

CE 400 / CE 500

Process Safety Management

Lecture 26 Risk Mitigation Strategies

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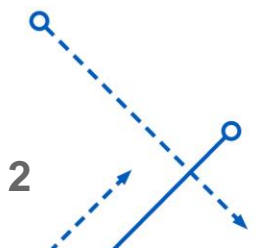
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So we have determined a Risk Level of I or II...

- This lecture will look at some strategies for reducing the Risk Level to III or IV

	F1	F2	F3	F4
C4	III	II	I	I
C3	IV	III	II	I
C2	IV	IV	IV	III
C1	IV	IV	IV	IV

- The strategies all focus on either reducing the Consequence or reducing the Frequency of the incident under consideration



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

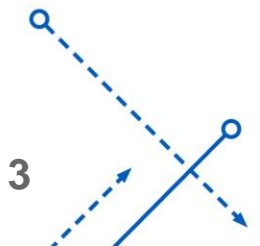
- Safeguard is always ready

3. Active Safeguards

- Safeguard needs to be called into action and/or needs to function

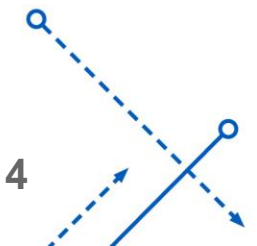
4. Procedural Safeguards

- Rules that need to be followed



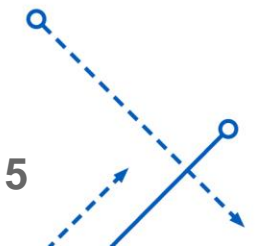
Process Safety Hierarchy – 1st Choice: Inherently Safer

- Inherent: Identify and implement ways to completely eliminate or significantly reduce hazards, rather than develop add-on protective systems and procedures
- Identify technology that operates in less severe conditions
- Minimize
 - Smaller continuous reactor versus large batch reactor
 - Reduce Inventories
 - Raw materials
 - Hazardous Intermediates
 - In process hold up



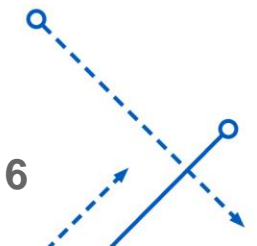
Process Safety Hierarchy – 1st Choice: Inherently Safer

- Substitute
 - Mechanical pump seals versus packing
 - Less prone to leaking
 - Welded piping versus flanged
 - Less toxic solvents
 - Higher flash points, boiling points, etc
 - Use water as heating element versus oils



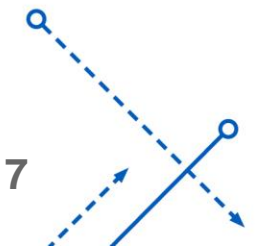
Process Safety Hierarchy – 1st Choice: Inherently Safer

- Moderate
 - Use vacuum to lower boiling points
 - Run at lower pressures and temperatures
 - Operate at conditions where runaway reaction risk is reduced
 - Lower concentrations and temperatures
 - Refrigerate storage vessels
 - Keep incompatible chemicals in different areas of the plant
- Simplify
 - We will cover this as part of Human Factors



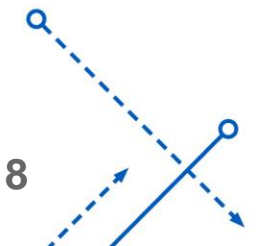
Process Safety Hierarchy – 2nd Choice: Passive Safeguards

- Added safety features that do not require action by any device – no interaction with control systems or personnel required
 - Dikes
 - Flame Arrestors
 - Blow out panels
 - Barricades and reinforced walls



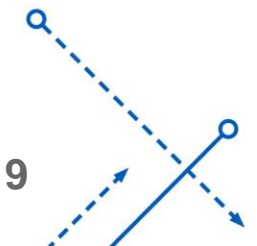
Process Safety Hierarchy – 3rd Choice: Active Safeguards

- Added safety features that do require action by devices – interaction with control systems and/or personnel is required
 - Process Control System
 - Basic Process Control System
 - BPCS actually operates the process
 - Safety Interlocks
 - Safety Control System operates emergency procedures
 - More reliable system than BPCS
 - Automatic Shutdown Systems
 - Fire Suppression Systems



Process Safety Hierarchy – 4th Choice: Procedural Safeguards (also known as Administrative Controls)

- Operating Procedures
- Safety Rules
- Operator Training
- Emergency Response Procedures



Process Safety Hierarchy

Inherently Safer Technology

- Your process no longer has this particular hazard
- Your process has the hazard but it's consequence or frequency is reduced without needing any additional steps

Passive Safeguards

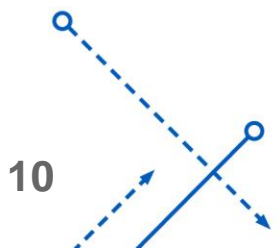
- No intervention is required by personnel or control system
- No “moving parts”

Active Safeguards

- Action must be initiated by control system or personnel
- Active safeguard must function properly

Procedural Safeguards

- Personnel need to actually follow the procedures and rules

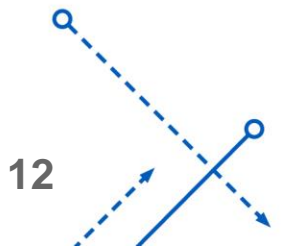


Methods to Reduce Severity

- Reduce Occupancy *Administrative Control*
 - If people are not present, they cannot be hurt!
 - Only allow personnel into areas of highest hazard on need to operate basis
 - Some areas are only occupied during yearly shutdown periods
- Personnel who are not operating or maintaining process should be located well out of range of the hazardous effects of process incidents
Administrative Control/Inherent
 - Non-essential personnel are those that do not need to be located near the process to actually run the process
 - This is called Facilities Siting and will be dealt with in more detail in a subsequent lecture

Methods to Reduce Severity

- Reduce Magnitude of Force or Toxic Dispersion Effects Inherent
 - Limit the amount of materials that could lead to explosion or toxic effects
 - Smaller inventories of raw materials
 - Avoid large batch reactors
 - Substitute for less hazardous materials
 - Lower vessel operating pressures
 - Final pressure in an explosion depends on initial pressure



Methods to Reduce Severity

- Contain or Direct Pressure *Passive*
 - Reinforced Walls and Blowout Panels
 - Sacrificial panels that fail at lower pressure
 - Reinforced walls withstand higher pressure than the blowout panels
- Emergency Vents on Tanks *Passive*
 - If tanks is exposed to external fire, the contents will boil and contained vapor can lead to overpressurization of vessel
 - Emergency Vent discharges the vapor and prevents overpressurization of tank
- Equipment Pressure Ratings *Inherent*
 - Tank rated to contain overpressure of explosion in head space



Methods to Reduce Severity

- Secondary Containment *Passive*
 - Overfills and Leaks prevented from reaching the ground
- Fire Suppression *Active*
 - Sprinkler Systems / Halide Systems extinguish fires to limit damage
 - Explosion systems respond instantaneously to stop combustion reaction before pressure build up

Methods to Reduce Frequency

- Process Simplification Inherent
 - Less steps and/or less components leads to less possible faults
 - Also to less opportunity for operator error...
- More Reliable Design Inherent
 - Redundancy reduces chance that a fault leads to unacceptable consequences
 - Equipment components that have lower failure rates
- Human Factors Inherent
 - Recognize operator mistakes waiting to happen and reduce the likelihood that they will (or can) make those mistakes

Methods to Reduce Frequency

- Interlocks *Active*
 - Sensors identify dangerous process conditions and initiate steps to return process to safe operation
 - May be an actual shutdown of process
 - Always on alert
- Pressure Relief Devices *Active/Passive?*
 - Allow pressure/flow to be relieved to a safe location
 - One can debate whether this is reducing frequency or severity
 - Reduces frequency of loss of containment and/or equipment damage
 - Reduces severity of event when an overpressure situation occurs, but does not reduce the likelihood of the event...