CE 400 / CE 500

Process Safety Management

Lecture 27 Process Safety in Design

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Process Safety Hierarchy

There are four basic strategies and there is a preferred order of implementation

1. Inherently Safer Technology
   - Hazard is eliminated or reduced
2. Passive Safeguards
   - Safeguard is always ready
3. Active Safeguards
   - Safeguard needs to be called into action and/or needs to function
4. Procedural Safeguards
   - Rules that need to be followed

Design Applications

- Early in the design process we need to start thinking about what may go wrong during operations
- Design system in such a way that one error does not lead to unacceptable consequences
  - Back up systems and redundancy
  - Eliminate enabling conditions
  - Mitigate the effects of the error

Input Errors to BPCS*

- Fat Finger
  - Inputting wrong number by mistyping
    - Can limit range of values that the control system will accept
- Selection of wrong unit
  - Operator tries to give command to a different process unit than they intend to do
    - This will be discussed with Human Factors
  - Can program operating logic such that it will not accept certain commands if they lead to unsafe conditions

* Basic Process Control System

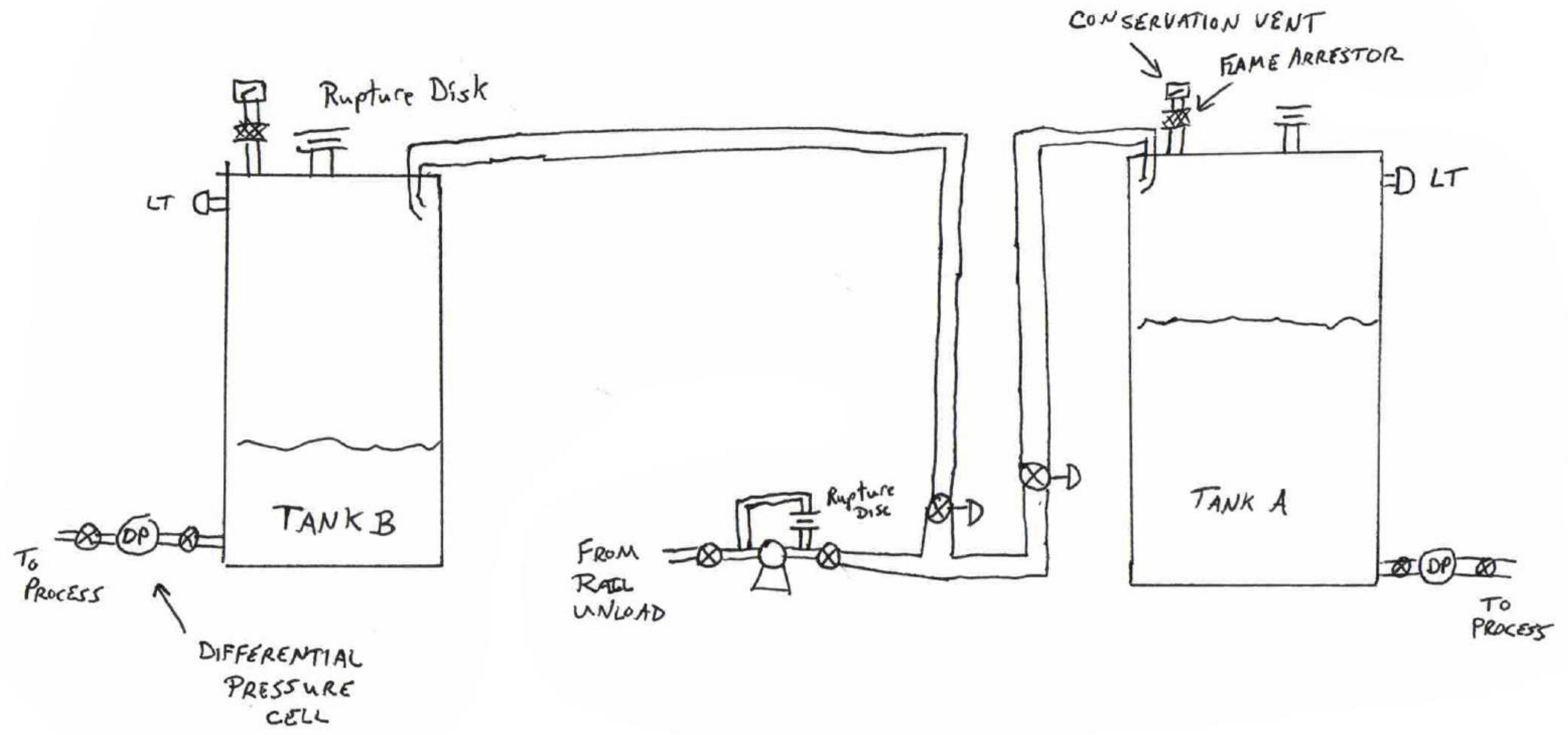
Common Pump Failures

- Pump Fails to deliver desired flow
  - Pump motor stops / Pump Jams / Pump decouples from motor / check valves malfunction on diaphragm pump / pump speed incorrect
  - Methods required depend on consequence and time scale
    - A warning alarm may be sufficient for low consequence or long time scale
    - Emergency Shutdown interlock may be required for higher consequence or shorter time scale
- Leaks
  - Usually occur at drive shaft
  - Mechanical Seals or Magnetic Couplings
  - Diaphragm pumps do not have a shaft to seal

Common Pump Failures

- Pump Flow is blocked and can lead to overpressure and Loss of Containment
  - This is only a problem for Positive Displacement Pumps
  - Centrifugal and Diaphragm Pumps do not generate overpressure
    - They are not generally acceptable for metering operations
    - They are a good choice for transferring materials
- Pressure Relief Valves and Rupture Discs can provide overpressure protection
  - They are required for positive displacement pumps handling hazardous materials
    - Disc bursts or valve opens at a set pressure and flow is directed back to source or to inlet of pump

Common Tank Filling Design

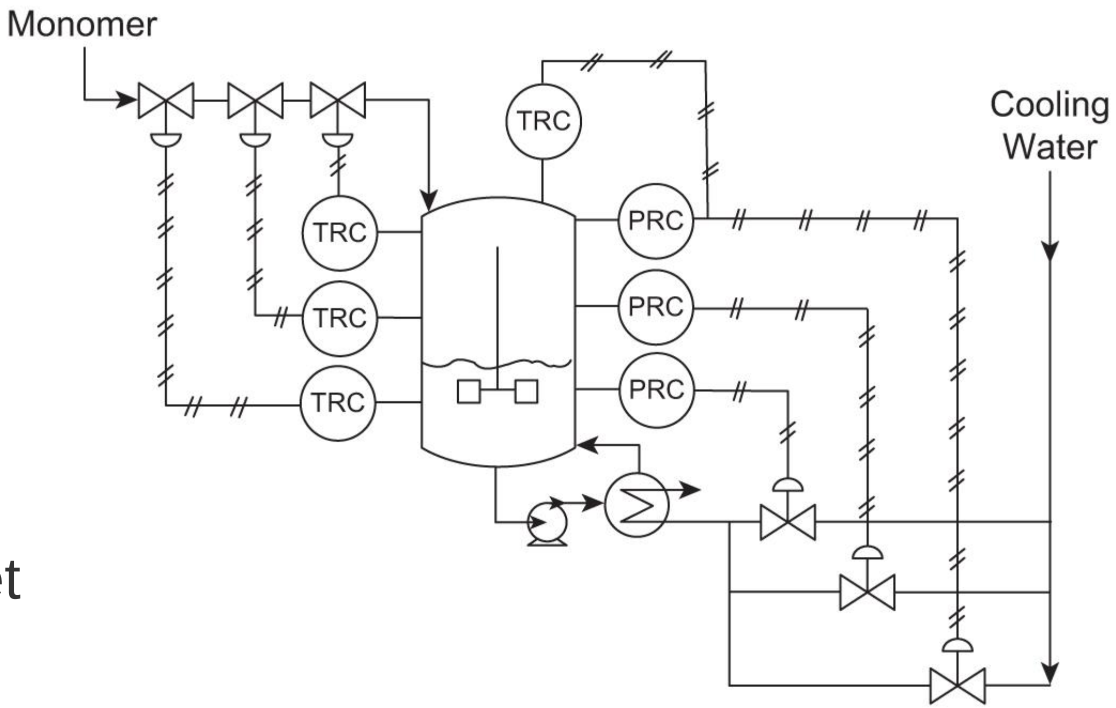


Common Tank Filling Design

- Tank level is monitored via Differential Pressure Measurement
  - Smaller tanks may use weight cells
- When level reaches a lower limit (or via operator request) pump is started and actuated valves direct the flow to desired tank
- When level reaches desired amount the pump is shut off
- Because the differential pressure cells sometimes give faulty readings there is a high level transmitter as a back up
- A pressure relief loop is in place in case the manual valve after pump were to be left closed
- BPCS is monitoring the level in the tank it assumes is getting flow to determine shut off
  - You would probably choose to have it monitor for High Level in both tanks
  - Both high level transmitters should shut off pump
- Normal in and out breathing occurs through flame arrestor and conservation vent
- Emergency Vent with Rupture Disc is in place in the event of external Fire
- Flow is directed down the wall (or through dip tube) for a flammable liquid
- The need for Secondary Containment must be considered

Redundancy

- One of the best ways to reduce frequency is to have redundant components
- If you are trying to maintain a connection, you want to the paths to be in a Parallel Fashion – Cooling Water
  - If any one of them functions you get cooling water
- If you may need to stop a connection, you want redundant valves to be in a Series fashion – Monomer Flow
  - If any one of them functions you stop the flow



1). Temperature or pressure too high: open cooling valves and close monomer valves.
2). Motor or agitation fails: the same.
3). Heat balance off: the same.
4). In all cases, the double block and bleed valves in the monomer lines would be activated.

Anticipate Loss of Air

- Actuated valves use air pressure to open or close
- Want to choose an actuator that will position the valve in the manner that is “fail safe”
  - Valve on left opens if you lose plant air and valve on right closes if you lose plant air
- Similar design considerations for 3-way valves

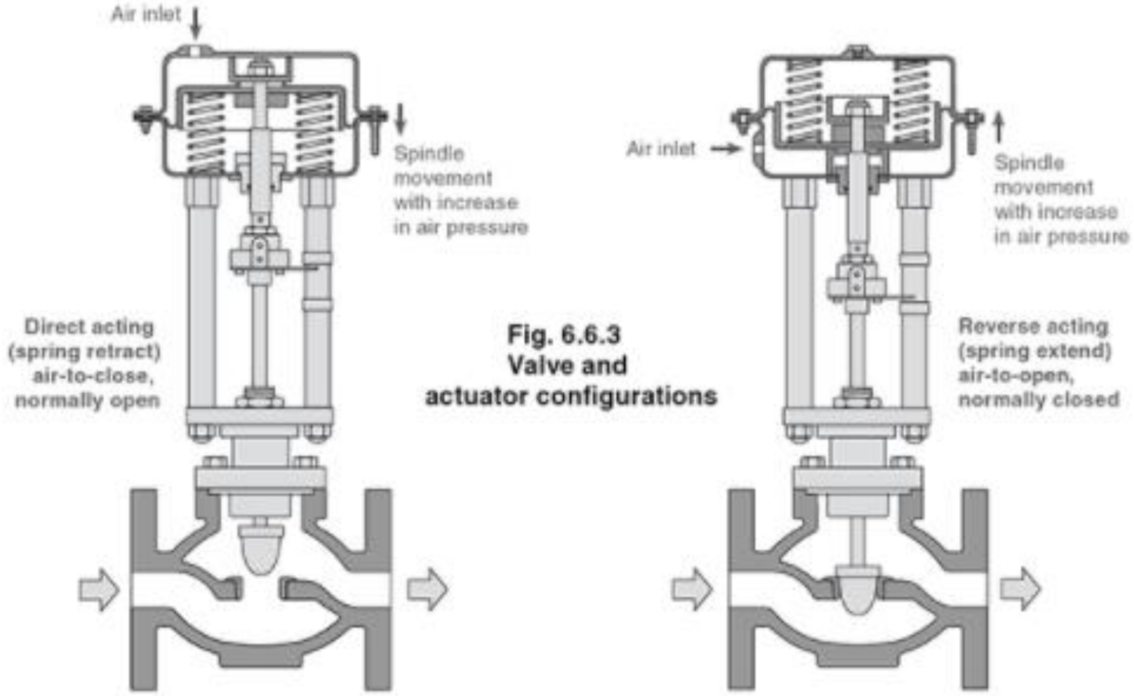


Fig. 6.6.3 Valve and actuator configurations

Anticipate Loss of Power

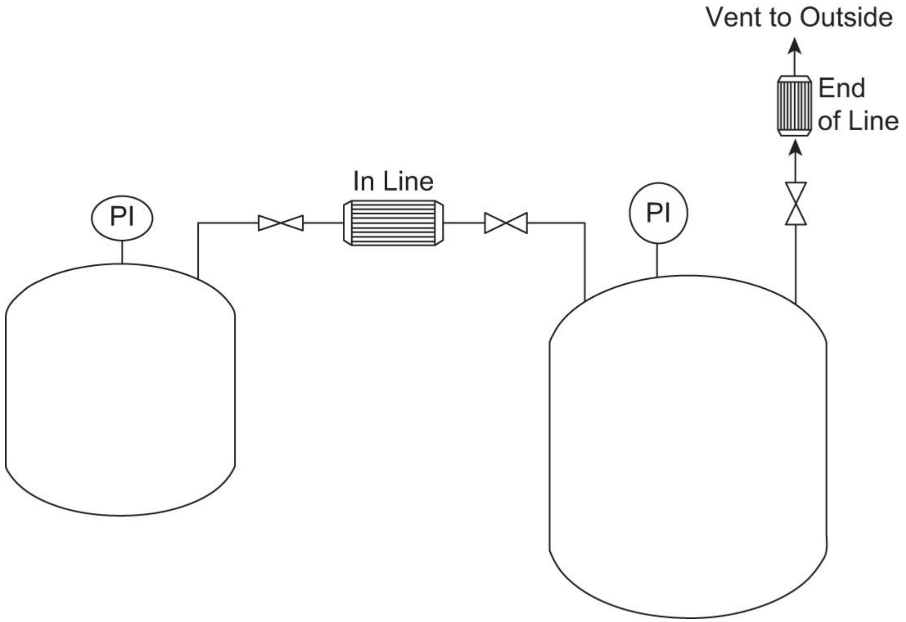
- Back up power supply
- Air operated emergency shut down systems
- Design so that loss of power does not present a hazard
  - Preferable, but probably not feasible

Loss of Containment

- Remember the Fire Triangle
  - Fuel
  - Oxygen
  - Ignition Source
- First goal is to avoid LOC
  - High level detection
  - Pressure Relief
- But assume that it **WILL** happen at some point
  - Ventilation to keep fume level under the LEL
  - Electrical Classification to eliminate ignition sources
    - But remember static electricity does not care about electrical classification!
- Fume Sensors can be tied to interlocks that shut off flow of flammable materials
- Secondary Containment keeps release in electrically classified area and prevents release to ground

Flame Arrestors

- Flame arrestor on end of vent prevents outside ignition source from igniting tank head space
- If tanks have common vents be sure to place flame arrestor between them
  - Prevents explosion in one from igniting the other
- Determine if you think detonation is a possibility versus deflagration – the design is different!



Relief and Containment Systems

- PRV discharges two phase release
- Cyclone separator sends solid/liquid to quench tank
- Cyclone separator sends vapor on to scrubber
- From scrubber goes through seal pot (isolates system upstream from flare)
- Flare has continuous flame which burns vapor release
  - Now discharging CO_2 and water rather than toxic/flammable material