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Handbook for Process Safety in Laboratories and Pilot Plants:
A Risk-based Approach

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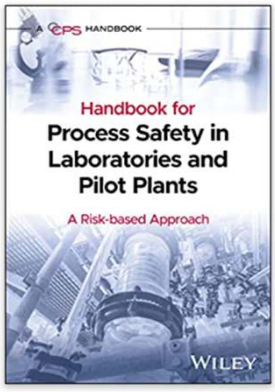

Acknowledgments

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Some Ingredients in our Alphabet Soup

LAPP – Laboratory and Pilot Plants

MOC – Management of Change

PHA – Process Hazards Analysis

PSM – Process Safety Management (Systems)

RBPS – CCPS Risk Based Process Safety

Outline

- Who: Handbook Audience
- Why: Laboratory and Pilot Plant (LAPP) Incidents
- What: Handbook Scope
- Where: Starting Point
- When: Leaks and Spills
- How: Management Systems
- Summary

Handbook Audience

- Any Laboratory and Pilot Plant (LAPP) staff working with or managing hazardous materials and energies
  - Chemical processing facility laboratories
  - Product Research and Development (R&D) laboratories
  - University, government, or other industry laboratories

Handbook Audience, *continued*

- LAPP engineering and scientific professionals
- LAPP technical support staff
- LAPP managers

Managing a laboratory or pilot plant requires diligent attention to ***how changes in experiments and in experimental set-ups can (and do) change the risk.***

LAPP Process Safety – Reducing the Risk

Requires a Commitment to Process Safety

- Process Safety Culture
- Operational Discipline

Requires Leadership Support to Implement Process Safety Systems

- Researchers and Principal Investigators (PIs)
- University faculty overseeing research or educational labs
- Engineers scaling-up processes for pilot plants

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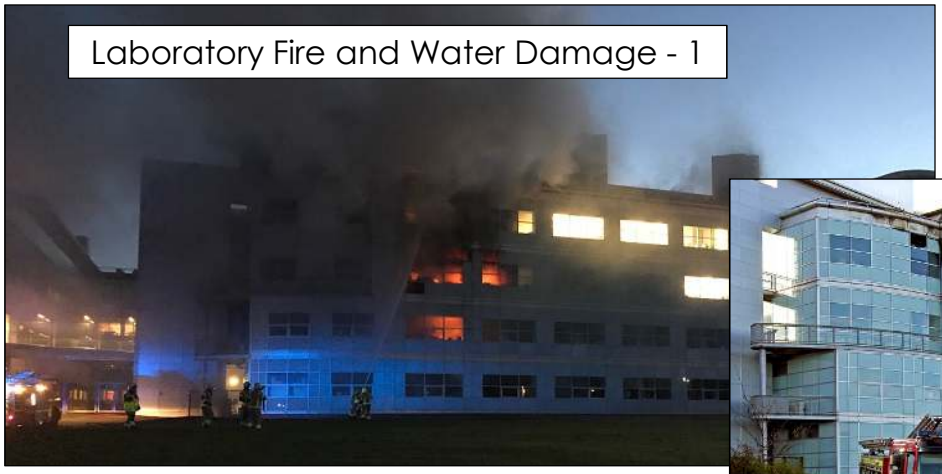
Laboratory and Pilot Plant Incidents

Laboratory Explosion and Fire Damage

Laboratory and Pilot Plant Incidents

Laboratory Fire and Water Damage - 1



Laboratory and Pilot Plant Incidents

Laboratory Fire and Water Damage - 2

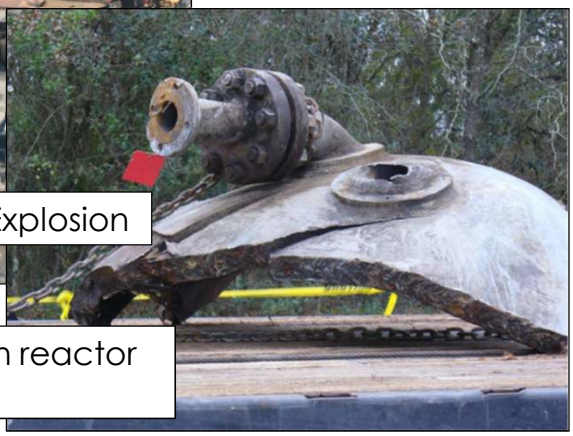
Laboratory and Pilot Plant Incidents

Hood after the Runaway Reaction Explosion

Equipment: Glass distillation column and condenser

Laboratory and Pilot Plant Incidents

Site after the Runaway Reaction Explosion



Equipment: 650-gallon reactor with 3-inch thick walls

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Handbook Scope

Scope: To help LAPPs prevent the loss of control of hazardous materials and energies focusing on these broad hazard categories:

1) Chemical – hazardous materials

2) Physical – hazardous energies (temperatures, pressures, etc.)

Handbook Scope

Scope includes ***how LAPP staff manage*** the material's chemical hazards and the process' physical hazards:

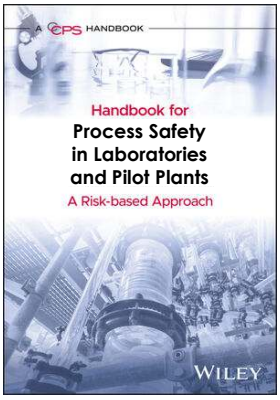
1) Chemical transformations (reactions)
2) Changes in physical state, concentration, or form
3) Physical mixing, separation, and purification

Handbook Framework

- Committing to Process Safety
- Understanding Hazards and Risks
- Managing Risk: Engineered and Administrative Controls
- Managing Risk: Management Systems
- Learning from Experience

Appendices

- Case Reports
- Examples and Tools
- Control Banding Strategies
- Glass Equipment Design



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Where to Start in the LAPP

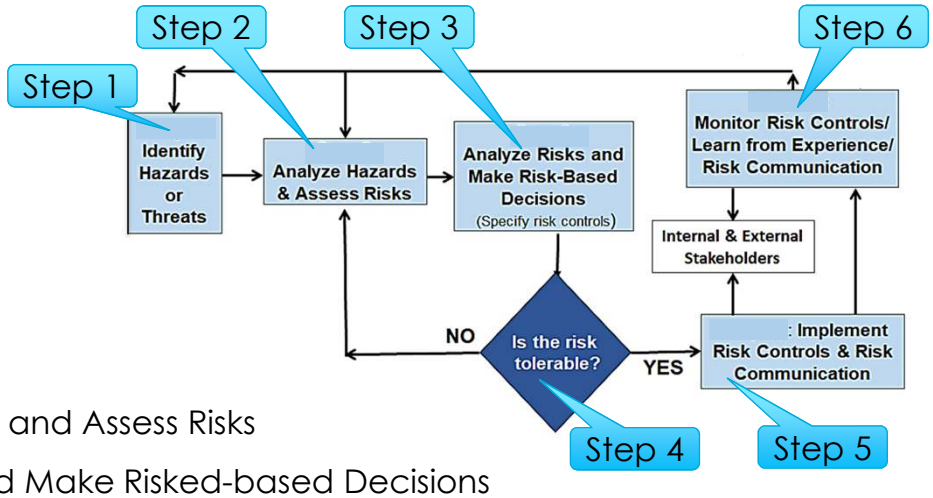
Key Success Factor: Establish a standardized Risk Matrix

Risk = Likelihood x Consequence

Likelihood	Very low	Low	Moderate	High	Very high
Very high					High
High					
Moderate			Medium		
Low					
Very low	Low				
	Consequence				

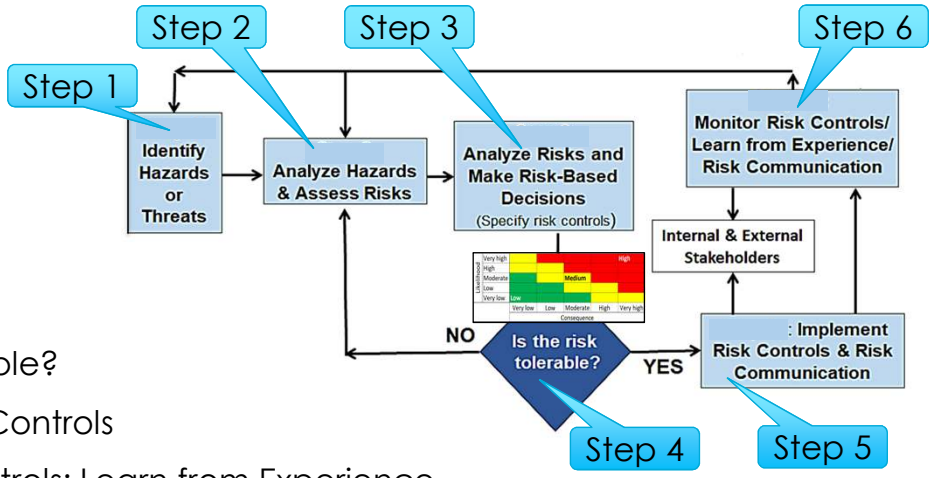
Risk Tolerance
- Unacceptable
- Tolerable
- Acceptable

Where to Start in the LAPP



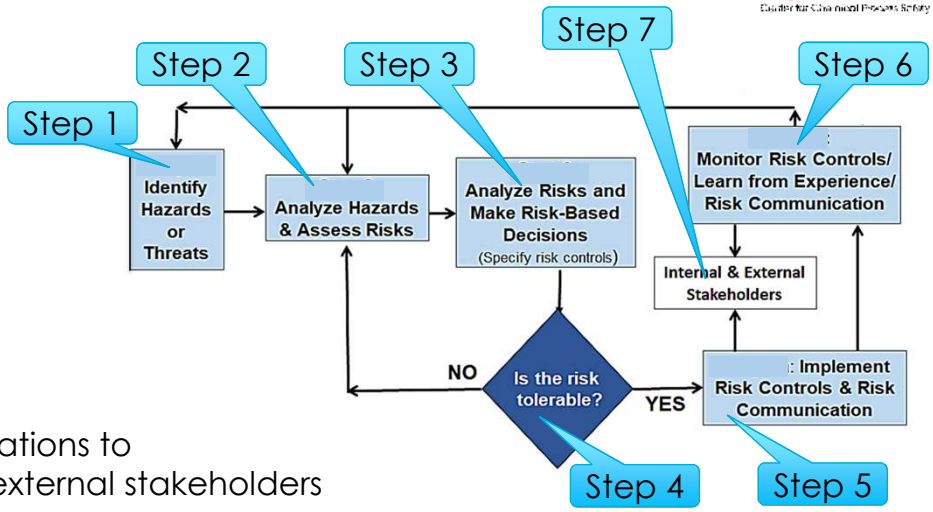
1) Identify Hazards
2) Analyze Hazards and Assess Risks
3) Analyze Risks and Make Risked-based Decisions

Where to Start in the LAPP



4) Is the Risk Tolerable?
5) Implement Risk Controls
6) Monitor Risk Controls; Learn from Experience

Where to Start in the LAPP



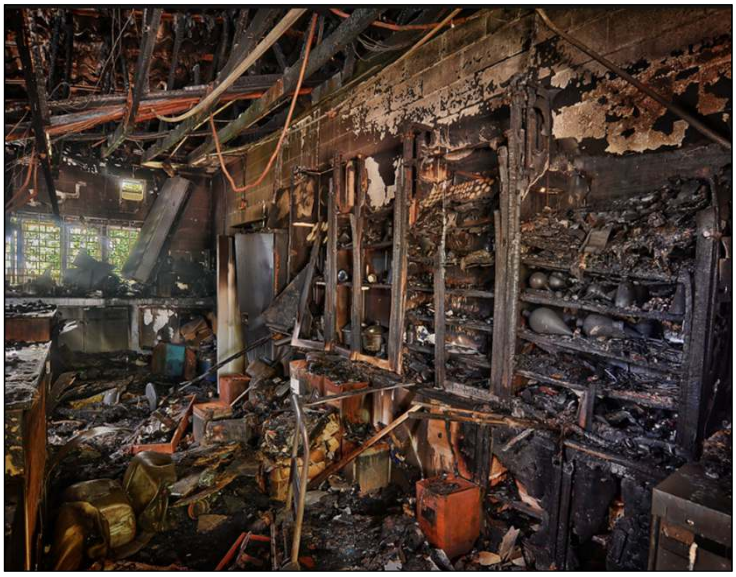
7) Risk communications to internal and external stakeholders

Step 1) Understand Hazards

Toxic gases

Step 1) Understand Hazards

Fires



Step 1) Understand Hazards

Explosions:

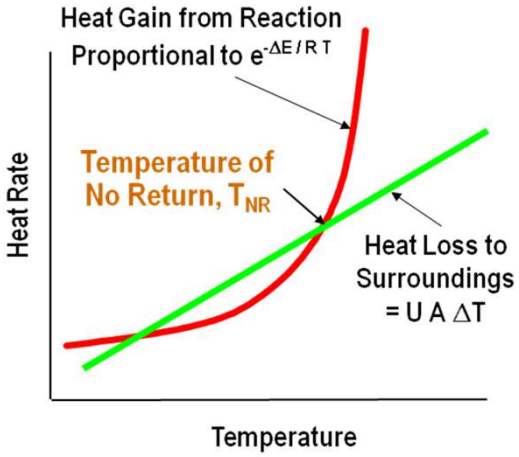
Step 1) Understand Hazards

Reactivity:

- Exothermic reactions
- Runaway reactions

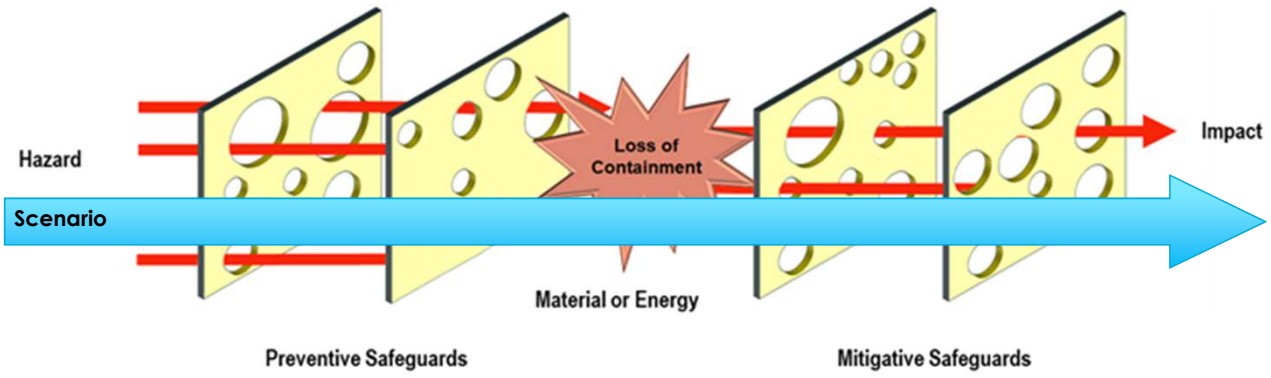
Determine:

- Temperature of No Return



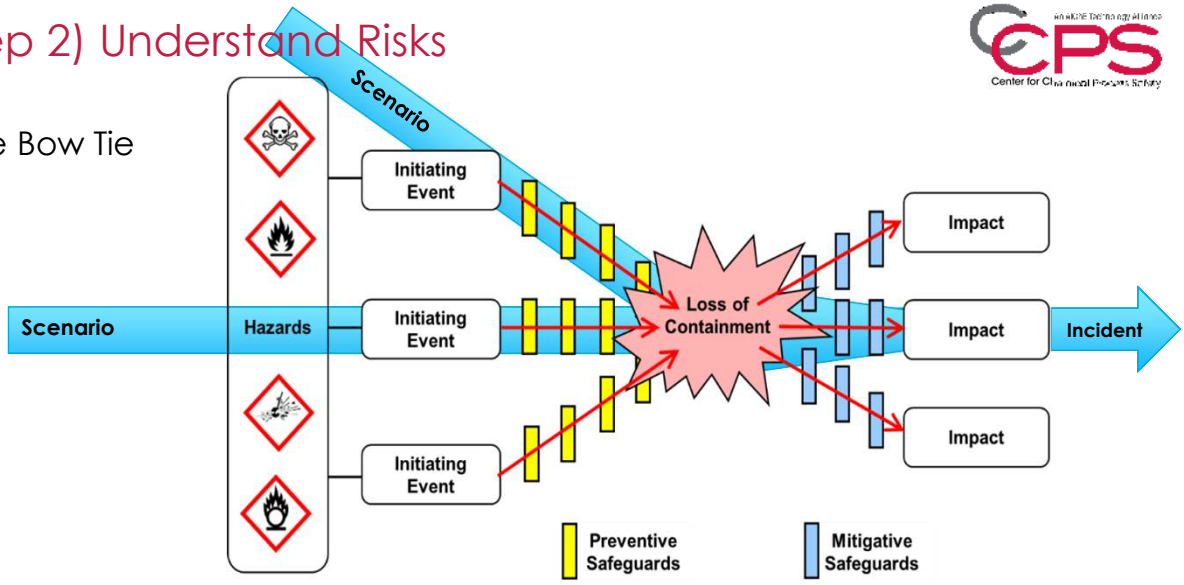
Step 2) Understand Risks

Identify Scenarios: The Swiss Cheese Model



Step 2) Understand Risks

The Bow Tie

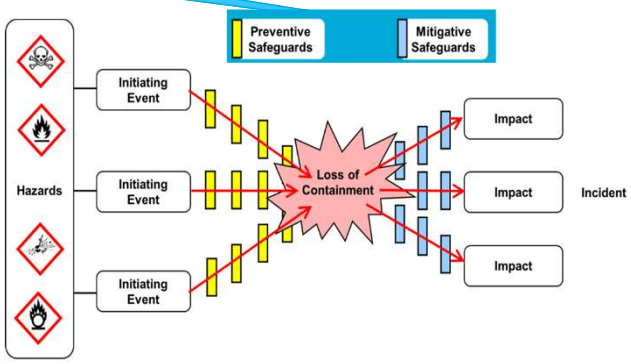


Step 3) Manage Risks

Management Systems

Discussed
- Process Safety Culture
- Operational Discipline
- Hazards and Risks

Next
- Incidents



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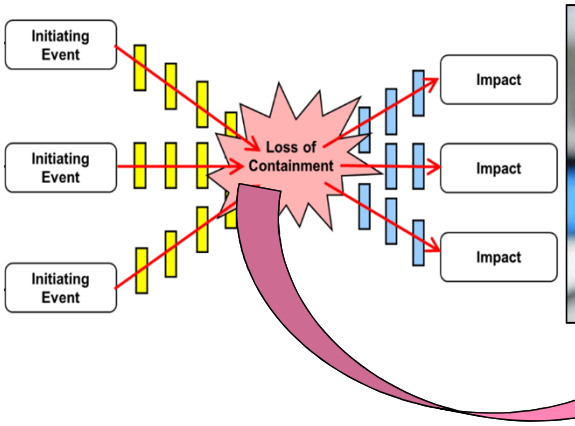
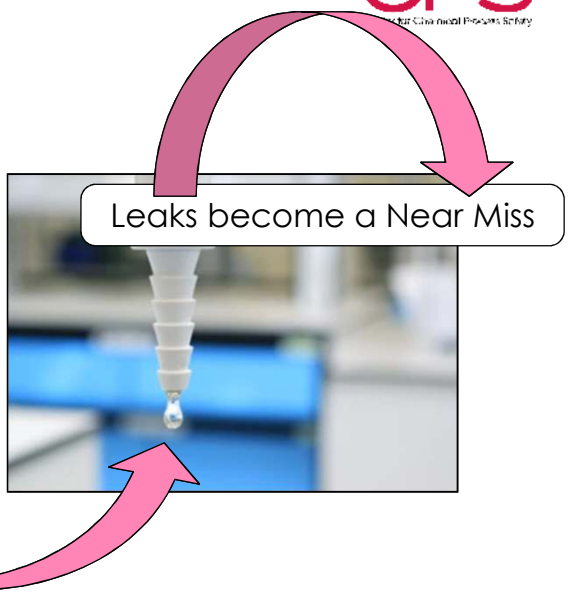
Leaks and Spills in the LAPP

Leaks are a Loss of Containment

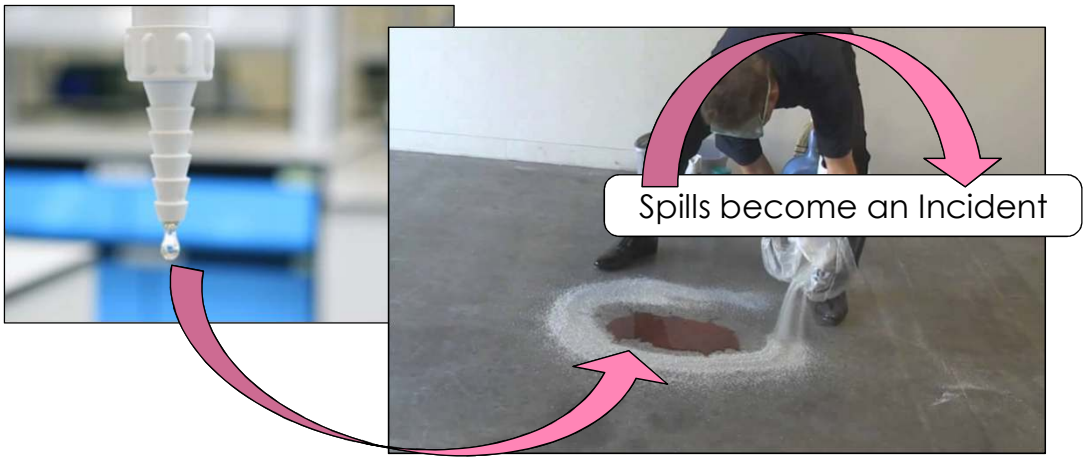




Leaks become a Near Miss

Leaks and Spills in the LAPP

Unchecked Leaks may lead to Spills



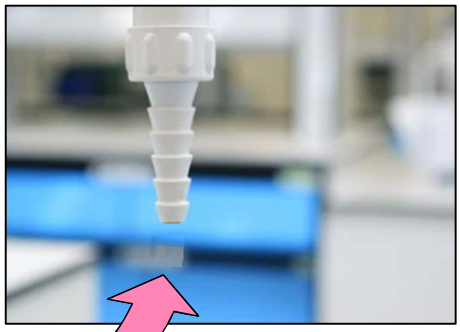
Spills become an Incident

Leaks and Spills in the LAPP

Incident Investigations identify Root Causes

Leaks and Spills in the LAPP

Root Causes are used to help prevent a future incident



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Management Systems

Managing risk includes

- Procedures
- Equipment condition (new, used, modified)
- Safeguards (Protective Layers)
  - Preventive (before loss of containment)
  - Mitigative (after loss of containment)
  - Emergency response

Management Systems

Managing risk includes

- Management of Change (MOC)
  - Ingredients and ingredient concentrations
  - Temperatures and pressures
  - Experimental equipment and set-up
- Training
- Incident Investigations

Management Systems

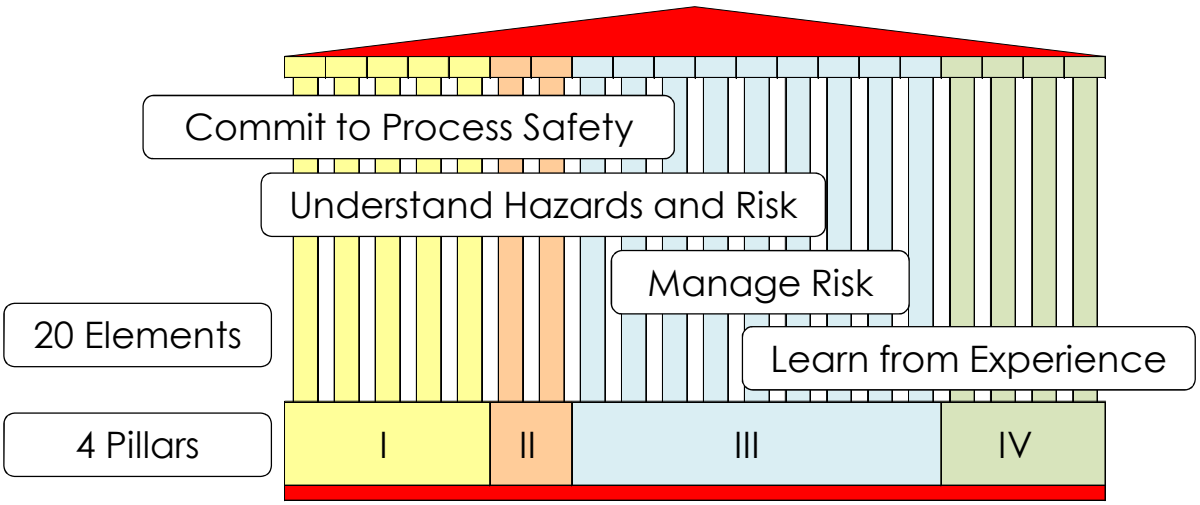
- Management of Change (MOC)
  - Ingredients and ingredient concentrations
  - Temperatures and pressures
  - Experimental equipment and set-up

Recall:

Managing a laboratory or pilot plant requires diligent attention to **how changes in experiments and in experimental set-ups can (and do) change the risk.**

Management Systems

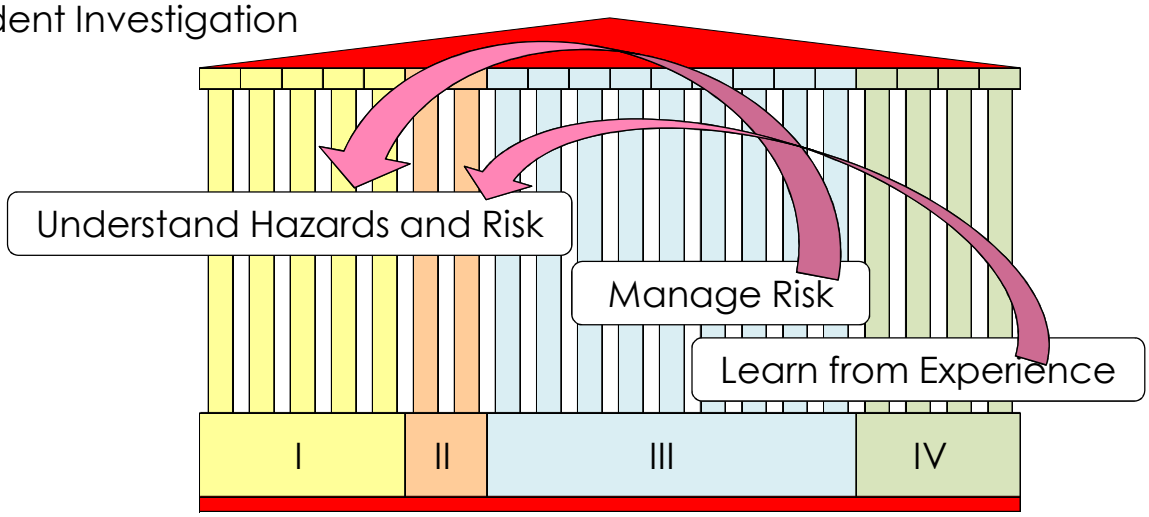
Risk Based Process Safety (RBPS)



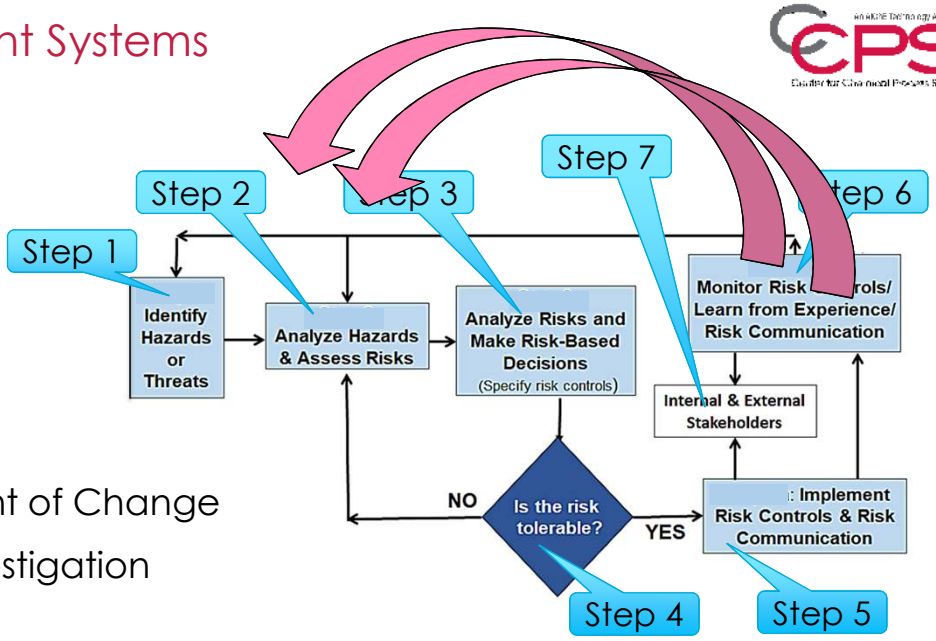
Management Systems

Management of Change

Incident Investigation



Management Systems



Management of Change

Incident Investigation

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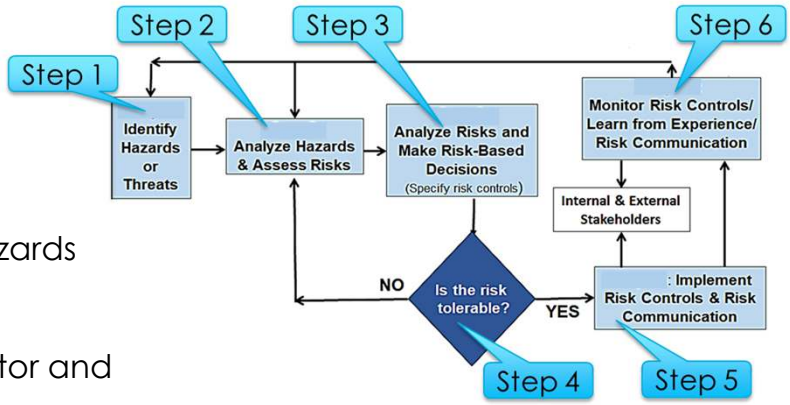
Summary

- Laboratory and Pilot Plant incidents can result in serious injuries, fatalities, and significant property damage
- Scope includes how LAPP staff can manage the material's chemical hazards and the process' physical hazards
- Handbook focuses on how hazardous chemicals and energies can be managed safely

Summary



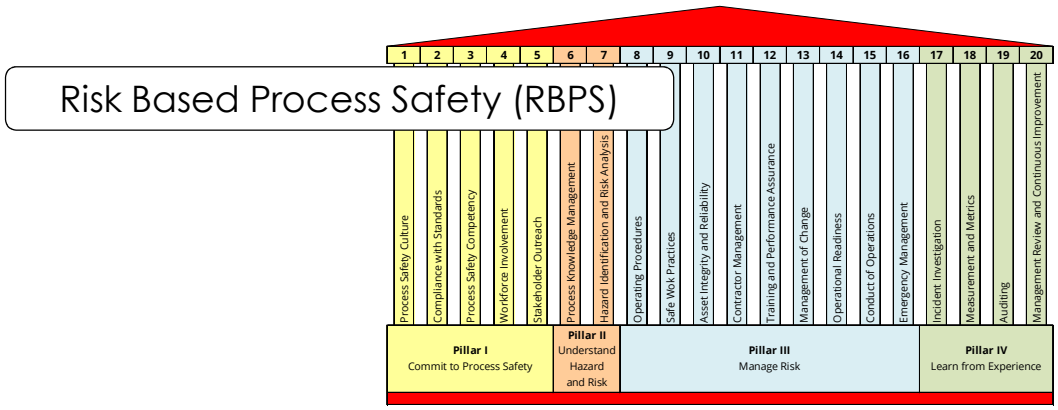
- The starting point is hazards identification
- The last step is to monitor and control the risks

Summary

- Investigating leaks and understanding their root causes will help prevent spills

Summary

- Management systems help prevent the loss of containment of hazardous materials and energies



Questions?

Thank you for your attention