Phillips 66
Fire & Explosion

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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 than 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

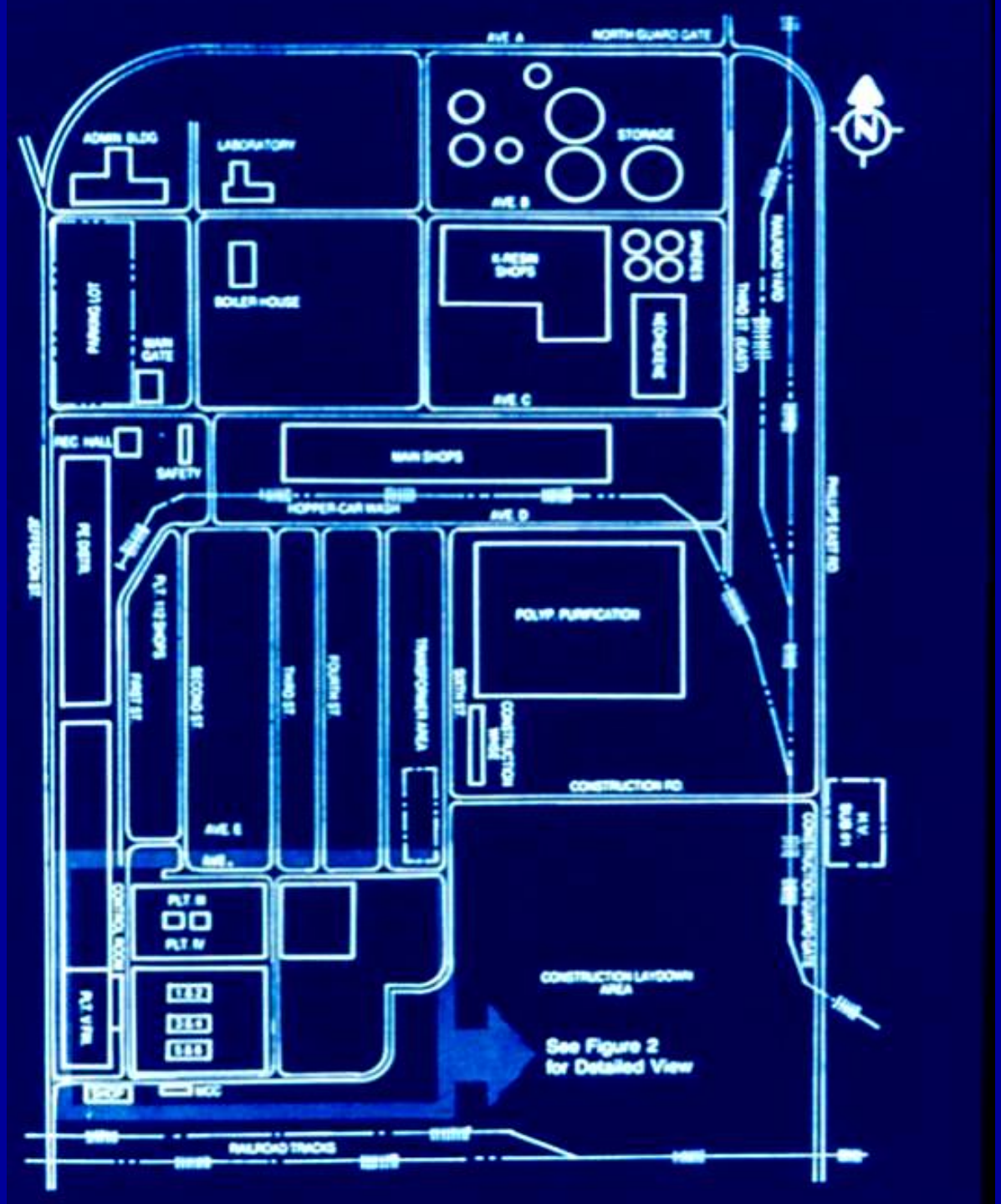
Houston Chemical Complex
Pasadena Texas
October 23, 1989

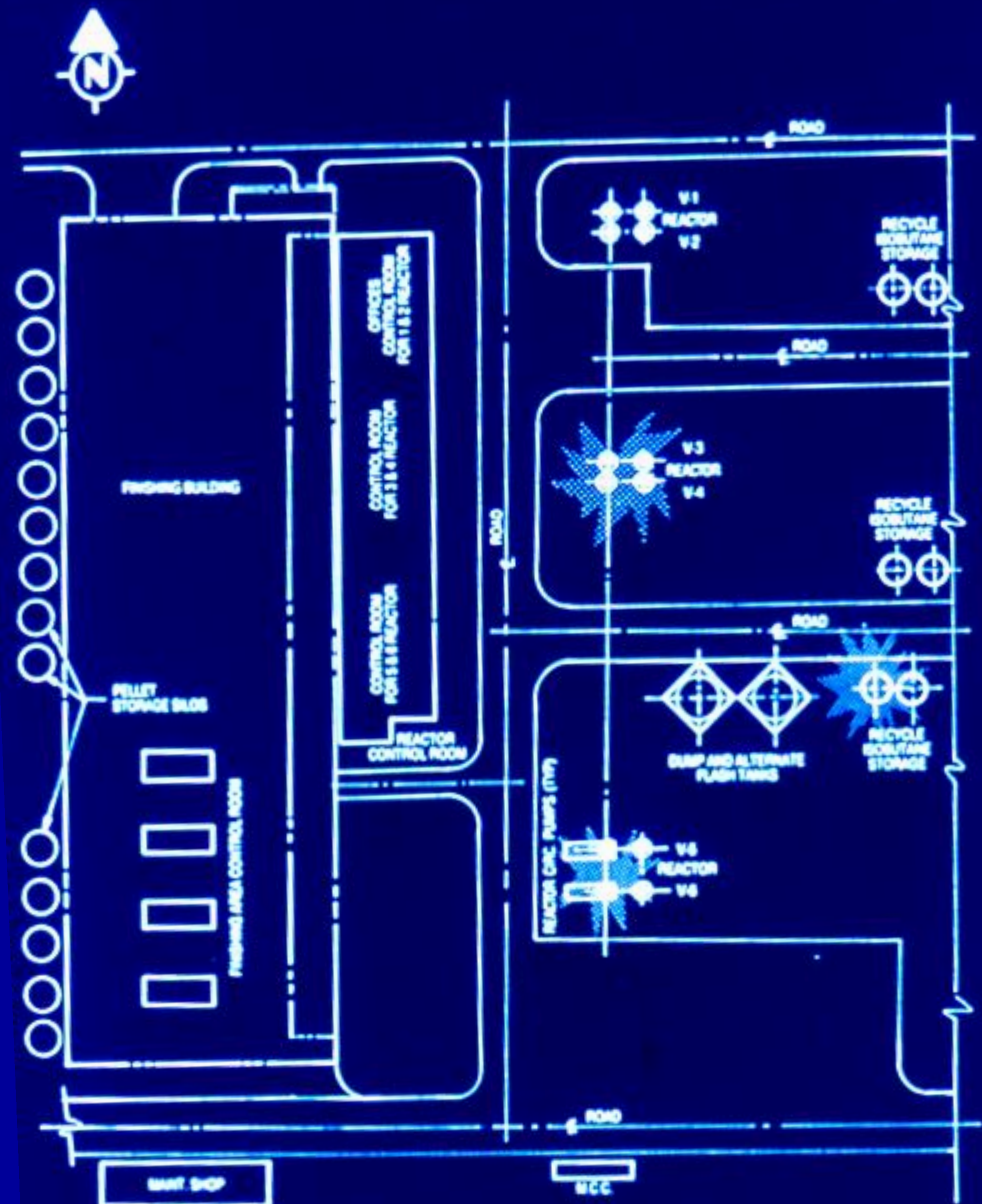
Fire and Explosion in PE Reactor

- Sudden gas release through open DEMCO valve – 85,000 lb_m 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


AVE. A
NORTH GUARD GATE
ADMIN BLDG
LABORATORY
STORAGE
AVE. B
PARKING LOT
GUARD GATE
BOILER HOUSE
X-RESIN SHOPS
DRUMS
HOPPER
RAILROAD YARD
AVE. C
REC HALL
SAFETY
MAIN SHOPS
HOPPER CAR WASH
AVE. D
POLYP PURIFICATION
CONSTRUCTION MAT'L
CONSTRUCTION RD
AVE. E
PLT III
PLT IV
CONSTRUCTION LAYDOWN AREA
See Figure 2 for Detailed View
RAILROAD TRACKS

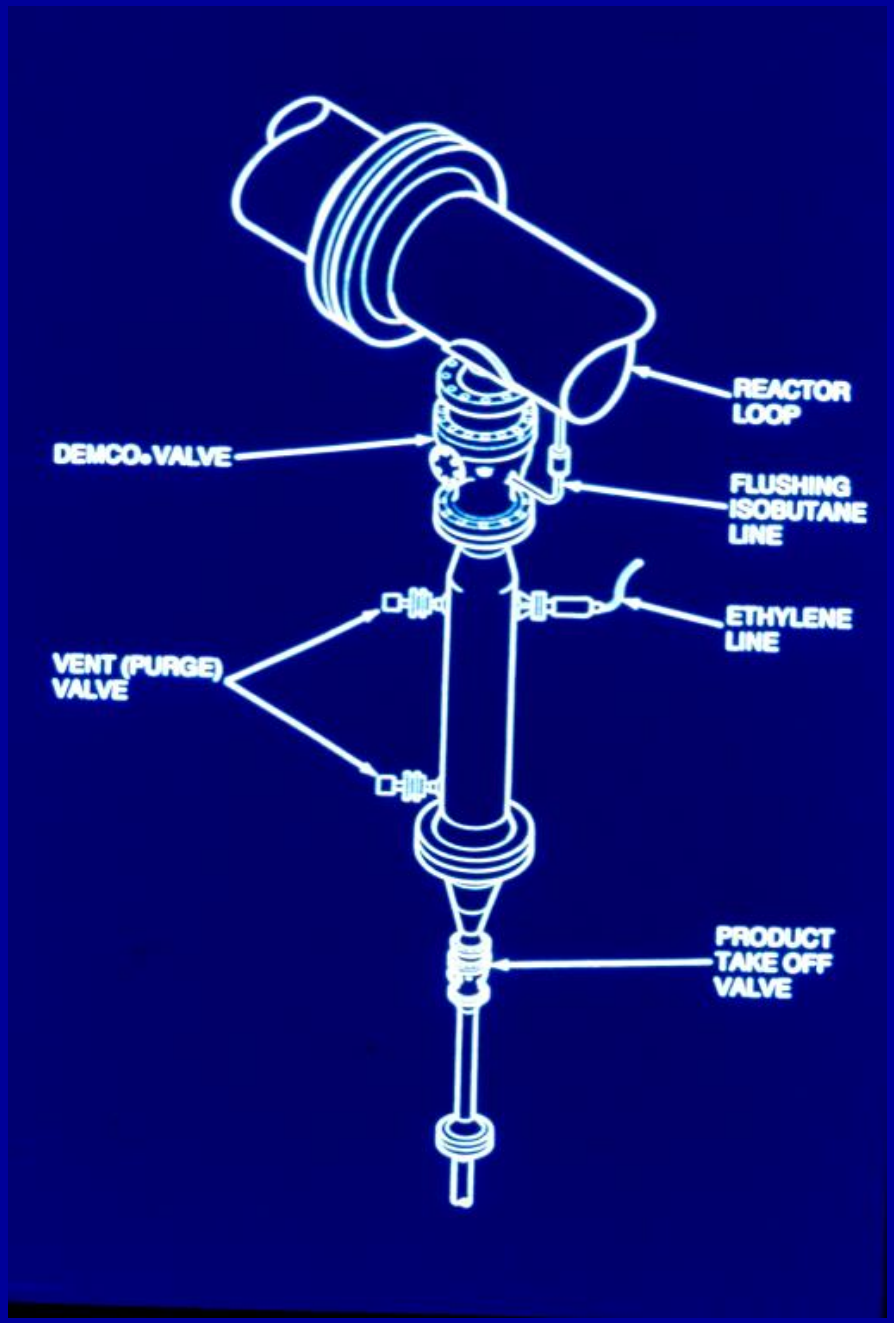


N
ROAD
V-1
REACTOR
V-2
RECYCLE
ISOBUTANE
STORAGE
ROAD
V-3
REACTOR
V-4
RECYCLE
ISOBUTANE
STORAGE
ROAD
DUMP AND ALTERNATE
FLASH TANKS
RECYCLE
ISOBUTANE
STORAGE
V-5
REACTOR
V-6
FINISHING BUILDING
PELLET
STORAGE SILOS
REACTOR
CONTROL ROOM
ROAD
MAINT SHOP
M.C.C.

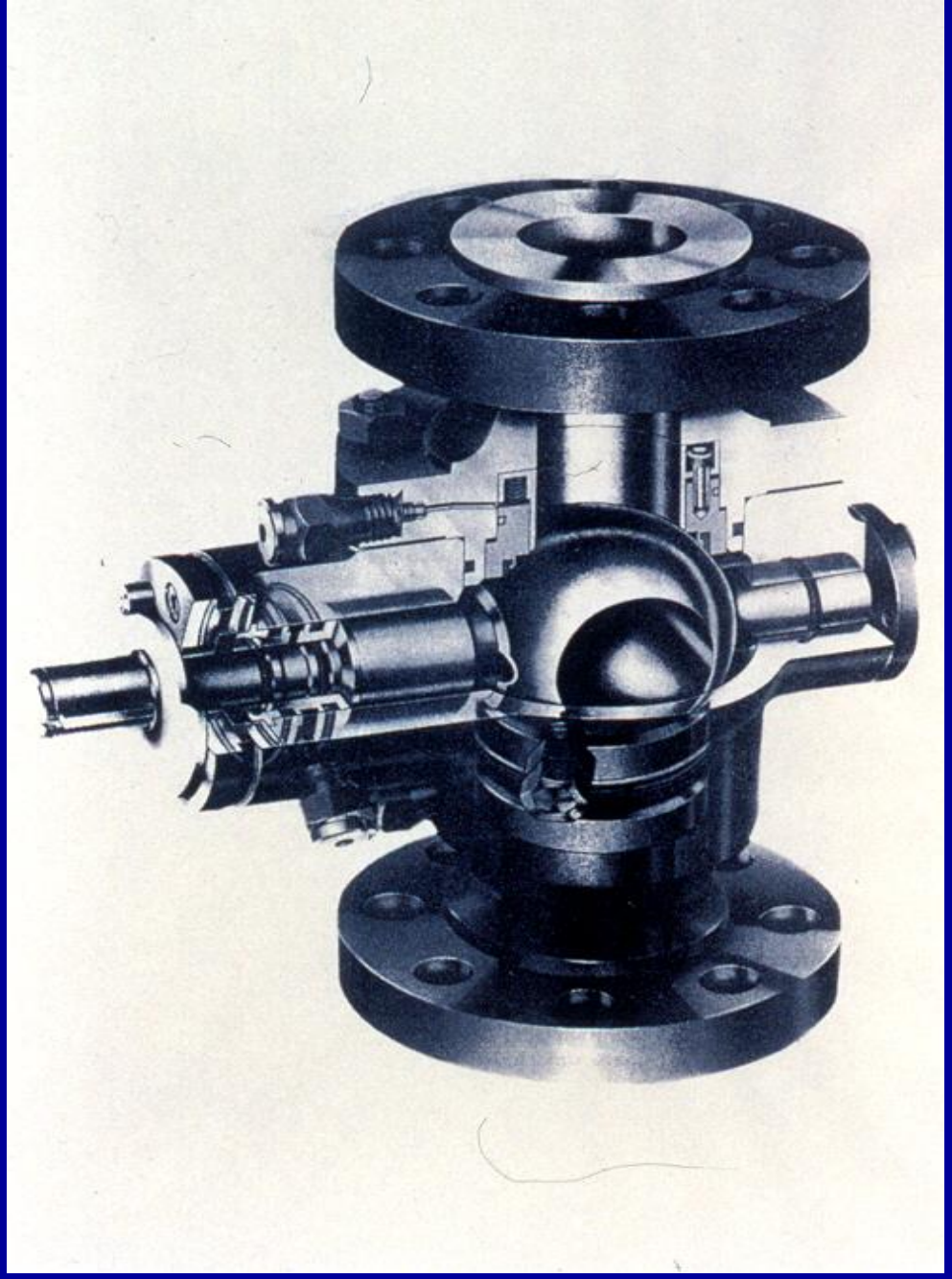
Immediately Prior to Explosion

- 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