

# Phillips 66 Fire & Explosion

Robert M. Bethea  
Texas Tech University

# 29 CFR 1910.147: Lockout/Tagout

- Jan. 1977: “Request for Technical Issues”
- June 17, 1980: “Advanced Notice of Proposed Rulemaking”
- July, 1983: Preliminary draft issued for comment
- Apr. 29, 1988: Published in *Federal Register* as a proposed standard
- Oct. 31, 1989: Effective date of standard



# 29 CFR 1910.119: Process Safety Management

- Based on lessons learned: Flixborough, Seveso, Bhopal & many other disasters
- Congress: feared that an “American Bhopal” could occur
- 1985: Center for Chemical Process Safety formed
- Aug., 1985: highly hazardous chemicals released from a plant in Institute, WV

# 29 CFR 1910.119: Process Safety Management

- OSHA: program needed to examine practicality for prevention of disastrous releases and mitigation of effects of non-preventable releases
- 1986: EPA issued SARA Title III and initiates program in response to the potential for catastrophic releases

# 29 CFR 1910.119: Process Safety Management

- 1990: API published RP 750: Management of Process Hazards
- July 17, 1990: PSM standard formally proposed
- May 26, 1992: Effective date of OSHA's PSM standard

Houston Chemical Complex  
Pasadena Texas  
October 23, 1989

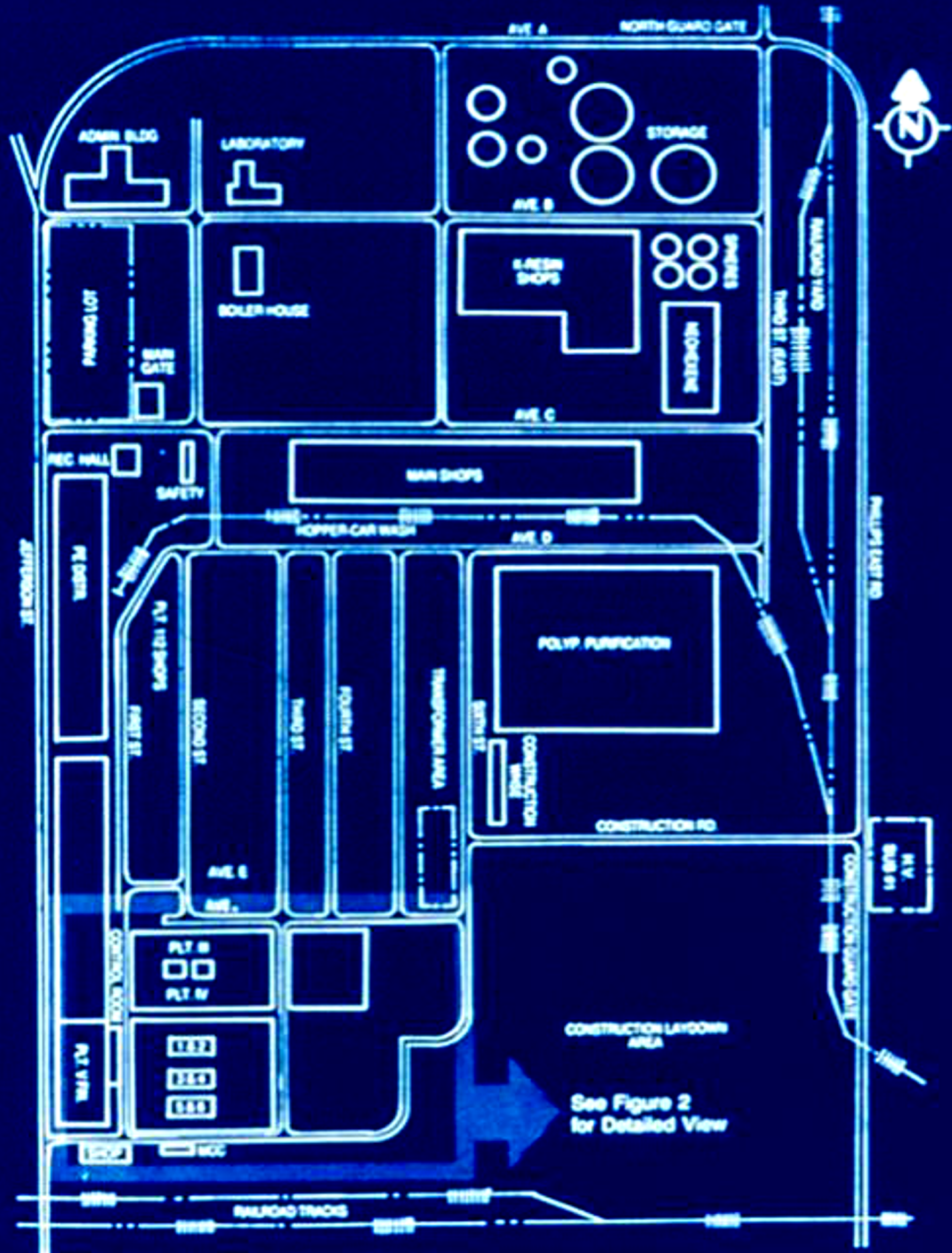
# Fire and Explosion in PE Reactor

- Sudden gas release through open DEMCO valve – 85,000 lb<sub>m</sub> mixture of hydrogen, ethylene, hexene & isobutane
- Unidentified ignition source “found” within 2 min.
- Explosion equivalent to 2.4 tons of TNT
- Second explosion 10-15 min. later:  
2 isobutane storage tanks
- More explosions during next 2 hrs.

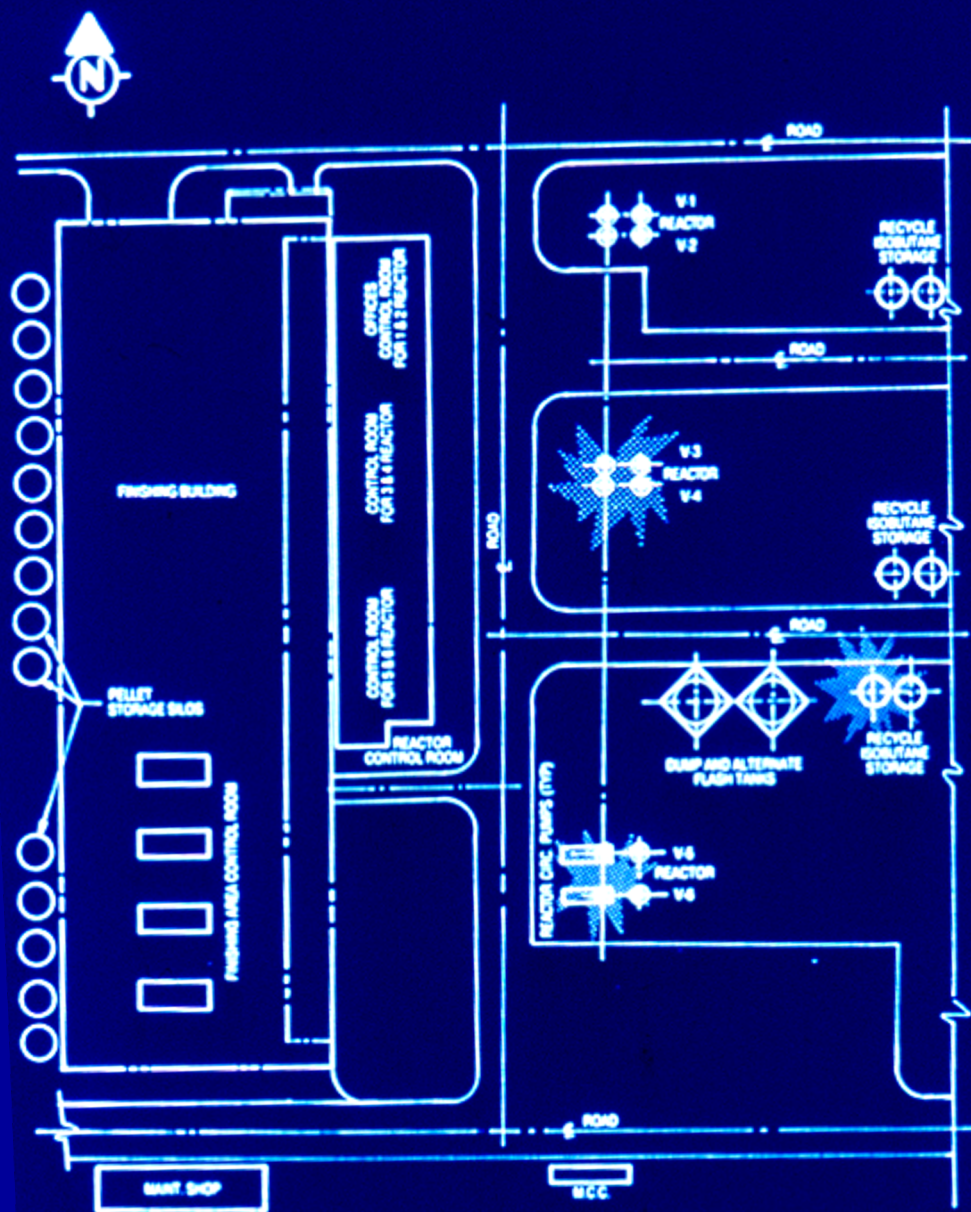


# Consequences

- 23 workers killed: 2 contractor, 21 Phillips
- Debris scattered over 6-mile radius
- 2 polyethylene plants completely destroyed
- Property damage: \$715 million (1/1/93)
- Business interruption loss: \$700 million (1/1/93)
- Disruption of plant fire-fighting water
- Only 1 effective diesel backup fire-water pump



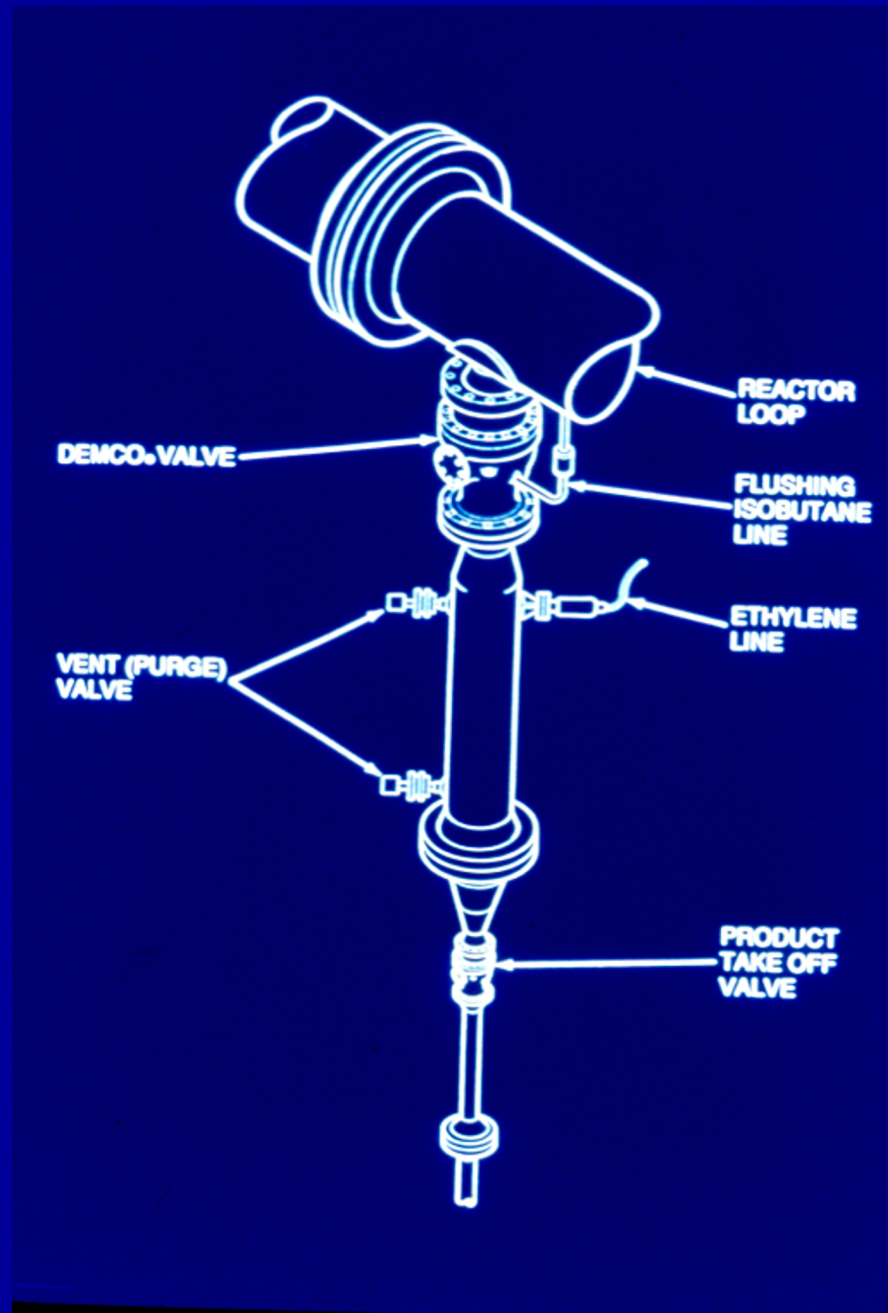




# Immediately Prior to Explosion

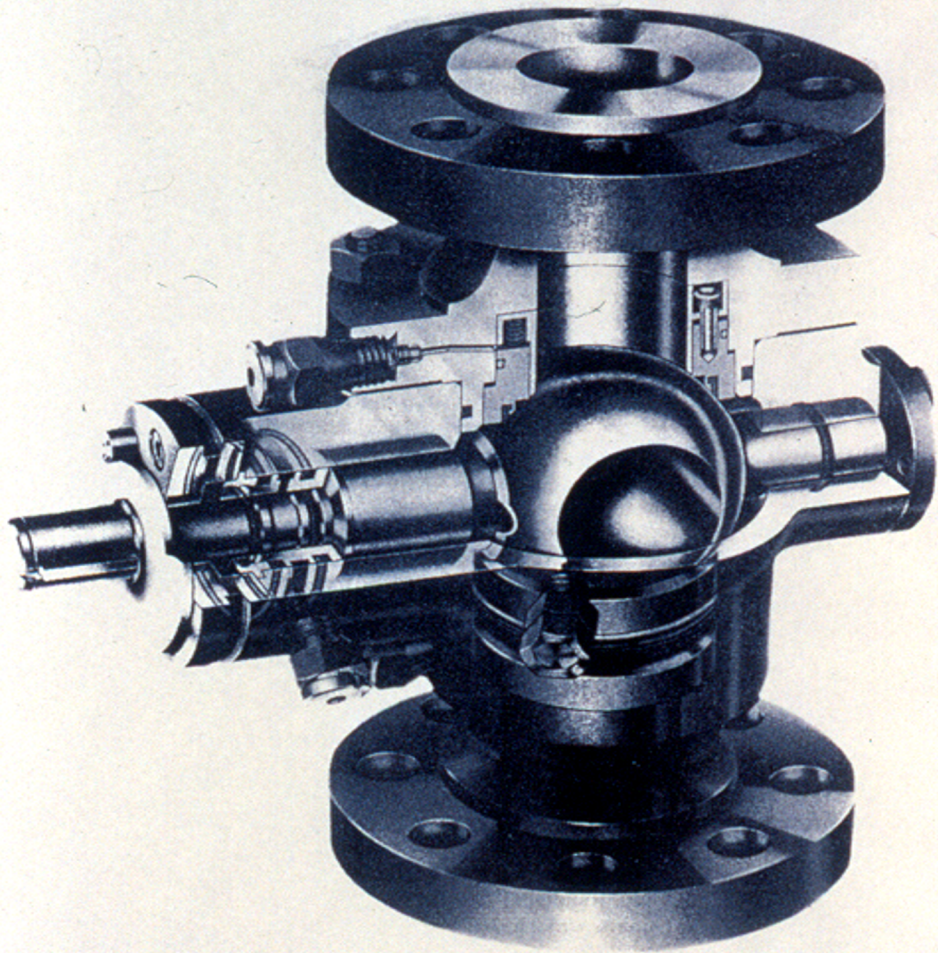
- 3 settling legs on Reactor 6 were plugged
- All legs prepared by Phillips operator:  
ready for maintenance  
DEMCO valve in closed position  
air hoses disconnected
- Fish Engineering (maintenance contractor)  
partially disassembled no. 4 leg  
extracted polyethylene “log”  
requested Phillips operator assistance

# Reactor Settling Leg





# Demco Valve



# The Explosion

- Vapor released from disassembled settling leg
- High operating pressure (600 psi): 99% of reactor contents dumped in a few sec.
- Huge unconfined vapor cloud formed & moved rapidly downwind
- Potential ignition sources: forklift, diesel crane, welding & torch cutting, gas-fired catalyst activator (open flame), vehicles near polyethylene plant office

# The Explosion – cont.

- Ignition within 90-120 seconds
- Second explosion 10-15 min. later: two 20,000-gal. isobutane storage tanks
- Third explosion: 15-30 min. later: another polyethylene plant reactor failed catastrophically





# Immediate Response

- Initial response: Phillips fire brigade
- Site command: Phillips fire chief
- Local response units: fire, police, ambulance
- Channel Industries Mutual Aid (CIMA)  
106 members in Houston area  
mission: emergency assistance to  
members: fire-fighting, rescue, first-aid  
personnel, equipment
- EPA technical assistance team



# Firefighting

- Common process/fire-fighting water system
- Fire hydrants sheared off by blast
- Inadequate water pressure
- Regular service fire pumps disabled by fire
- Only 1 backup diesel fire pump available
- Hose laid to remote water sources
- Fire control by CIMA members, local fire departments, Phillips foam trucks
- Control within about 10 hrs.



# Search and Rescue

- U.S. Coast Guard, Houston fireboats evacuated more than 100 people across Ship Channel
- Coordination by Harris County Medical Examiner and County Coroner
- Efforts delayed until fire & heat subsided
- Difficult because of damage & danger of structural collapse
- OSHA preserved, evaluated evidence

# Investigation Results

- DEMCO valve open at time of release
- Air hoses connected in reverse position
- Inadequate valve lockout system
- Local procedures did not incorporate required double block valves or blind flange insert when a line in a chemical or hydrocarbon service is opened

# Unsafe Conditions

- No lockout device in place on DEMCO valve actuator mechanism
- Air supply hoses could be connected during maintenance
- Identical air hose connectors for “open” and “closed” sides of valve
- Air supply valves for actuator hoses in “open” position

# Contributing Factors

- No dedicated fire-water system
- Combined plant/fire-water system not physically protected
- No remotely-operated isolation valves on water system
- Site layout & proximity of high-occupancy structures to hazardous operations

# More Contributing Factors

- Inadequate separation between buildings
- Crowded process equipment
- Insufficient separation between reactor & control room for emergency shutdown procedures

# Co-operating Agencies

- CIMA
- Texas Air Control Board
- Harris County Pollution Control Board
- FAA
- U.S. Coast Guard
- OSHA
- EPA



# Findings

1. No process hazard analysis had been utilized in the Phillips polyethylene plants.
- 2a. Phillips' existing safe operating procedures for opening lines in hydrocarbon service were not required for maintenance of the polyethylene plant settling legs.

# Findings - continued

- 2b. No provision for redundancy on DEMCO valves, no adequate lockout/tagout procedure, improper design of [DEMCO] valve actuator mechanism.
- 3. An effective safety permit system was not enforced with regard to Phillips or contractor employees to ensure proper safety precautions during maintenance.

# Findings -continued

- 4. No permanent combustible gas detection & alarm system in the reactor units to provide early warning of leaks or releases.
- 5a. Ignition sources were located near to or downwind from large hydrocarbon inventories.

# Findings -continued

- 5b. Ignition sources were introduced into high-hazard areas without prior flammable gas testing.
- 6. Inadequate separation between occupied locations and/or vital control equipment & process units.

# Findings -continued

7. Ventilation system intakes for buildings in close proximity to or downwind from hydrocarbon processes or inventories.
8. Fire protection system was not maintained in a state of readiness necessary to provide effective firefighting capability.

# Learning from the Phillips Disaster

- Necessity for crisis management planning at corporate level
- Value of continual employee training in emergency response procedures
- Value of participation in a cooperative emergency response network
- Insufficient coordination among responders with news media

# Findings from Cooperative Review

- Federal & state officials at scene did not always coordinate activities, sometimes provided contradictory information
- Need for a backup emergency command center
- Preplanned triage sites essential
- Phone calls delayed use of Emergency Broadcast System
- EOC warnings gave no toxicity information

# Cooperative Review Accomplishments

- Development of a central contact point for information
- Development of checklist for reporting & responding to emergencies
- Agreement on standard signals for outdoor warning systems



# Recommendations from Cooperative Review

- Application for an emergency broadcast system transmitter
- Include backup emergency operations center in all emergency plans

# Implications for ChE Curricula

- Practice in using PHA techniques
- Include concepts of inherently safer designs
- Exposure to selecting & sizing PRVs
- Lockout/tagout procedures
- Emergency shutdown & evacuation
- Understand & use safety features & procedures in plant environments
- Necessity for developing teamwork skills