont'd

- Approximately 1,500 people worked at the facility, including 905 company employees and approximately 600 daily contract employees, who were engaged primarily in regular maintenance activities and new plant construction.
- In addition to the loss of life and injuries, the explosion affected all facilities within the complex, causing $715.5 million worth of damage plus an additional business disruption loss estimated at $700 million
- The two polyethylene production plants nearest the source of the blast were destroyed, and in the HCC administration building nearly 0.5 mile away, windows were shattered and bricks ripped out
- The initial explosion threw debris as far away as six miles.

The Cause and the Results

- The accident resulted from a release of extremely flammable process gases that occurred during regular maintenance operations on one of the plant's polyethylene reactors
- More than 85,000 pounds (42 tons) of highly flammable gases were released through an open valve almost instantaneously forming a vapor cloud that traveled rapidly through the polyethylene plant
- Within 90 to 120 seconds, the vapor cloud came into contact with an ignition source and exploded with the force of 2.4 tons of TNT
- Ten to fifteen minutes later, the initial explosion was followed by the explosion of a 20,000 gallon isobutane storage tank, then by the catastrophic failure of another polyethylene reactor, and finally by other explosions, estimated at about six in total

Area Affected by the Explosion



Firefighting Difficulties

- The firefighting water system at the HCC was part of the process water system
- When the first explosion occurred, some fire hydrants were sheared off at ground level by the blast - the result was inadequate water pressure for firefighting
- The shut-off valves which could have been used to prevent the loss of water from ruptured lines in the plant were out of reach in the burning wreckage
- No remotely operated fail-safe isolation valves existed in the combined plant / firefighting water system
- The regular-service fire-water pumps were disabled by the fire which destroyed their electrical power cables

Firefighting Difficulties Cont'd

- Of the three backup diesel-operated fire pumps, one had been taken out of service, and one ran out of fuel in about an hour
- Firefighting water was brought in by hoses laid to remote sources: settling ponds, a cooling tower, a water main at a neighboring plant, and even the Houston Ship Channel.
- The fire was brought under control within about 10 hours as a result of the combined efforts of fire brigades from other nearby companies, local fire departments, and the Phillips Petroleum Company foam trucks and fire brigade

The reality for those affected…

- "I saw a white gas in the air. We heard the alarm," said contract worker Mike Sinai, 23, who was airlifted to Hermann for observation of his respiratory system and later was discharged.
- Some survivors said they saw workers blown off their feet as they tried to run out of the plant.
- "I saw a guy get hit with flying debris," Sinai said. "He didn't get up. Nobody stopped to help. People were falling into ditches."
- As debris rained down around them, fire boats evacuated some plant workers immediately after the explosion and ferried them across the Ship Channel, said plant spokesman [Jerre] Smith.
- Many area residents described harrowing moments. Shirley Morales, 37, who lives about a mile from the plant, was mopping her kitchen floor when "something started rumbling the house around."
- "It knocked things off my walls and blew my windows and screens out. I thought a bomb had hit my house. I ran outside, and then I saw the flames," she said.
- Windows were blown out of nearby schools, and concerned parents arrived to take their children home early.

So, how did this happen?

The "Phillips Process"

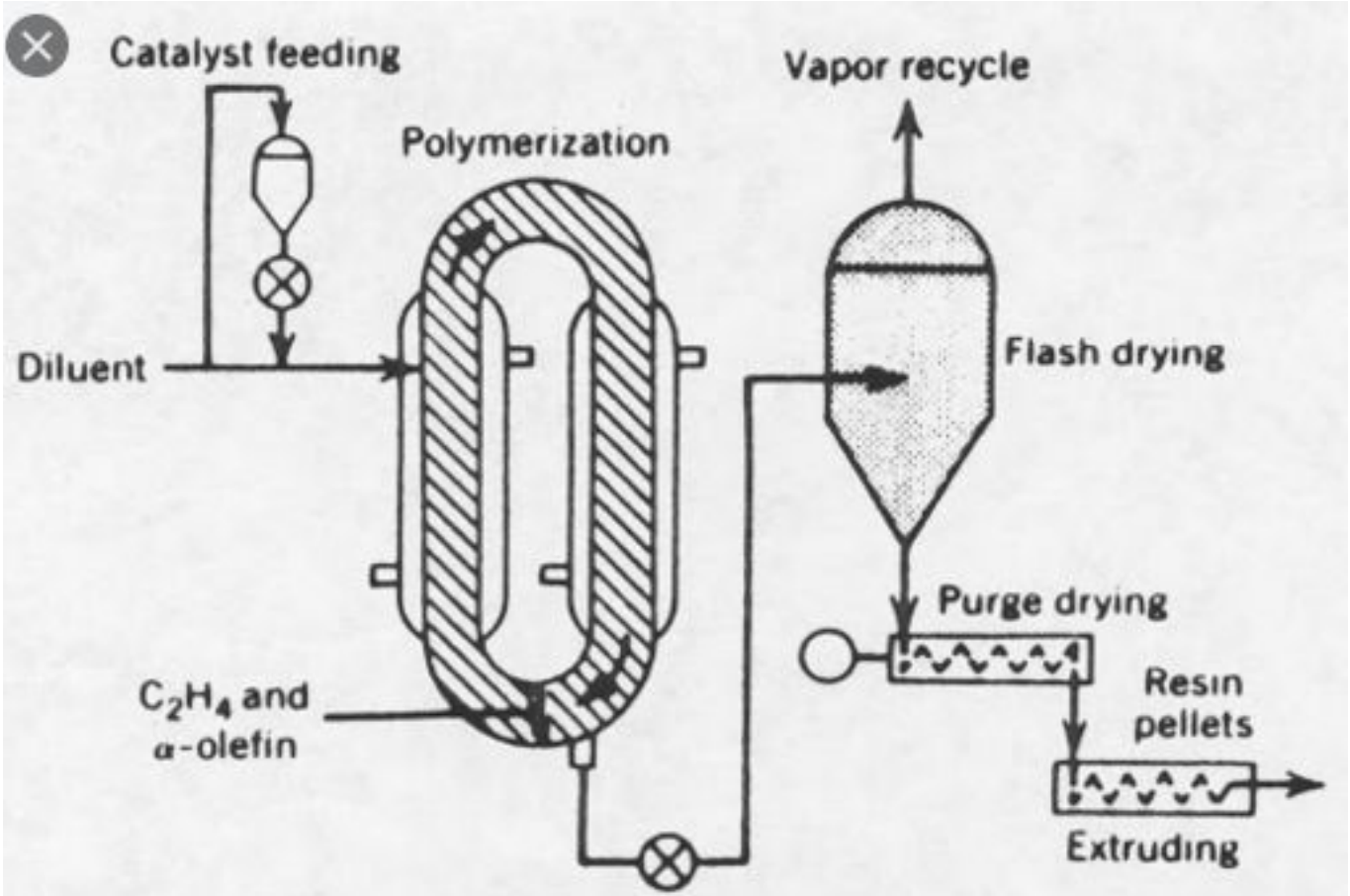
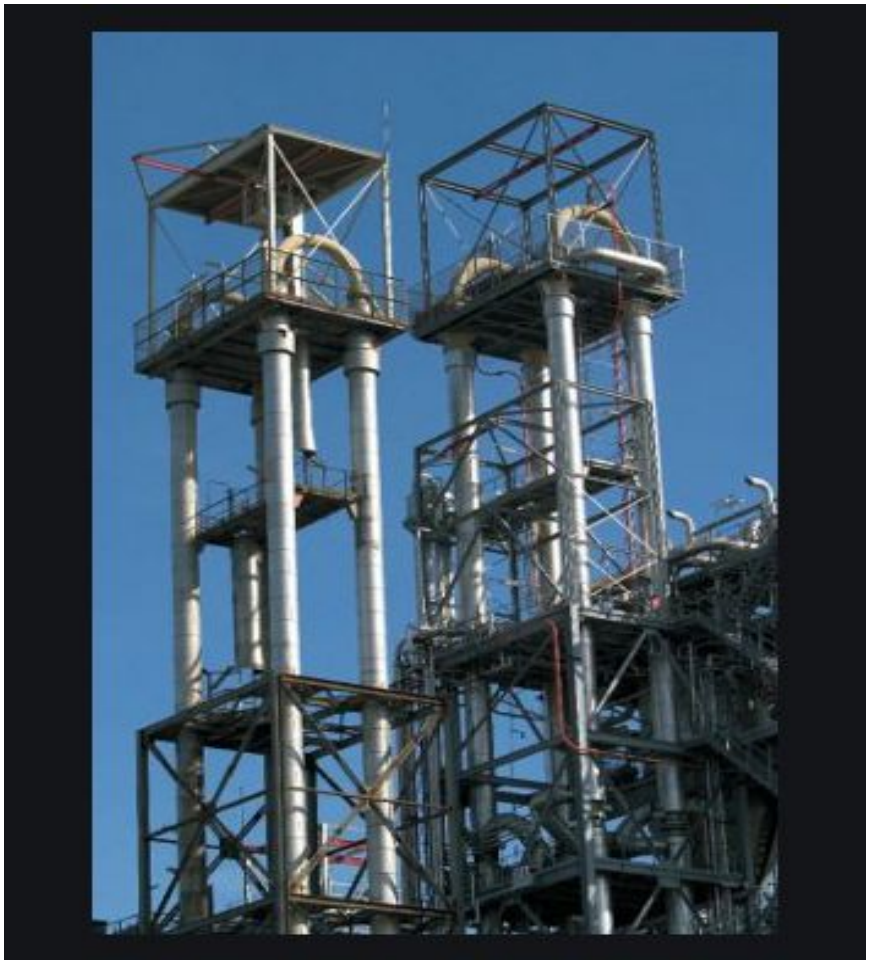
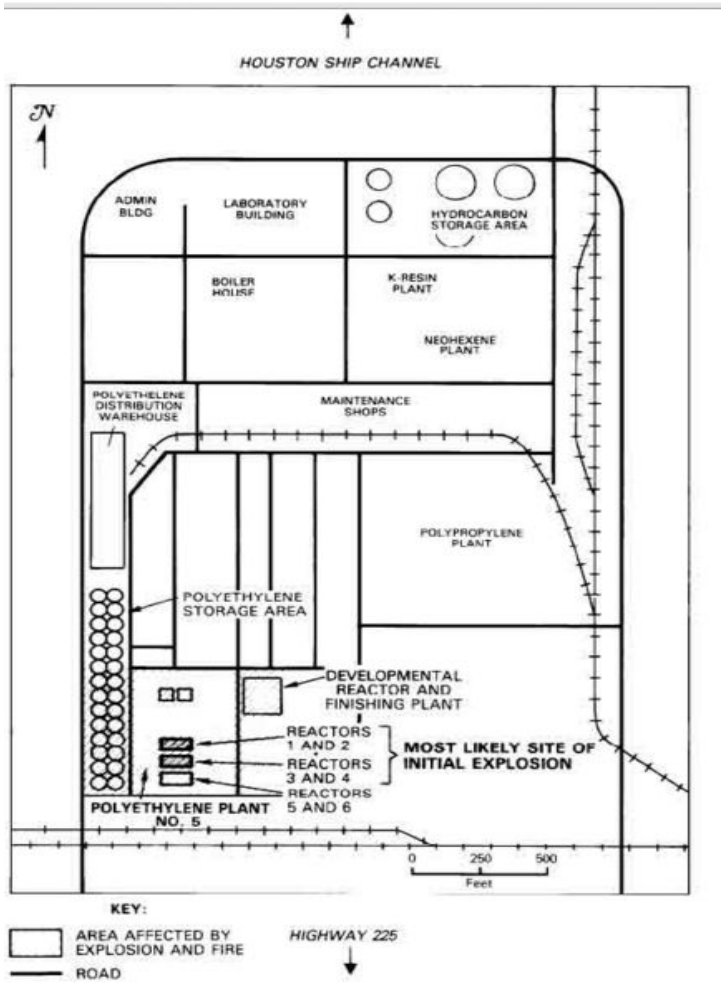


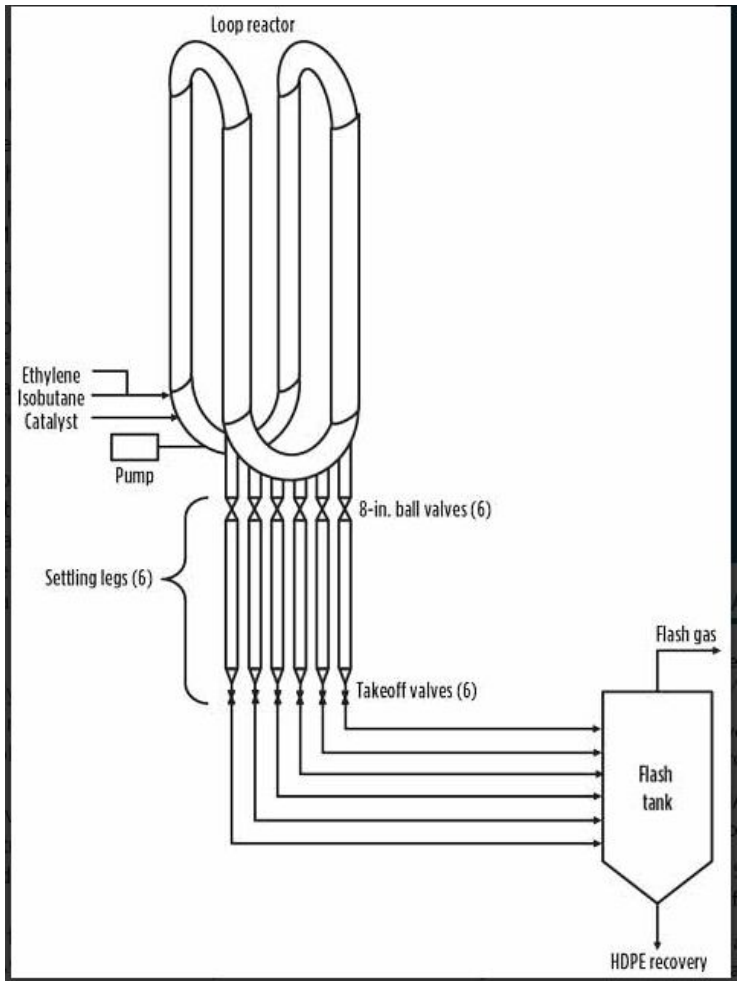
Fig. 10. Phillips loop reactor process (78).

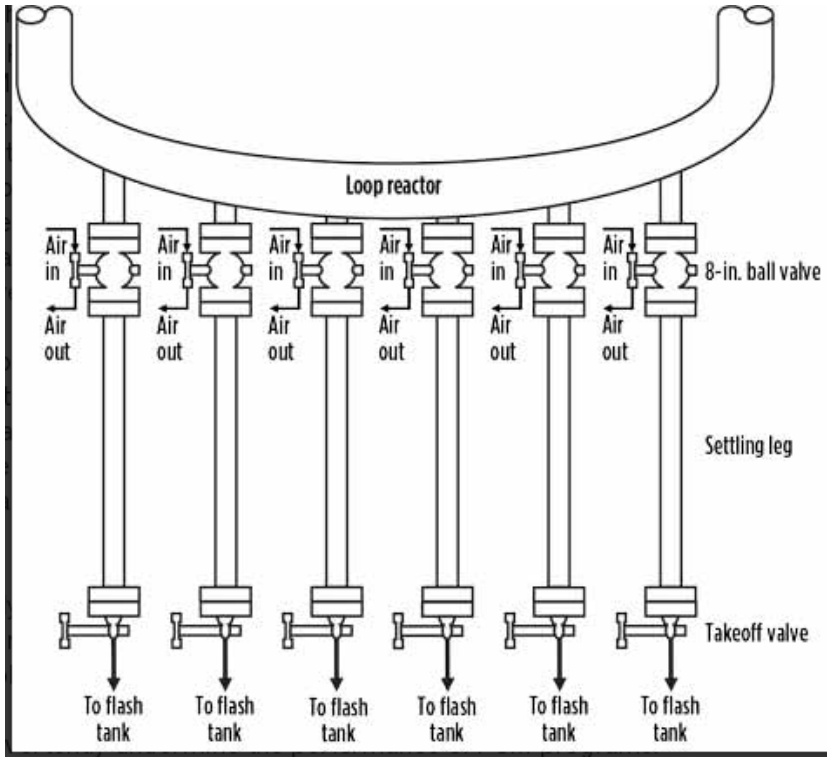
Loop Reactor and Location on Site





Loop Reactor with "Settling Legs"





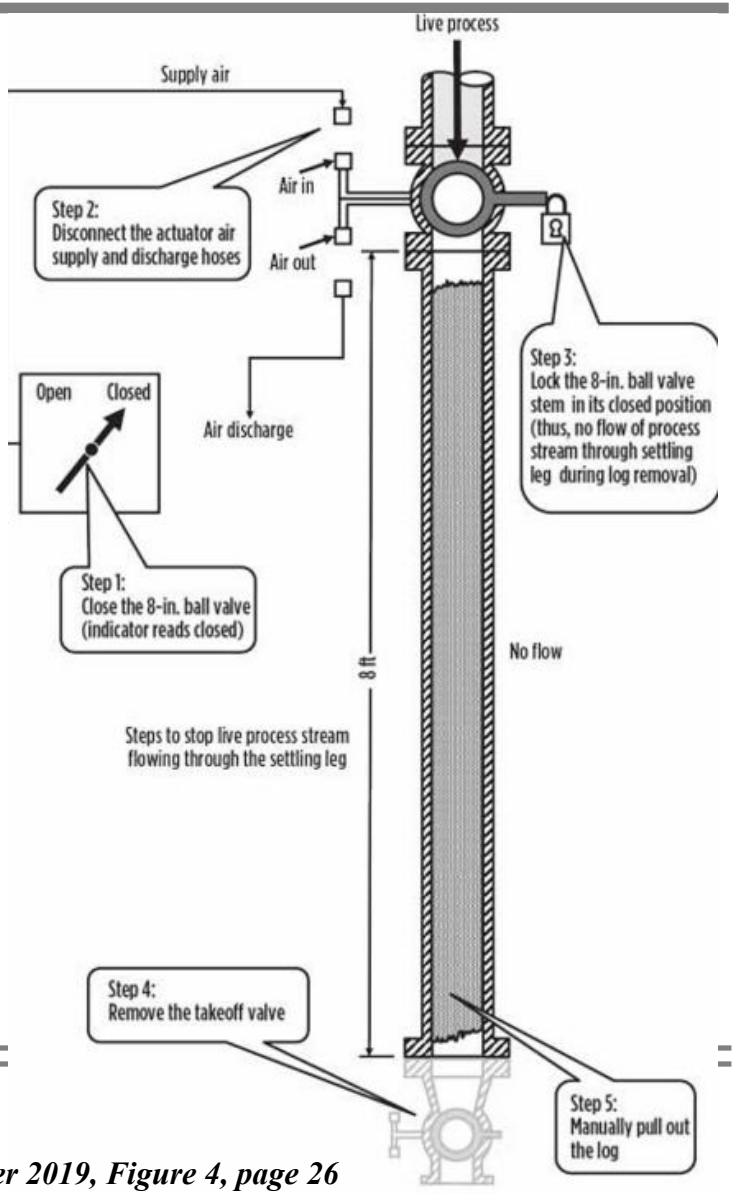
"Settling Legs", where polyethylene fluff collected

Hydrocarbon Processing, October 2019, Figures 1 & 2, pages 25 and 26

Settling Leg Maintenance

- Polyethylene fluff would often not flow freely through the settling legs, but instead, accumulate into a solid polyethylene “log” which had to be periodically removed
- The Pasadena plant had developed a site-specific, alternate isolation procedure that met the *intent* of the corporate isolation policy:

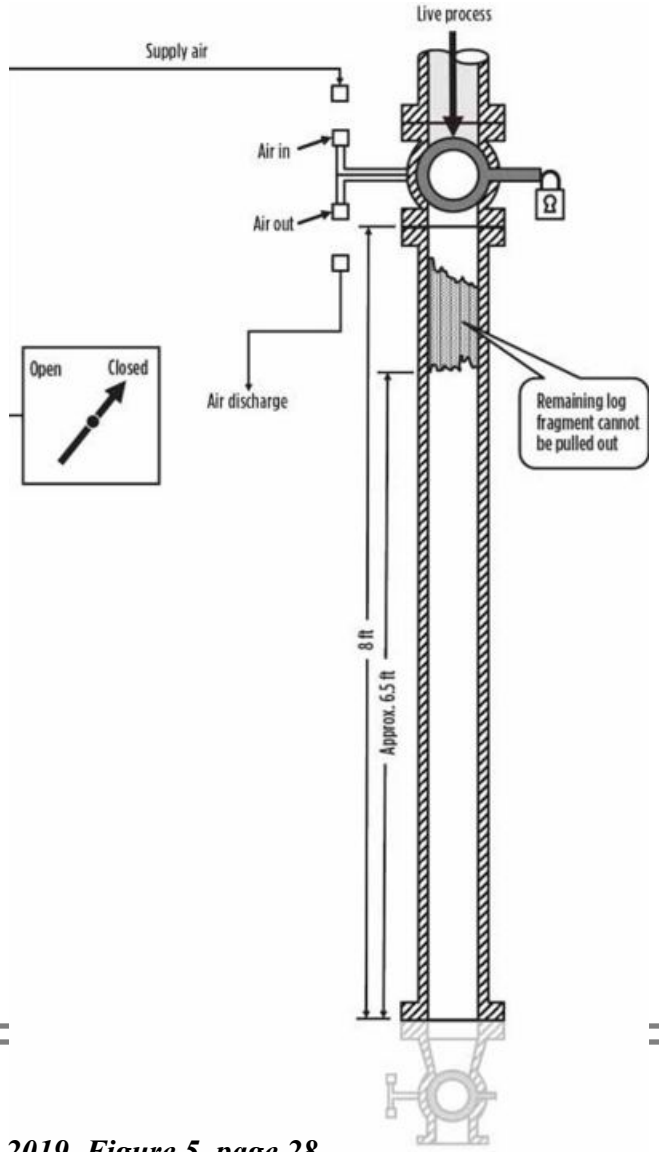
  1. Close the 8” ball valve
  2. Disconnect the air lines to the valve
  3. Lock the valve in the closed position



Hydrocarbon Processing, October 2019, Figure 4, page 26

Incident Summary

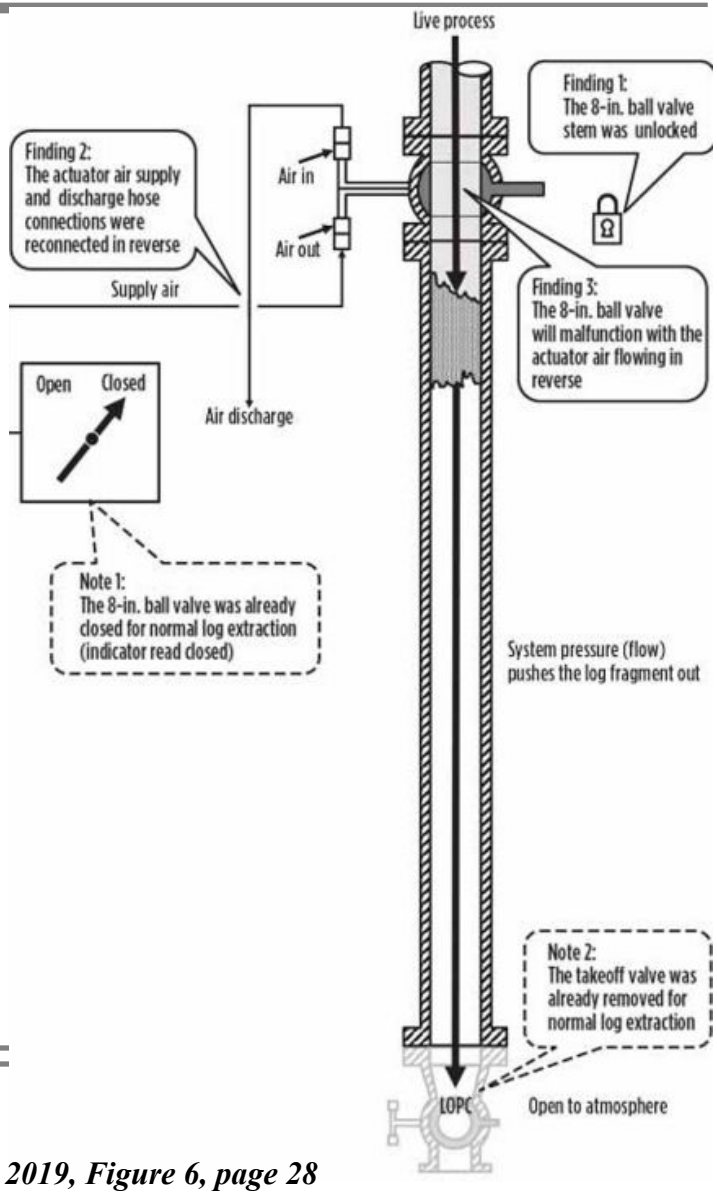
- 3 of the 6 settling legs of Reactor 6 were plugged on October 22, 1989
- Operations personnel isolated the three legs per the site's alternative isolation procedure
- Maintenance contractor then contacted to remove the logs from each of the plugged legs
- The 1st leg was disassembled and unplugged w/o difficulty, with the reactor still operating
- The following morning, the maintenance contractor started working on the 2nd leg
- During extraction, the log broke, leaving a portion in the settling leg just out of reach



Hydrocarbon Processing, October 2019, Figure 5, page 28

Incident Summary Cont'd

- OSHA's investigation concluded that the fire and explosion was caused by the release of flammable process gases
- Could not verify the specific sequence of events, since no one in direct control of the equipment survived the explosion
- It did determine that the site's alternative isolation practice was inadequate to prevent someone from inadvertently or deliberately opening the 8-inch ball valve
- Personnel familiar with the loop reactor operations explained why someone might intentionally open the valve while the settling leg was disassembled ……



Hydrocarbon Processing, October 2019, Figure 6, page 28

Incident Summary Cont'd

- **Polyethylene log removal is an example of where control of the 8-inch ball valve might be temporarily returned to the operator**
- **Process pressure could then be used to push a portion of a log that was out of reach, out of the settling leg**
- **This explanation seems to fit the information contained in the OSHA report:**
  1. *The 8-inch ball valve was found open*
  2. *The manual lock was removed from the valve stem*
  3. *The ball valve actuator air hoses were found reconnected – (however, they were reconnected in reverse)*
- **On the morning of the incident, permission to conduct this work-around was requested and denied twice before the release**

Investigation Results

- **OSHA's major findings included:**
  - Lack of process hazard analysis
  - Inadequate standard operating procedures (SOPs)
  - Non-fail-safe block valve
  - Inadequate maintenance permitting system
  - Inadequate lockout / tagout procedures
  - Lack of combustible gas detection and alarm system
  - Presence of ignition sources
  - Inadequate ventilation systems for nearby buildings
  - Fire protection system not maintained in an adequate state of readiness

Investigation Results Cont'd

- **Additional factors found by OSHA included:**
  - **Proximity of high-occupancy structures (control rooms) to hazardous operations**
  - **Inadequate separation between buildings**
  - **Crowded process equipment**
  - **Insufficient separation between the reactors and the control room for emergency shutdown procedures**
- **Quoting from a key OSHA document:**
  - *"At the conclusion of the investigation (April 19,1990), OSHA issued 566 willful and 9 serious violations, with a combined total proposed penalty of $5,666,200 to Phillips Petroleum Company, and 181 willful and 12 serious violations with a combined total proposed penalty of $729,600 to Fish Engineering and Construction, Inc., a maintenance contractor on the site."*

Investigation Consequences

- **OSHA citations:**
  - *As a result of a settlement between OSHA and Phillips Petroleum Company, OSHA agreed to delete the willful characterization of the citations and Phillips Petroleum Company agreed to pay a $4 million fine and institute process safety management procedures at HCC and the company's sister facilities at Sweeney, TX; Borger, TX; and Wood Cross, UT.*
- **Today, the facility continues to manufacture polyethylene.**
- **This complex employs 450 workers for the production of specialty chemicals, including 150 operations and maintenance personnel.**
- **This facility experienced additional fatalities in 1999 and 2000.**

Respect standards, policies and administrative controls

- Local site was expected to comply with corporate policy for isolating settling legs
  - Corporate policy required double-block valves or a blind be installed prior to performing invasive maintenance
  - Local site developed and implemented an alternate procedure contrary to corporate standard
  - Corporate procedure would not have prevented the ball valve from opening accidentally, or from connecting the airlines in reverse…..
  - …but the process release would not have occurred if the policy had been applied
- Human error will always be a possible source of system malfunction, but adherence to standards, policies and administrative controls can help mitigate the affects

Lessons Learned

- **Adhere to safe work practices:**
  - **Avoid the inclination to pursue alternative methods that may appear to offer an easier way to do things**
  - **When alternative methods previously applied "by exception only" become common and routine, you get "*normalization of the deviance*"**
- **Process design, operating and maintenance procedures are linked to an overall process and safety risk management program**
- **When a system does not meet it's design intent, investigate to find the root cause and correct it – do not design work-arounds that deviate from corporate standards**

Lessons Learned Cont'd

- **Comply with standards and regulations:**
  - **Created and implemented for the benefit of workers**
  - **Protect workers from what they do *not* know and cannot afford to learn through experience**
  - **Many standards and regulations originate from previous incidents**
- **Avoid the temptation to modify corporate standards with a substitute practice that meets the intent of the prescribed approach**
- **Facilities should invest in, and work to close any conformance gaps and achieve minimum specifications dictated in corporate standards**

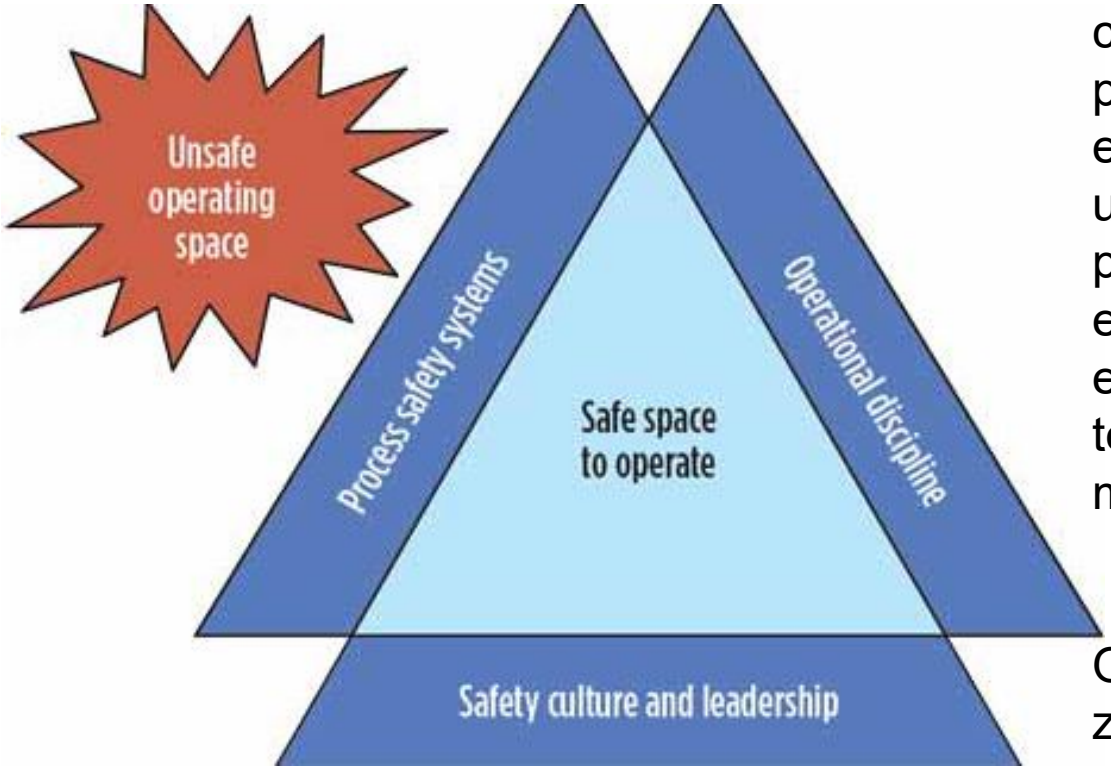
Lessons Learned Cont'd

- **Don't remove or disable safeguards:**
  - **Many incidents happen when safeguards (engineering or administrative), fail or are deliberately by-passed**
  - **Temporarily disabling safeguards when required in order to perform a specific job should be controlled with a rigorous management system**
- **Removing safeguards for anything other than the maintenance or testing of the safeguard itself is unacceptable**
- **The temporary removal of safeguards should never be considered "normal"**

Lessons Learned Cont'd

- **Maintain operating and maintenance discipline:**
  - **Everyone must have the operational discipline to "carry out each task the right way, each time"**
  - **"Everyone" includes all personnel, engineers, operators, mechanics, supervisors, managers, etc.**
- ***Operational discipline* is one of the three essential foundations for a successful process safety and risk management program, *(along with safety culture and leadership, and process safety systems)***
- **Weaknesses in operational discipline at any point in the equipment's lifecycle can adversely affect the "safe operating zone" of a facility**

Safe Operating Zone



A safe operating zone is created by simply operating a process every day within the equipment's safe design limits, using standard operating procedures and maintaining equipment within the guidelines established in an inspection, testing, and preventative maintenance program

Operating in a safe operating zone maintains process stability, and more importantly, saves lives

Hydrocarbon Processing, October 2019, Figure 7, page 30

"There is no expedient to which a man will not resort to avoid the real labor of thinking."

Sir Joshua Reynolds

Psibilski@.ALZOUSA.com

- https://www.youtube.com/watch?v=gzl8_95UaiE
- https://www.youtube.com/watch?v=FCIBvrqi6YI