Conducting an Effective Process Hazard Analysis

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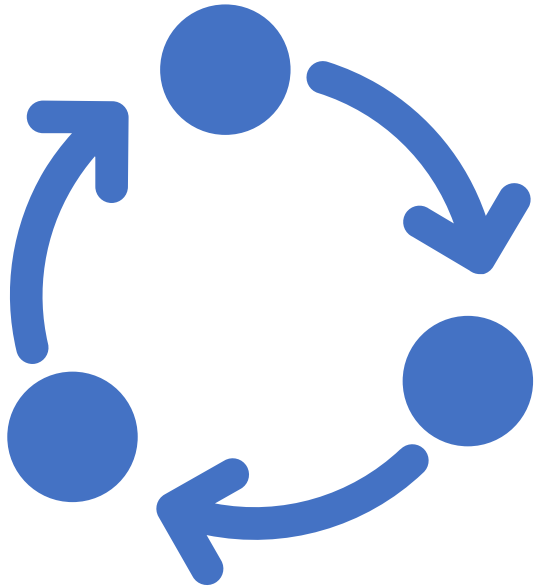
Agenda

Process Hazard Analysis (PHA)

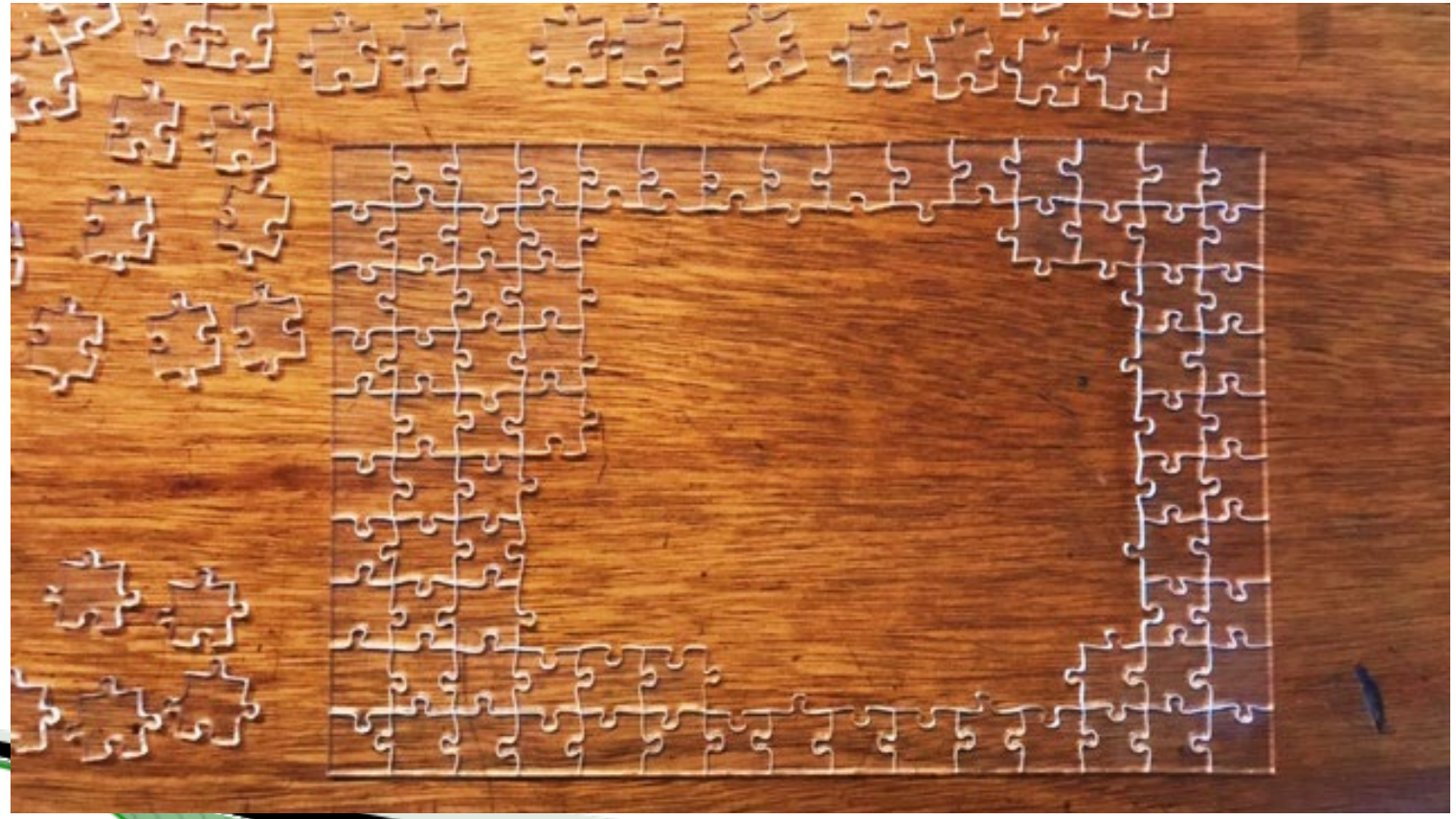
- Introduction and Overview
- Regulatory Requirements
- Update or Revalidate
- Methodologies
- PHA Team
- Items to Address in PHA
- Lessons Learned



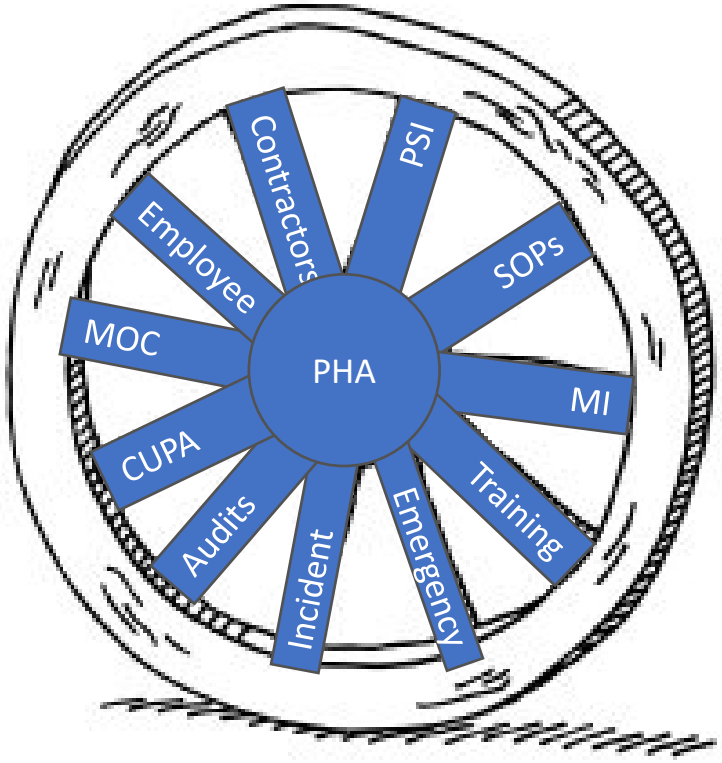
Objectives

- Understand the PHA process
- Improve PHA documentation
- Acquire tools for use in PHAs
- Evaluate the effectiveness of a PHA
- Identify potential gaps in safety

Process Hazard Analysis



Process Hazard Analysis



Process Hazard Analysis

Purpose

- Identify and analyze significant hazardous situations of a process; and
- Aid in decision making for improving safety and managing risk.

Desired outcomes

- Fewer incidents;
- Reduced consequences; and
- Evaluate compliance.

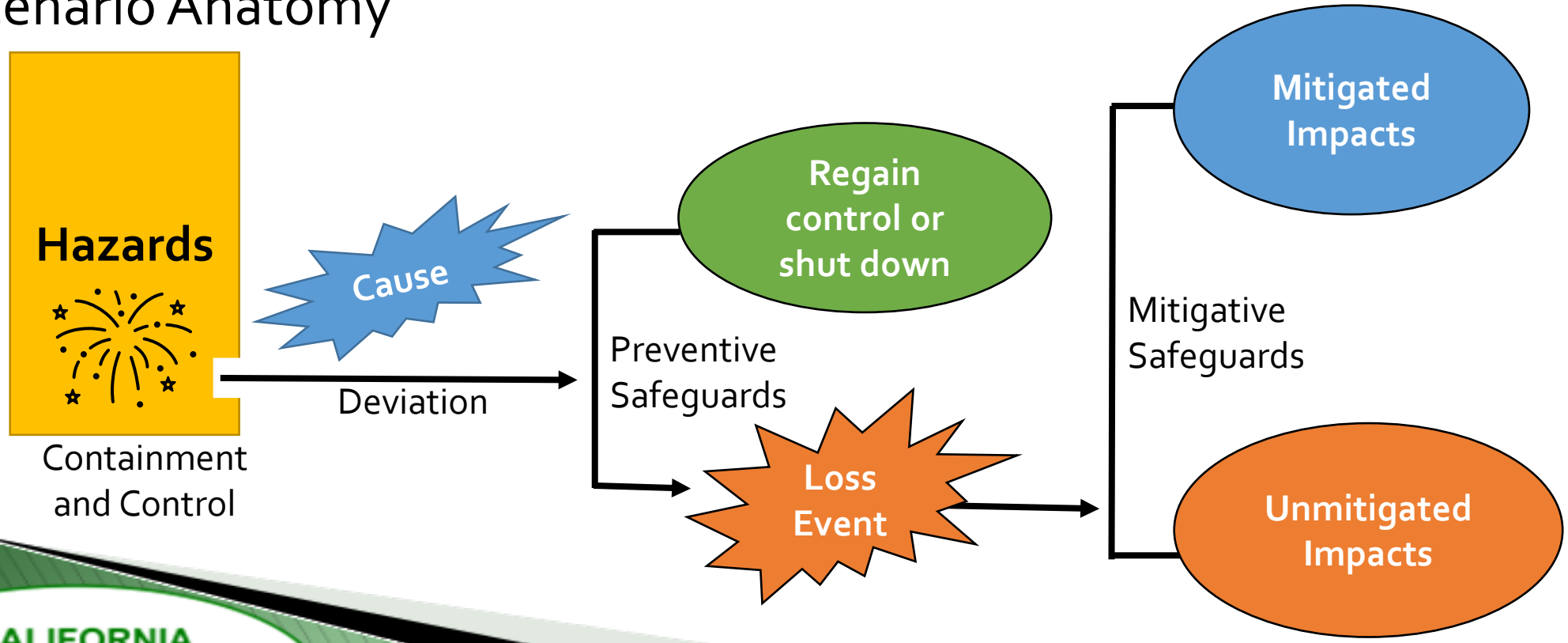
Process Hazard Analysis

Limitations

- Impossible to identify and assess the significance of all possible causes and outcomes;
- Studies are a snapshot in time;
- Results may be subjective based on team knowledge and experience; and
- No certainty that all hazardous conditions and potential incident scenarios are covered.

Process Hazard Analysis

Scenario Anatomy

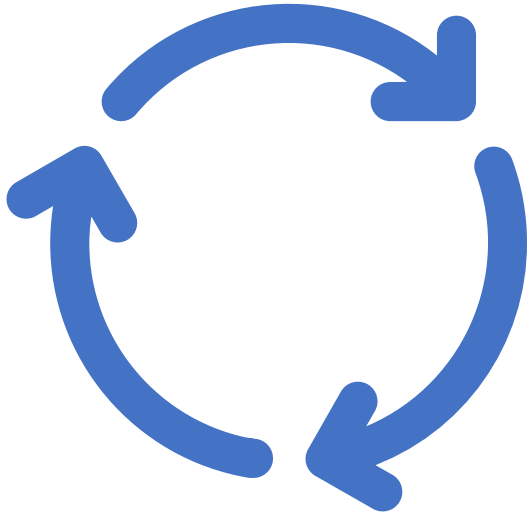


PHA Scope and Objectives

- What are the boundaries of the process?
- Will the PHA address both operability and hazardous consequences?
- Will the evaluation include health, safety, economic and production quality impacts?
- Are double jeopardy scenarios included?

PHA Process

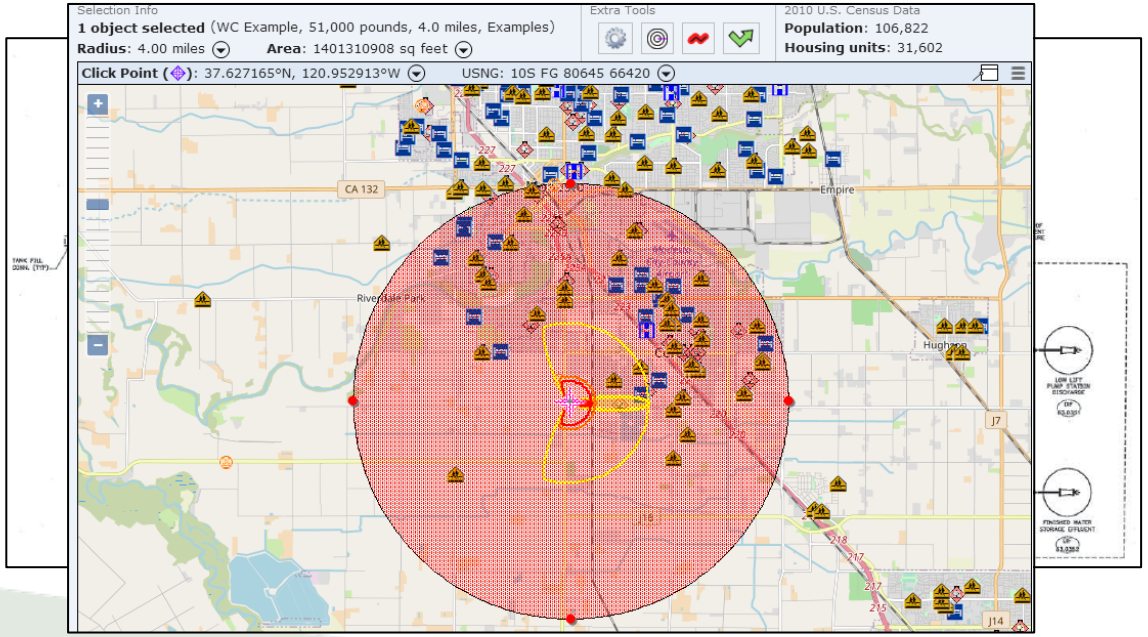
- Gather information on the process;
- Review and evaluate potential gaps;
- Perform study with qualified team;
- Address recommendations; and
- Update and revalidate.



PHA Process

Gather information on the process:

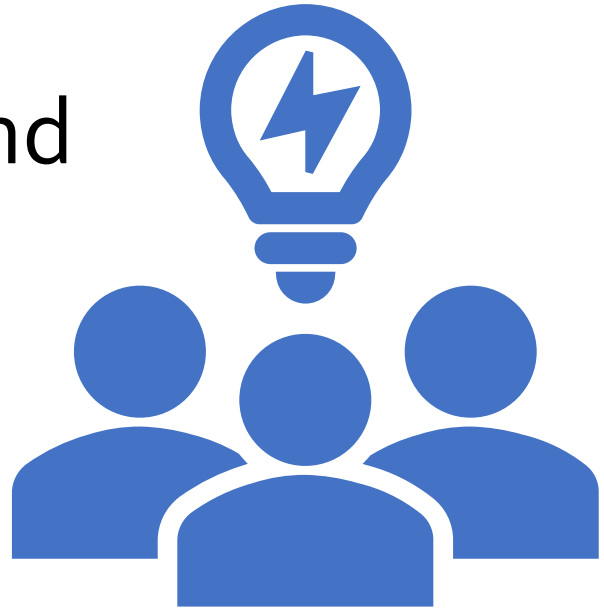
- Reference information (BFD, P&IDs, operating limits, procedures, EAP/ERP, facility siting information, etc.);
- Previous incidents; and
- Walkdown:
  - Equipment condition
  - Access and egress
  - Guarding



PHA Process

Review and evaluate potential gaps:

- Complete and accurate;
- Formulate questions for team; and
- Conform to industry standards.



PHA Process

Perform study with qualified team:

- Walkdown the process;
- Orientation on PHA Methodology;
- Review potential causes (initiating events);
- Document containment control, safeguards and; mitigation measures for scenarios;
- Evaluate safety and health effects of failures; and
- Suggest additional safeguards or recommendations where appropriate.

PHA Process

Address Recommendations

- Recommendations may not always be explicit:
  - Implement as described; or
  - Decline to adopt.

PHA Process

Decline to adopt a recommendation

- Document, in writing and adequate evidence, one of the following: Analysis contains material factual errors;
  - Recommendation is not necessary to protect health & safety of employees of owner and/or contractors;
  - An alternative measure would provide sufficient level of protection; or
  - Recommendation is infeasible

Infeasibility shall not be based solely on cost.

PHA Process

Any Questions?

PHA Requirements

- Perform an initial PHA prior to submittal of the RMP
  - With appropriate complexity of the process; and
  - Identify, evaluate, and control the hazards involved in the process.
- Update and Revalidate based on the PHA completion date at least every 5 years

PHA Requirements

Update or Revalidation

- CalARP Revalidation Definition: "**Revalidation**" means a critical review of a hazard review or a process hazard analysis (PHA) with **qualified team members** of the most recent hazard review or PHA studies to verify that **past studies remain valid and that changes made to the covered process are properly assessed.**

PHA Requirements

Revalidation Requirements:

- Hazards are well understood;
- Existing safeguards are properly documented;
- Past recommendations have been addressed;
- Accurate risk ranking of each scenario; and
- Incidents and near misses at the stationary source and industry are evaluated.

OSHA Standard Interpretation, 1910.119(e)(6) - Steps for updating and revalidating a Process Hazard Analysis (PHA). - 01/22/1998

PHA Requirements

- Ohio EPA Simple Revalidation Checklist
- Could be a starting place to check on changes
- Follow up with further evaluation, review and changes to the PHA

CHECKLIST FOR SIMPLE REVALIDATION

Questions	Yes/No	Comments
Previous PHA		
1. Have all OSHA PHA requirements been adequately addressed?		
2. Is documentation from the previous PHA available?		
3. Have all recommendations from the previous PHA been resolved?		
Modifications to the Process		
1. Was a management of change system implemented before or in conjunction with the completion of the previous PHA?		
2. Is safety and health assessment or hazard evaluation documentation available for process modifications made since the previous PHA?		
3. Have process modifications been evaluated to determine whether additional engineered or administrative controls are necessary to maintain continued safe operation of the process?		

Ohio EPA Simple Revalidation Checklist

PHA Requirements

Update, Revalidate or Edit?

- Minor changes and the addition of information about a change to the PHA file are not considered a 'revision' of the PHA.
- Major changes that invalidate a PHA, leading you to 'update' or 'revalidate' the PHA so that it accurately reflects the hazards of the process, are considered a revision.

Update and submit the RMP within 6 months of a change that requires a revised PHA (major change or modification).

EPA FAQ: What constitutes a revision of the PHA?

PHA Requirements

Update, Revalidate or Edit?

- Updating [PHAs]: The owner/operator must update the [PHA] at least once every 5 years or whenever there is a major change in the process.
- The owner/ operator must resolve significant problems identified in the new [PHA] before the changed process is started up.

PHA Requirements

Update, Revalidate or Edit?

- CalARP Major Change Definition:

  (1) Introduction of a new process;

  (2) New process equipment or new regulated substance that results in any operational change outside of established safe operating limits; or

  (3) Any alteration in a process, process equipment, or process chemistry that introduces a new hazard or increases an existing hazard.

PHA Audience Question

An ammonia refrigeration facility completed an update of their PHA two years ago. They added a new screw compressor to the existing engine room and a new evaporator to an existing processing area with ammonia detection. Minor changes were made to operating limits, PSI, MI program and SOPs were made.

PHA Audience Question

Should this facility conduct an update, revalidation or edit of their PHA?

PHA Methodology

Coordinate with the AA (CUPA) on methodology and use one of the following:

- What-If
- Checklist
- What-If / Checklist
- Hazard and Operability Study (HAZOP)
- Failure Mode and Effects Analysis (FMEA)
- Fault Tree Analysis
- An appropriate equivalent methodology

PHA Methodology: Checklist

- Easy and quick to perform
- Respond to questions

- No cause and consequence
- Not always process specific

PROCESS HAZARD ANALYSIS CHECKLIST			
Date			
Team Members			
SITE	Yes	No	NA
Do storage, use, and tra… easy access for emergency response?			
Are storage, use, and tr… incompatible materials a… isolated from hydrocarbons?			
Are storage, use, and tr… transfer areas isolated from a source of corrosion, fire, and explo… protected from vehicle impact?			
GENERAL CONDIT…ONS, OPERATION AND MAINTENANCE	Yes	No	NA
Are work areas clean?			
Are adequate warning s…gns posted?			
Is lighting sufficient for a… operations?			
Are the right tools provi…ed and…			
Is PPE provided and ad…equate?			
Are cylinders protected …rom v…			
Are cylinders and feed l…e areas kept free of any objects that can fall on them (e.g., ladders, s…helve…			
Are leak detectors with …ocal and remote audible and visible alarms present, operable, and t…ested (or is alternate means used to measure concentrations)?			

Limited Documentation on:

- Detection method
- Safeguards
- Consequences
- Safety and health effects of failure of controls

PHA Methodology: What-If/Checklist

- Less structured than other methods
- Works well for brainstorming
- What-if/checklists may be available for certain industries.
  - If used, questions should be site-specific and appropriately complex

PHA Methodology: What-If/Checklist

- Easy to understand
- Less time and effort
- Results are dependent on experience and thoroughness

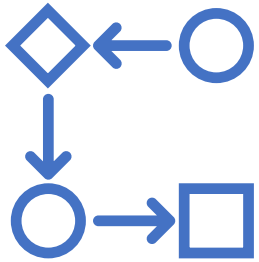
What If...	Consequences/ Hazard	Safeguards	C	L	R	Recommendations/ Action
Emergency Shutdown Valve 23 (ESD - 23) fails to close when needed? (This can occur due to extremely cold weather, reliability due to inspection/ testing/maintenance or design problems)	Release of highly flammable materials in the operating area. Potential for fire/explosion with employee injuries/fatalities	1. Specific Inspection/testing/ maintenance program for ESDs 2. Valve actuator sizing 3. ESD-23 is fail closed design	4	2	B	1. Due to cold weather modify MI procedures to increase ESD valve testing to 1/2wks. 2. Inspection records for ESD 23 not in file, follow-up to assure ESD-23 inspected as required by MI procedures 3. No equipment data sheet was found for actuator for ESD-23, follow-up with engineering to assure design is correct. 4. Consider over sizing valve actuator

Covers hazards and consequence of failure

Safeguards and control methods

PHA Methodology: HazOp

- Intended to identify system design and operational features that could lead to a chemical release
- Guide-word Deviation Matrix used to review the design, operation, and maintenance of a process



PHA Methodology: HazOp

Guideword Deviation Matrix							
Design Parameters	**More**	**Less**	**None**	**Reverse**	**Part of**	**As well as**	**Other than**
Flow	High flow	Low flow	No flow	Back flow	Wrong concentration	Contaminants	Wrong materials
Pressure	High pressure	Low pressure	Vacuum				
Temperature	High temperature	Low temperature					
Mixing	Excessive mixing	Poor mixing	No mixing			Foaming	
Level	High level	Low level	No level				
Reaction	High reaction rate	Low reaction rate	No reaction	Reverse reaction	Incomplete reaction	Side reactions	Wrong reactions
Time	Too long	Too short					Wrong time
Sequence	Step too late	Step too early	Step left out	Steps performed backwards	Part of step left out	Extra action included	Wrong action taken

PHA Methodology: HazOp

- Systematic approach to hazard scenarios
- Node focus can miss scenarios on interactions
- Significant time and effort

Deviation	Causes	Consequences	Safeguards	Recommendations/ Actions	C	L	R
Loss of Agitation	Agitator motor fails Electrical utility lost Agitator mechanical linkage fails Operator fails to activate	Un-reacted HHC in the reactor carried over to Storage Tank 3 (ST-3) and is released to the enclosed work area. Probable injuries or fatalities to workers due to highly acute toxic material hazard	HHC detector and alarm	1. Consider adding alarm/shutdown of the system for loss of agitation to the reactor 2. Ensure adequate ventilation exists for enclosed work area and/or use an enclosed ST-3 3. Update PSI file and Op. Procedure HHC-39 to include consequence of deviation, engineering controls including safety system information, e.g. SIS and emergency ventilation	4	2	B

Hazards and consequence of failure

Safeguards

PHA Methodology

Any Questions?

PHA Requirements

- Address findings and recommendations
- Document resolution of recommendations
  - Action to be taken
  - Develop a written schedule (estimated completion)
  - Final resolution taken
  - Actual completion date

PHA Requirements

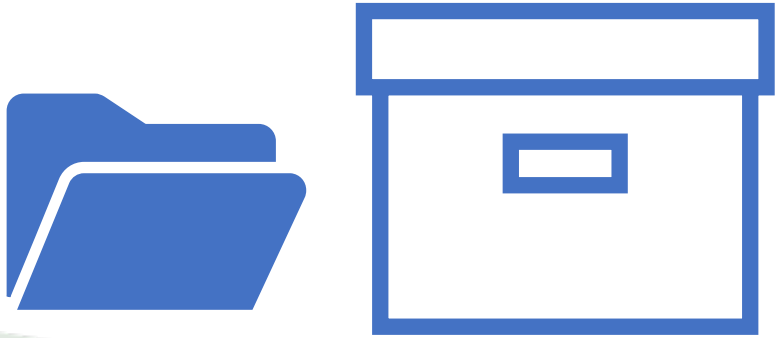
No.	L	C	R	Node	Safeguards and Control Measures	Suggested Safeguards and Control Measures	Estimated Completion Date	Management Response/Action Taken	Assigned To	Date Complete
1.03	2	3	B	Node 1 System Overview	Autodial message to operator on chlorine alarm. Alarm strobe and siren at well. Quarterly bump testing of chlorine sensors. Operators observe condition of sites every 3-days. Continuous SCADA monitoring of alarms. Ventilation system runs continuously.	Update the Chlorine Leak Alarm Response Procedure to include the phone numbers for Emergency Response Agencies including the CUPA, California Office of Emergency Services and the National Response Center. Include in the procedure, the level that would require a notification of outside agencies. Document the coordination of emergency response actions with local fire department and hazmat response team.	2/20/2020	Updated Chlorine Leak Alarm Response Procedure and EAP to include emergency contact phone numbers and notification requirements for chlorine releases. Sent EAP to local fire department and county hazmat response team and invited agencies to attend emergency evacuation drill.	Chief Plant Operator, John Doe	1/20/2020 2/10/2020

PHA Requirements

- Timetable for Completing Recommendations:
  - Agreeable by the CUPA;
  - Within 2.5 years; or
  - The next planned turnaround, if required.

PHA Requirements

- Communicate actions to employees affected by recommendations; and
- Retain PHAs and documentation on resolution of recommendations for the life of the process.



PHA Requirements

Any Questions?

Facility Siting

- Evaluate whether process location creates risks for onsite personnel or offsite public or environmental receptors.

Item	Question	Answer (Y, N, N/A)	Justification
GENERAL CONSIDERATIONS			
1.	If plant contains flammables above PSM/RMP/CalARP TQ, are they located outdoors to reduce risks?		
2.	Is plant exposed to hazards from neighboring plants?		
3.	Are there detection systems and/or alarms in place to assist in warning neighboring plants and the public if a release occurs?		
4.	Does site security prevent access by unauthorized persons while not hindering emergency services (e.g., fire fighters, paramedics)?		
5.	Are there below-ground-level locations (pits, ditches, sumps) where toxic or flammable materials can collect?		
6.	Are emergency shutdown switch locations protected against potential hazards, in easily accessible locations, and provided with knocking guards?		
7.	Can transportation of hazardous materials or impact of spillage be reduced by suitable site location?		
8.	Other general site concerns (specify)?		
BUILDING PROTECTION			
9.	Is ground or paving sloped so that flammables will not accumulate beneath vessels?		
10	Could drainage system cope with both storm water and fire fighting water?		
11	Are structures that are load bearing fireproofed if they are required to support vessels, equipment or pipework carrying flammable, toxic or hazardous materials?		

Contra Costa Health Services Facility Siting Checklist

Human Factors

"**Human factor**" means a discipline concerned with designing machines, operations, and work environments so that they match human capabilities, limitations, and needs.

Human Factors

- Process safety relies on people
  - Execution of tasks
  - Response to incidents
- Procedures
- Equipment
- Controls
- Scheduling

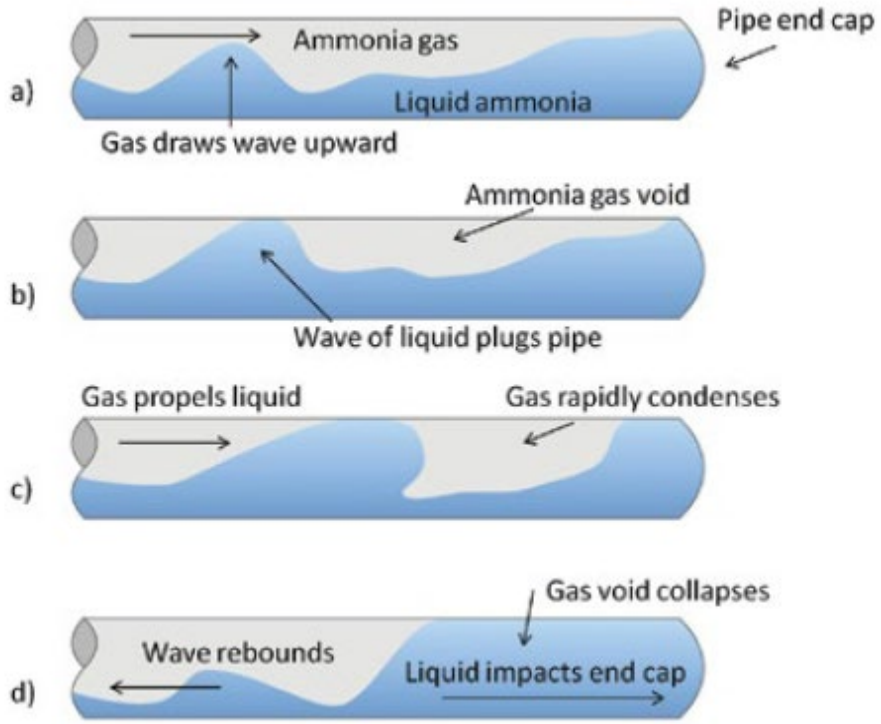
Contra Costa Health Services Human Factors Checklist

Previous Incidents

- Evaluate previous facility and industry incidents including near misses;
- Verify incident investigation findings have been addressed;
- Consider incidents at other facilities where duplication could occur; and
- Address causes in other areas of the process or facility.

Previous Incidents

Key Lessons for Preventing Hydraulic Shock



KEY LESSONS SUMMARIZED:

- For the design of ammonia refrigeration systems, avoid grouping multiple, large-capacity evaporators to a single set of control valves.
- Program the defrost control sequence to automatically depressurize or bleed the coil upon restart after an outage or interruption, prior to opening the suction stop valve to set the evaporator into cooling mode.
- Avoid the manual interruption of evaporators while in defrost and equip control systems with password protected controls to ensure only trained and authorized personnel have the authority to manually override system processes.
- For time-initiated hot gas defrost systems, ensure pump-out times are long enough to remove all liquid refrigerant from the evaporator coils prior to introducing hot gas, especially after low-load periods or power outages.
- In the event of an ammonia release, activate the emergency shut-down switch to de-energize pumps, compressors and valves instead of attempting to isolate leaking equipment while the refrigeration system is running.

PHA Team

- Experienced and knowledgeable team is essential
- Appropriate number of team members
- Requirements:
  - Expertise in engineering and operations
  - Specific knowledge and experience of the process
  - Knowledge of the methodology

PHA Team

Roles:

- Facilitator – Provides direction and organization
- Scribe – Responsible for documenting the study
- Contributors – Provide knowledge and expertise with practical experience in operations, maintenance and engineering.

Required Elements

Hazard: A physical or chemical condition that has the potential for causing harm to people, property, or the environment.

- Hazards of the process:
  - Hazardous consequences;
  - Process and facility conditions that could produce; and undesirable consequences.

Required Elements

- Engineering and administrative controls applicable to the hazards;
- Detection methods providing early warning of releases;
- Consequences of failure of engineering and administrative controls; and
- Evaluation of safety and health effects.

Required Elements

Safeguards and control measures:

- Compressor high discharge pressure cutout at **210 psig;**
- Emergency pressure control system activates at **225 psig;**
- PRVs set pressure of **250 psig** and relief to diffusion tank;
- Technicians verify operation condition during daily rounds;
- Local compressor alarms to HMI. Auto dialer response to equipment shutdown. Less than 1-hour contractor response.

Risk Ranking

- Likelihood (L) Expected frequency of cause to happen?
  - (With safeguards in place)
- Consequence (C) What is the expected outcome?
  - (Assuming safeguards fail)
- Risk (R) is based on likelihood and consequence levels.

Risk Ranking

Likelihood

1: Not expected to occur during the lifetime of the process

2: Expected to occur only a few times in the life of the process

3: Expected to occur several times during the life of the process

4: Expected to occur yearly

Risk Ranking

Consequence

1: No employee injuries

2: Minor injury or effects to employees or public

3: Major injury or effects to employees or public

4: Death or severe health effects to employees or public

Risk Ranking

Risk Ranking Matrix

LIKELIHOOD				
4	C	B	A	A
3	C	B	B	A
2	D	C	B	B
1	D	D	C	C
	1	2	3	4

CONSEQUENCE

Risk Ranking

Risk Level Explanation

A: Unacceptable, #1 priority to reduce risk

B: Undesirable, #2 priority to reduce risk

C: Tolerable with ongoing administrative and engineering controls

D: Acceptable as is

LIKELIHOOD				
4	C	B	A	A
3	C	B	B	A
2	D	C	B	B
1	D	D	C	C
	1	2	3	4
				CONSEQUENCE

Risk Ranking

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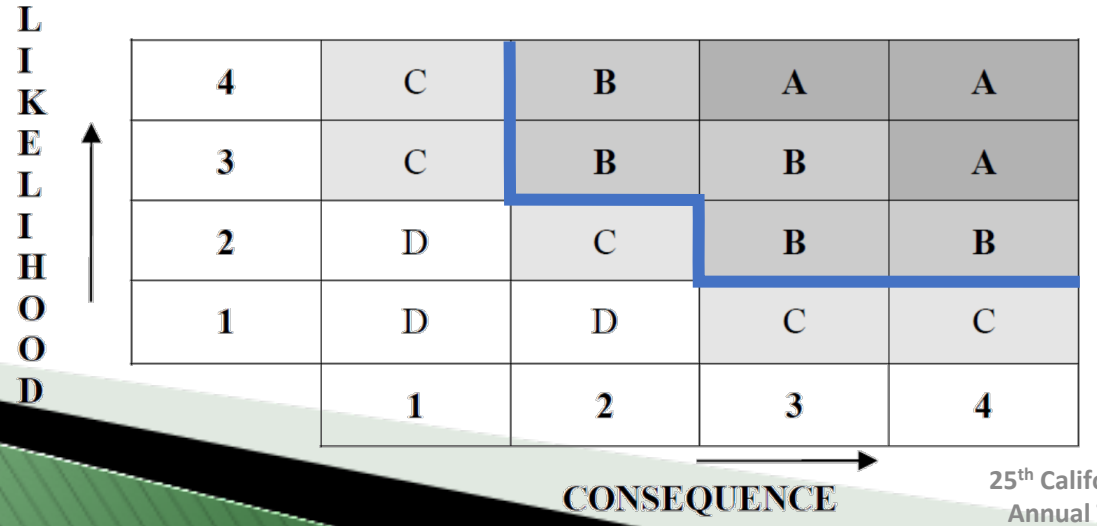
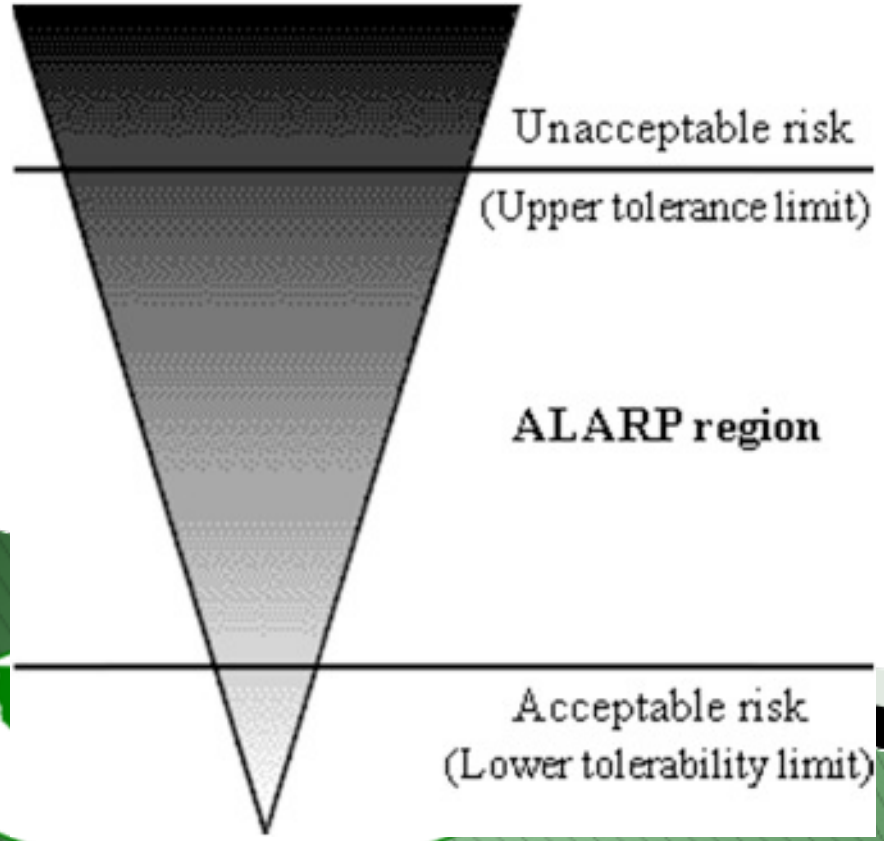
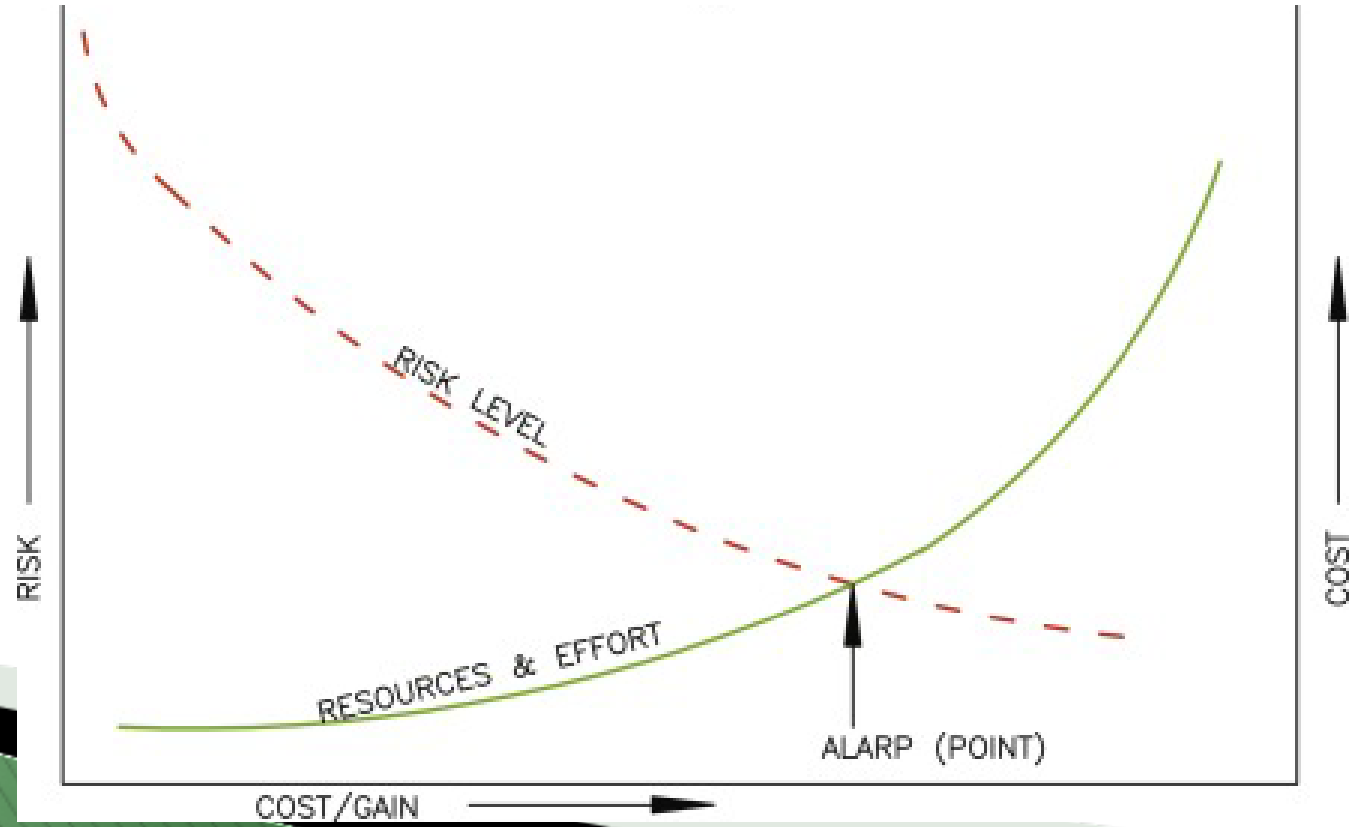


4	C	B	A	A
3	C	B	B	A
2	D	C	B	B
1	D	D	C	C
	1	2	3	4

Risk Ranking

As low as reasonably practicable (ALARP).



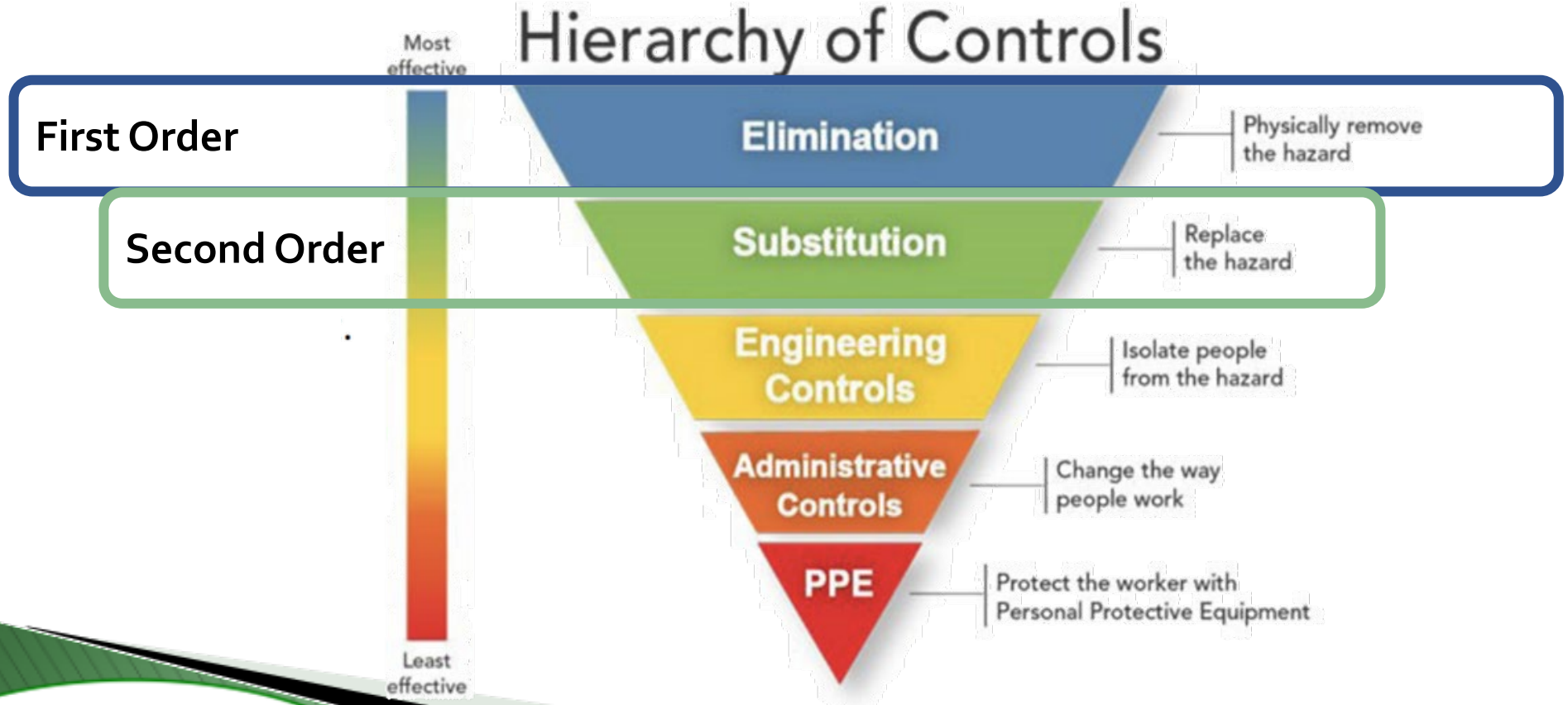


Risk Ranking

Hierarch of Hazard Controls

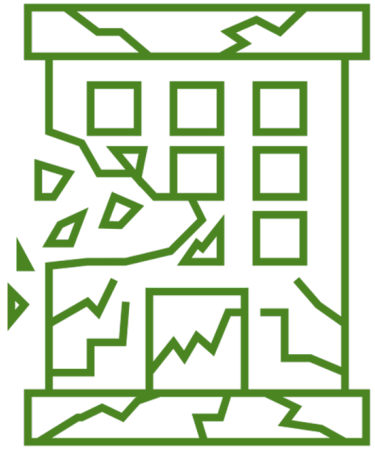
- First order of inherent safety – eliminate hazard;
- Second order – reduce severity or likelihood of a release without additional devices; and
- Passive, active and procedural protection layers.

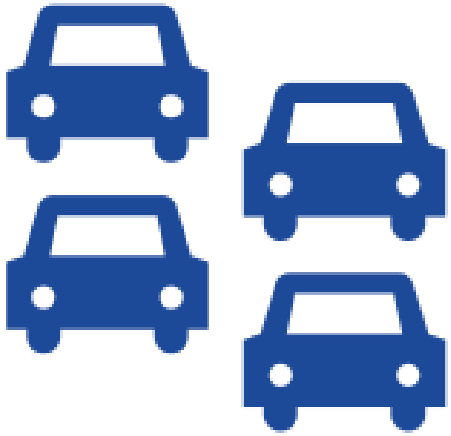
Risk Ranking



External Events

- Seismic;
- Natural Hazards;
- Traffic;
- Onsite Incidents; and
- Offsite Incidents.

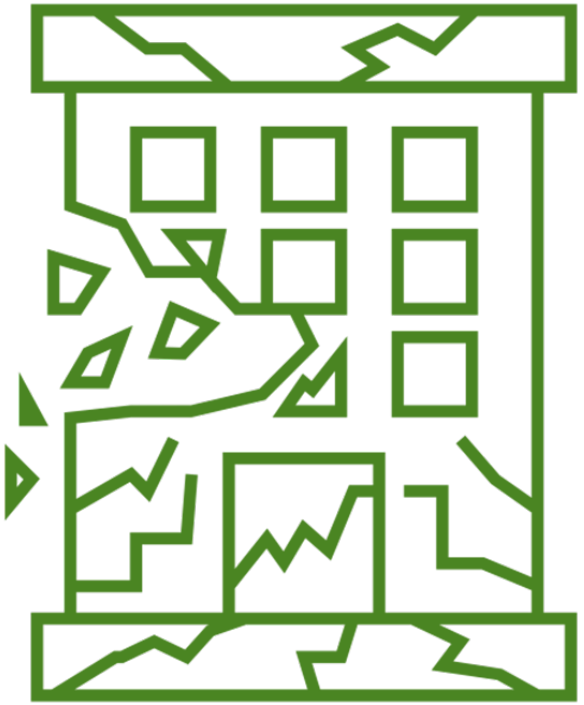




External Events

Seismic Assessments

- Revalidated at least every 5 years
- Required for RMP to be deemed as complete during review.



CalARP Seismic Assessment Guidance

External Events

CSB Investigation – Arkema Inc. Chemical Plant Fire Summary:

- Flooding resulted in loss of refrigeration;
- Organic peroxides decomposed and burned;
- 200 people evacuated; and
- 21 people evacuated due to exposure to toxic fumes.

External Events

Arkema PHA:

- Did not document flooding risk
- Loss of refrigeration initiating events
  - Compressor failure
  - Refrigerant leak
  - Loss of power

External Events

Safeguards to address loss of power:

- Emergency generators;
- Liquid nitrogen supply for alternative cooling;
- Manual temperature checks conducted every 2 hours and the capability to relocate organic peroxide products to another building or to a portable refrigerated trailer.

Temperature checks alone don't act as a safeguard. Specific detection and early warning of hazardous decomposition.

Safeguards are not independent of hazard initiating events. Flooding was the common failure mode.

External Events

- Low Temperature Warehouse PHA did not document flooding risk;
- Safeguards were capable of preventing loss of refrigeration in a 100-year flooding event.
  - Arkema was within FEMA 100 and 500-year floodplain;
  - Insurance report identified flood risk prior to incident; and
  - Hurricane Harvey was a 500-year flood event.

External Events

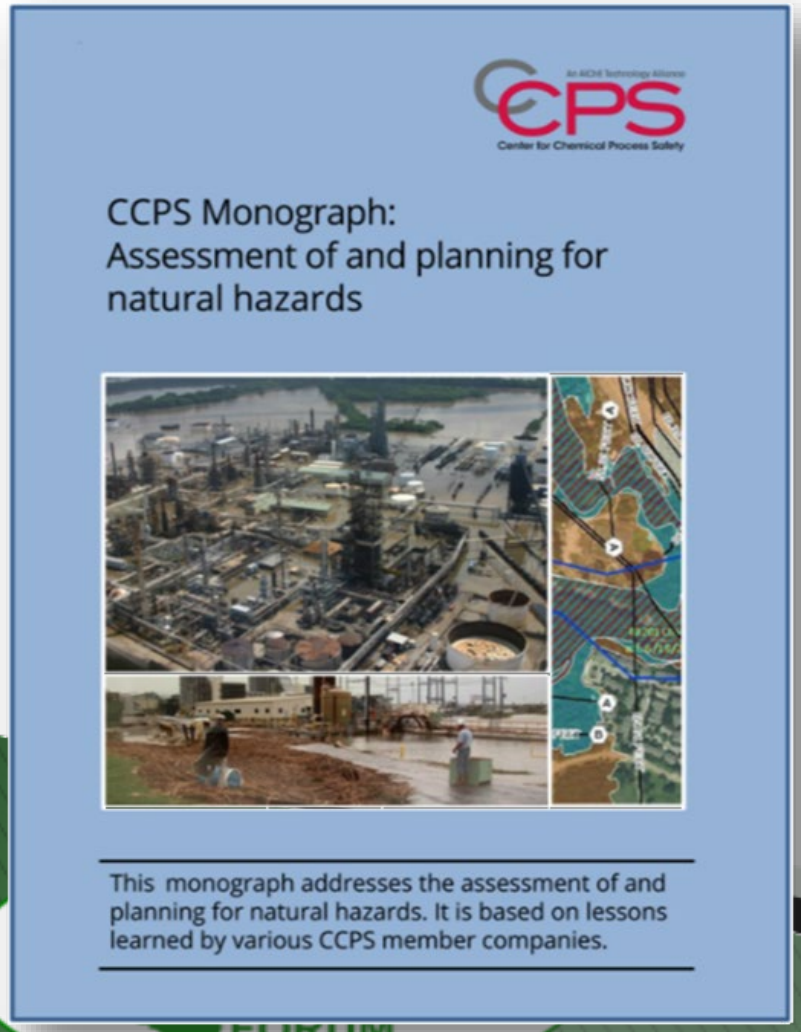
- Low Ter…nent flooding…
- Safegua…frigeration in a 100…
  - Arke…odplain;
  - Insur…ncident; and
  - Hurr…

External Events

Arkema response to CSB recommendations to reduce flood risk:

- Made improvements to facility to exceed 500-year flood elevation standard; and
- Installed subgrade detention storage to mitigate 100-year flood flow.

External Events



Natural Hazards

- Gather data
- Evaluate design criteria
- Actions
  - Assess risk
  - Close gaps
  - Response planning

[CCPS Monograph: Assessment of and Planning for Natural Hazards]

External Events

APPENDIX A: EXAMPLE SITE SCREENING FOR NATURAL HAZARDS, continued

Flood Hazard Table						
Critical Equipment / Building Impacted	Estimated 500-year Flood Level (m)(ft)	Estimated 100-year Flood Level (m)(ft)	Elevation (m)(ft)	Elevation Gap: 500yr/100yr (m)(ft)	Safeguards	Action: (one or more) • Close Gap • Assess Risk • Emergency Response

Wind Hazard Table					
Critical Equipment / Building Impacted	Wind design required per code (kph)(mph)	Existing Wind design basis (kph)(mph)	Wind Design Gap: (kph)(mph)	Safeguards	Action: (one or more) • Close Gap • Assess Risk • Emergency Response

Earthquake Hazard Table					
Critical Equipment / Building Impacted	Seismic design required per code	Existing Seismic design basis	Seismic Design Gap:	Safeguards	Action: (one or more) • Close Gap • Assess Risk • Emergency Response

Other Hazard Table					
Building Name	Snow Load design required per code	Storm Surge design basis	Extreme Temperature design basis	Other design basis:	Action: (one or more) • Close Gap • Assess Risk • Emergency Response

Considering natural hazard data as "process safety information" is a good practice.

Natural Hazard Screening

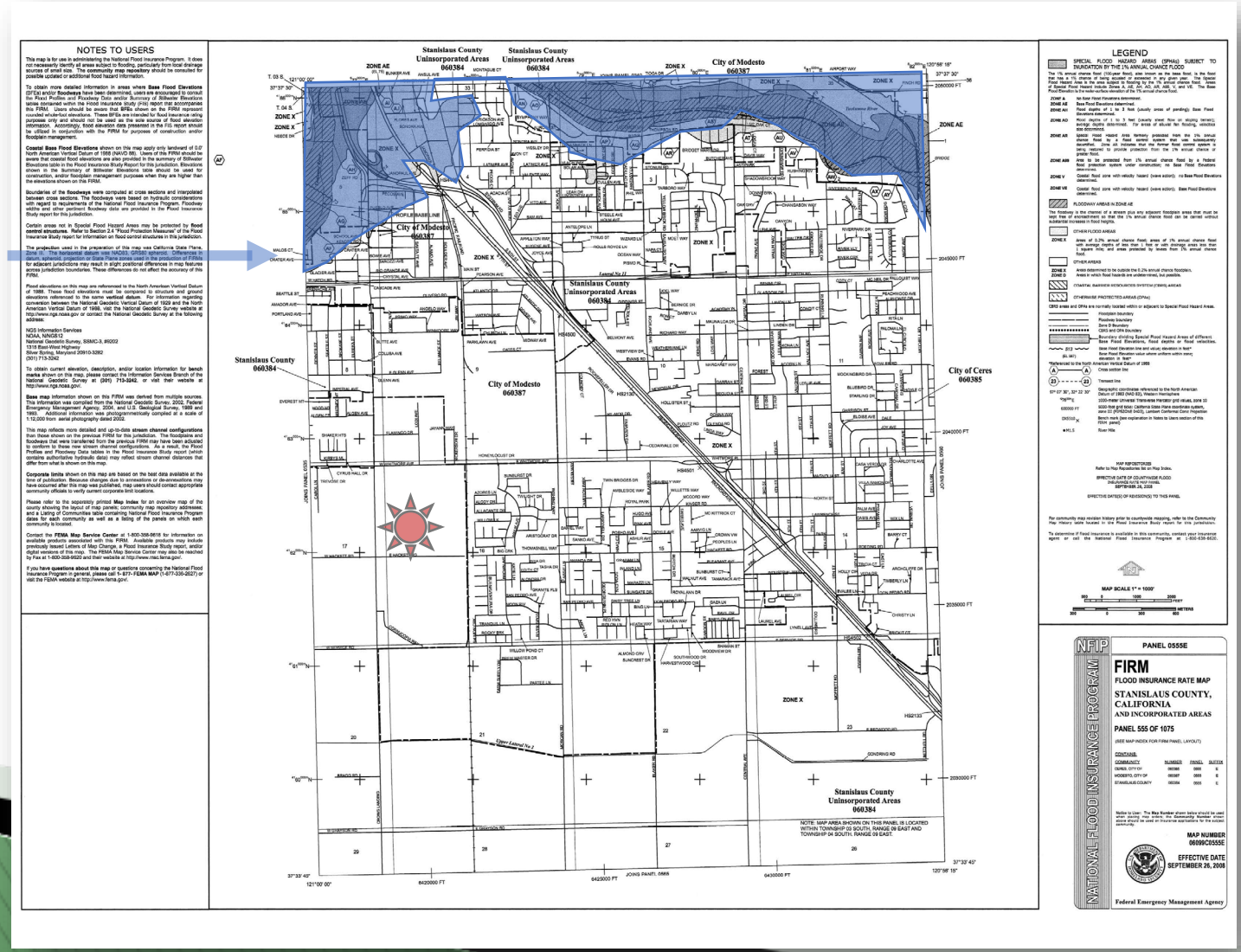
- Meteorological
- Geological

[CCPS Monograph: Assessment of and Planning for Natural Hazards]

External Events

FEMA Flood Maps

Potential flooding during 100- and 500-year events

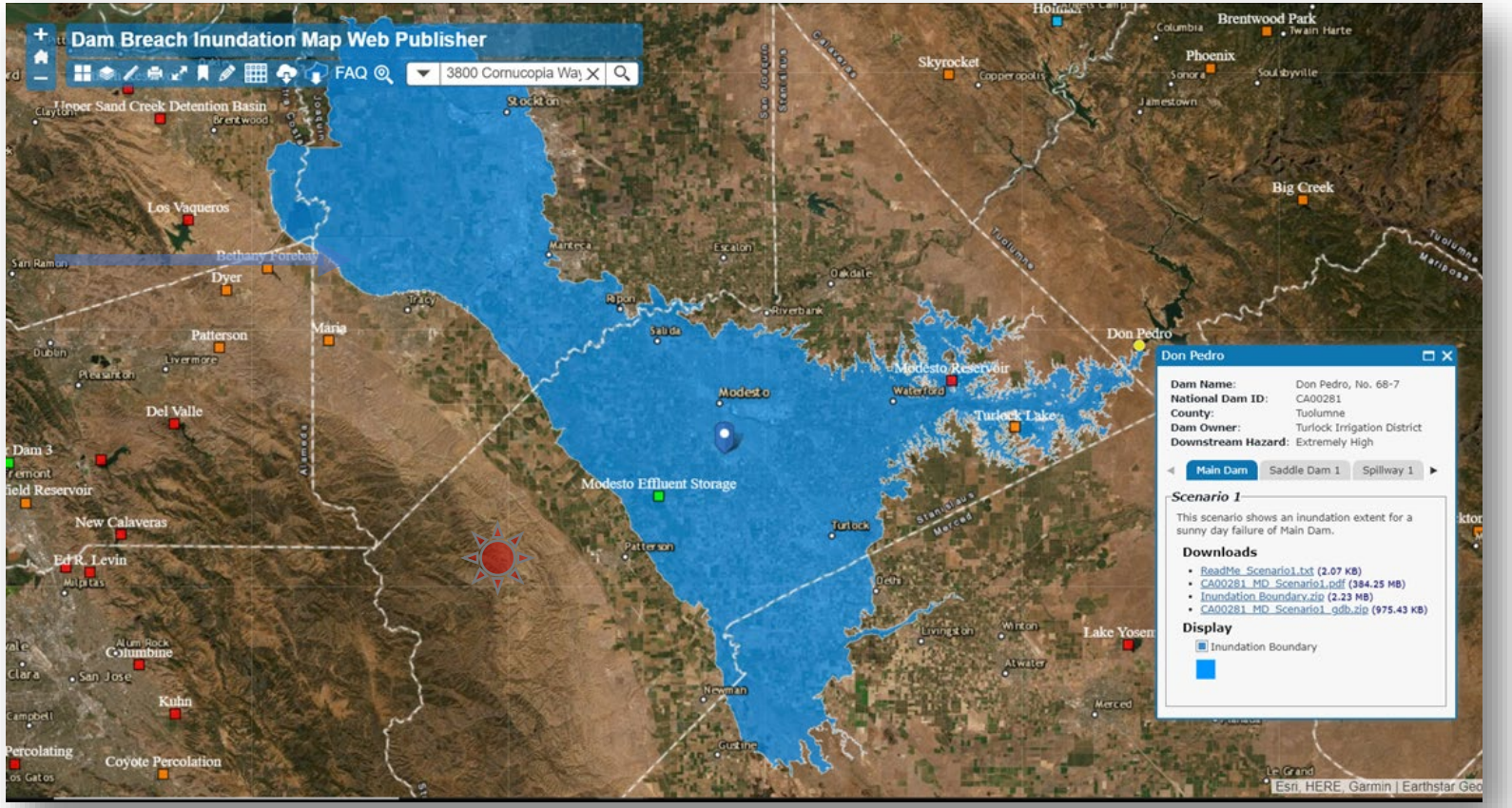


CALIFORNIA CUPA FORUM

External Events

Dam Breach Inundation

Don Pedro Dam



DSOD Dam Breach Inundation Map

External Events

Any Questions?

Process Hazard Analysis

Purpose:

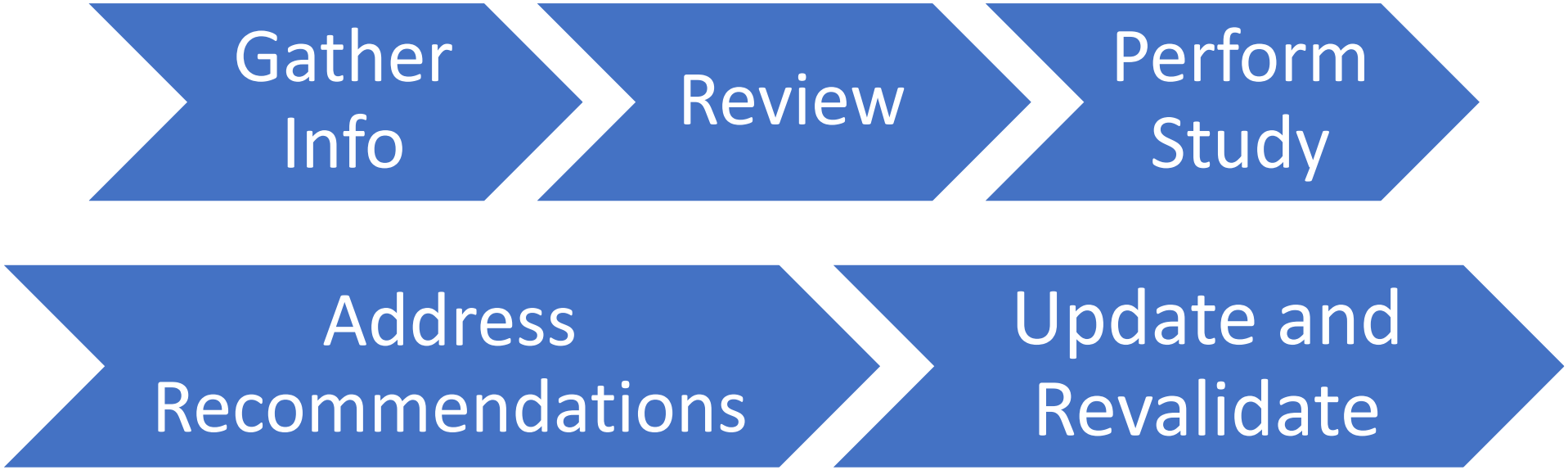
- Identify and analyze significant hazardous situations of a process; and
- Aid in decision making for improving safety and managing risk.

Desired outcomes:

- Fewer incidents;
- Reduced consequences; and
- Evaluate compliance.

Process Hazard Analysis

PHA Process



Any Questions?

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- EPA FAQ: What constitutes a revision of the PHA?
- Key Lessons for Preventing Hydraulic Shock in Industrial Refrigeration Systems
- CalARP Seismic Assessment Guidance
- CSB: Extreme Weather Safety Message Video
- DSOD Dam Breach Inundation Map
- ATC Wind, Snow, Tornado and Seismic Hazard