

AIHce 2017

Welcome to Seattle, Washington



PDC 305: What-If/Checklist Analysis

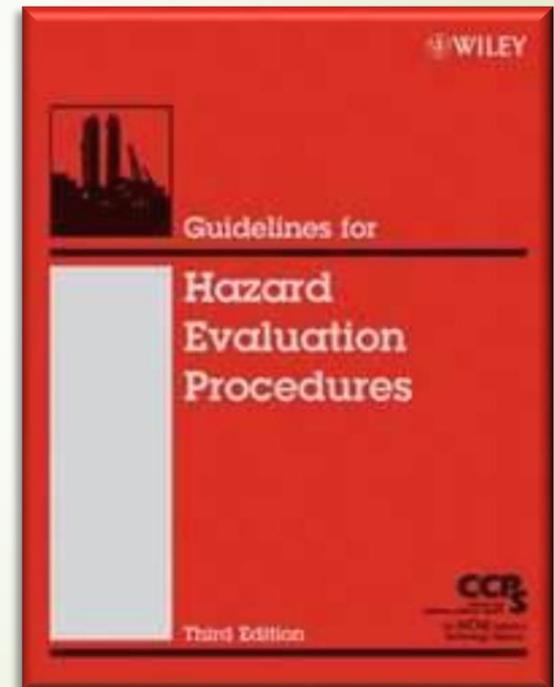


Parvati Consulting LLC

PDC Instructors

Kelsey L. Forde, CIH, CHHM
klforde@parvaticorp.com

Timothy S. Stirrup, IH, REM
tsstirrup@parvaticorp.com





Session Overview

- Purpose
 - Provided Redbook Guidelines for What-If/Checklist Analysis

- Objectives
 - Understand Use of Redbook as Standard
 - Understand Input into Process
 - Understand Steps to Complete Process
 - Understand Output from Process
 - Instructor Lessons Learned



Session Overview

- Module 1 – Quick Review
- Module 2 – Define What-If & What-If/Checklist Analysis
- Module 3 – Redbook What-If/Checklist Analysis
- Module 4 – What-If/Checklist Analysis Process
- Module 5 – What-If/Checklist Analysis Exercise
- Module 6 – Lessons Learned



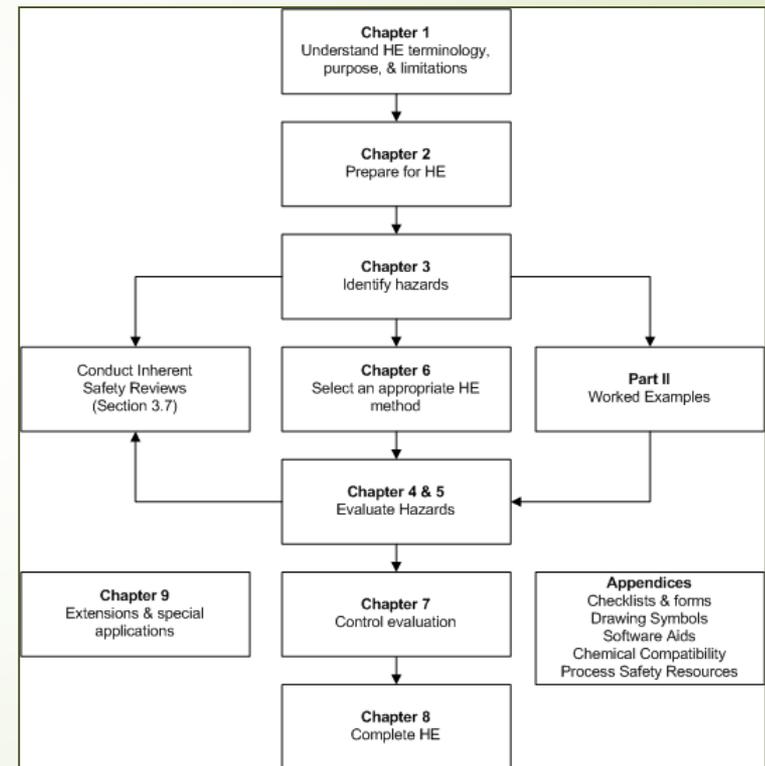
Module 1
Define What-If & What-If /Checklist Analyses



Redbook Outline & Flow

See Pg 9

- ▶ Chapter 2 – Preparation for Hazard Evaluations
- ▶ Chapter 3 – Hazard Identification Methods
- ▶ Chapter 6 – Selection of Hazard Evaluation Techniques





Selection of HE Techniques

- ▶ Select Appropriate HE Technique
 - ▶ Ensure Effort Not Wasted by Over-Studying a Problem with a More Detailed Approach than Necessary
 - ▶ Ensure Effective Analysis Completed to Derive Correct Controls
 - ▶ Unique Strengths & Weaknesses in Each HE Technique

- ▶ Allowed Some Freedom to Select One or More Proper Methods

- ▶ Selecting the Most Appropriate Hazard Evaluation Method is a Critical Step in Ensuring Success of a Hazard Evaluation



Selection of HE Techniques

- 6 Factors Influencing Selection (pg. 176)
 - Motivation/Type of Results Needed
 - Type of Information Available

 - Characteristics of Analysis Problem
 - Perceived Risk Associated With Facility/Process

 - Resource Availability
 - Analyst/Management Preference



Selection of HE Techniques

- ▶ Knowledgeable & Informed Manager Decision
 - ▶ Benefits, Strengths, Limitations, & Resource Requirements

- ▶ Qualified Analyst Recommendation Based on Factors
 - ▶ Reflect Preference/Ability of HE Techniques

- ▶ Potential Use of Detailed HE Technique in Less Detailed Way

- ▶ Ultimately Quality of Results from HE is Function of the Quality of Team/Team Efforts

- ▶ Use of Multiple HE Techniques
 - ▶ Broad Brush Technique to Narrow Issues
 - ▶ Detailed Technique to Improve Understanding of Specific Issues



Selection of HE Technique

- Chapter 4 – Non Scenario-Based Hazard Evaluation Procedures

- Chapter 5 – Scenario-Based Hazard Evaluation Procedures
 - **Section 5.1 – What-If Analysis**
 - **Section 5.2 – What-If/Checklist Analysis**
 - Section 5.3 – Hazard & Operability (HAZOP) Studies
 - Section 5.4 – Failure Modes and Effects Analysis (FMEA)
 - Section 5.5 – Fault Tree Analysis (FTA)
 - Section 5.6 – Event Tree Analysis (ETA)
 - Section 5.7 – Cause-Consequence Analysis (CCA) and Bow-Tie Analysis
 - Section 5.8 – Other Techniques



Relationship to OSHA PSM

- Process Hazard Analysis (PHA)
 - 29 CFR 1910.119 The employer shall use one or more of the following methodologies that are appropriate to determine and evaluate the hazards of the process being analyzed.
 - Checklist; What-If; **What-If/Checklist**; HazOp; FMEA; FTA; or an appropriate equivalent methodology
 - PHA Frequency – Every time there is a significant process change; a minimum of every five years
 - Include PHA as part of management of change (MOC) process
 - Retain PHA records for the life of the process



Module #2
Define What-If & What-If /Checklist Analysis



Define What-If Analysis

- ▶ Checklist Analysis
 - ▶ Written List of Items or Procedural Steps
 - ▶ Verify the Status of a System

- ▶ What-If Analysis
 - ▶ Brainstorming Approach
 - ▶ Group of Experienced People with the Subject Process
Ask Questions or Voice Concerns About Possible Undesired Events

- ▶ What-If/Checklist Analysis
 - ▶ Combines
 - ▶ Systematic Features of the Checklist Analysis
 - ▶ Creative, Brainstorming Features of the What-If Analysis



Checklist

- ▶ Purpose:
 - ▶ Verification of System Status Using Written List of Requirements/Procedural Steps
- ▶ Description:
 - ▶ List of Known Hazards, Design Deficiencies, and Incidents
 - ▶ List of Requirements/Procedural Steps
 - ▶ List of Other Parameters (e.g., chemical properties, codes/standards)
- ▶ Type of Results:
 - ▶ Typically List with "No," "Yes," or "Not Applicable" & Associated Corrections
- ▶ Resource Requirements:
 - ▶ Information to Create Checklist; Single Analyst; 2 – 12 Days
 - ▶ Creating Checklist is Intensive Effort
- ▶ Analysis Procedure
 - ▶ Select Checklist
 - ▶ Perform Walkthrough, Design, Procedure, Codes/Standards Review
- ▶ Documenting Results
 - ▶ Qualitative Report (w/ Completed Checklist) & Recommendations
 - ▶ Potential for Inherent Safety Review ~ Minimization, Moderation, & Simplification



What-If

- ▶ Purpose:
 - ▶ Brainstorming Approach to Identify Hazards/Hazardous Situations, or Event Sequences with Potential Undesirable Consequences ~ May Include Cause/Initiating Events
- ▶ Description:
 - ▶ Use of Facilitator, Scribe, & Team
 - ▶ Not Inherently Structured, Requires Skilled Facilitator
 - ▶ Ideally Divide Questions Based on Hazards and/or Process Areas
 - ▶ What If Can Be Effective & Efficient With Experienced Team/Facilitator
- ▶ Type of Results:
 - ▶ Random Tabular Listing of Hazardous Situations with Consequences & Safeguards
- ▶ Resource Requirements:
 - ▶ Supporting Information; Representative Team; 1 – 29 Days Duration
- ▶ Analysis Procedure
 - ▶ Collect Chemical Data, Process Description, Drawings, & Operating Procedures
 - ▶ Seed Analysis Tables for Workshop Meetings For Team Brainstorming
- ▶ Documenting Results
 - ▶ Qualitative Report (w/ Completed What If Analysis Worksheet) & Recommendations
 - ▶ Potential for Inherent Safety Review ~ Resolve “What-If Question”
 - ▶ May Provide Input into Further More Refine HE Analysis



What-If/Checklist

- ▶ Purpose:
 - ▶ Systematic Use of Checklist Using Brainstorming Approach to Identify Hazards/Hazardous Situations, or Event Sequences with Potential Undesirable Consequences ~ May Include Cause/Initiating Events
- ▶ Description:
 - ▶ Use of Facilitator, Scribe, & Team ~ Requires Skilled Facilitator
 - ▶ Structured Approach to Identify All Hazards/Hazardous Situations
- ▶ Type of Results:
 - ▶ Systematic Tabular Listing of Hazardous Situations with Consequences & Safeguards
- ▶ Resource Requirements:
 - ▶ Supporting Information; Representative Team; 1 – 31 Days Duration
- ▶ Analysis Procedure
 - ▶ Collect Chemical Data, Process Description, Drawings, & Operating Procedures
 - ▶ Seed Analysis Tables for Workshop Meetings For Team Brainstorming
 - ▶ Qualitatively Determine Significant of Effects and Relative Recommendations
- ▶ Documenting Results
 - ▶ Qualitative Report (w/ Completed What If Analysis Worksheet) & Recommendations
 - ▶ Potential for Inherent Safety Review ~ Resolve “What-If Question”
 - ▶ May Provide Input into Further More Refine HE Analysis



What-If/Checklist Terms

- Basic/Common Terms
 - Event ID#
 - Process/Facility Location
 - Hazard Type
 - What-If Question/Event Description
 - Consequence
 - Safeguards/Controls ~ Preventative/Mitigative
 - Recommendation & Actions
 - Cause
 - Initiating Event
 - Receptors

- Input into What-If Workshop Table



Example What-If/Checklist Table

Event ID #	Facility/Area	Process/Activity	Hazard	What-If Description	Consequence	Safeguards/Controls	Recommendations & Actions



Module 3

Redbook What-If/Checklist Analysis



What-If/Checklist Description

- Identify Hazards, Hazardous Situations, or Specific Event Sequences that Could Produce Undesirable Consequences

- Experienced Group Identifies
 - Abnormal Situations (Events)
 - Consequences (Impacts to Receptors)
 - Existing Safeguards (Controls)
 - Alternatives for Risk Reduction
 - Improvement Opportunities
 - Inadequate Controls

- Examination Of Possible Deviations From The Design, Construction, Modification, Or Operating Intent



What-If/Checklist Description

- Requires Basis Understanding of Process Intention

- Requires Ability to Mentally Combine Possible Deviations From Design Intent that Could Result in Accidents

- Potential Incomplete Results
 - Not Using Experienced Facilitator
 - Not Using Checklist Approach
 - Not Using Complete/Updated Information



What-If/Checklist Description

- What-If Not Inherently Structured As Other Techniques
 - Both Weakness & Strength (Why?)

- Used By Industry at Every Stage of Life Cycle

- Requires Skilled/Experienced Facilitator

- Adapt The Basic Concept To The Specific Application
 - Facility Based
 - Hazard Based
 - Process Based



What-If/Checklist Description

- ▶ Concept Encourages Brainstorming of Events That Begin with What-If
 - ▶ Not Like Jeopardy To Ask In Form of Question
 - ▶ What-If Reflects Philosophy Rather Than Structure

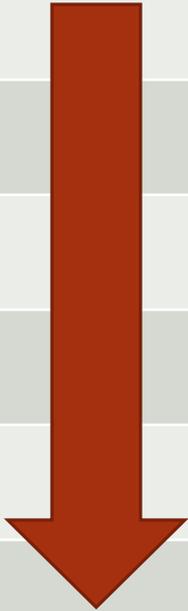
- ▶ Develop What-If Questions
 - ▶ Based On Experience
 - ▶ Applied To Drawings And Process Descriptions

- ▶ Brainstorming of “What If” Events
 - ▶ Across versus Down Worksheet
 - ▶ Not Necessarily Specific Pattern or Order to Questions



What-If/Checklist Table Down vs. Across

Event ID #	Process/Facility Location	Hazard	What-If/Event Description	Consequence	Safeguards/Controls	Recommendations & Actions





What-If/Checklist Description

- ▶ Facilitator Provides Structure/Order to Method
 - ▶ Determine Structure
 - ▶ Facility Based
 - ▶ Hazard Based
 - ▶ Process Based
 - ▶ Initiating Event Based (human error, mechanical failure, etc.)
 - ▶ Application of Checklist

- ▶ Scribe Records Events, Consequences, Controls, and Actions

- ▶ Questions Divided Into Specific Areas of Investigation Related to Consequences of Concern

- ▶ Address Questions By Team of Knowledgeable People



Types of Results

- ▶ Simplest Form Generates a List of Questions & Answers Regarding Process
- ▶ Ideally Tabular Listing of Hazardous Situations Together with Consequences, Safeguards, & Risk Reductions
- ▶ Results Typically **DO NOT** Include Ranking or Quantitative Implication for Event



Resource Requirements

- Performed at Any Stage of Life Cycle of Process
 - Conceptual Through Operation

- Use of Any & All Information Available During Stage of Life Cycle

- Minimum Team (~ 3 People) But Larger Team Preferred

- Better To Use Larger Group for Larger Process
 - Than To Use Small Group for Longer Period of Time
 - Divide Large Process Into Smaller Segments



Resource Requirements

- ▶ Once An Organization Gains Experience, The What-if Method Can Be A Cost Efficient Method For Evaluating Hazards During Any Project Phase
- ▶ Time And Costs Of The What-if Analysis Proportional to Complexity and Size of Process

Minimum Time Estimates for Using the What-if Analysis Method			
<u>Scope</u>	<u>Preparation</u>	<u>Evaluation</u>	<u>Documentation</u>
Small System	4-8 hours	4-8 hours	1-2 days
Large Process	1-3 days	3-5 days	1-3 weeks



Module 4

What-If/Checklist Process



What-If/Checklist Analysis Process

- Three (3) Step Process ~ Redbook
 - Step 1: Prepare for Review
 - Step 2: Perform Review
 - Step 3: Document Results
 - Step 4: Complete Actions/Follow Up

- Remember
 - Input from HI
 - HI Identifies Hazards
 - HI Screen of Hazards of Concern
 - Focus on Systems/Components Associated with Hazards of Concern
 - Determine Hazard Evaluation (HE) Method



Preparing for Review

- ▶ Up to Date Required Information
 - ▶ Chemical Data
 - ▶ Process Descriptions
 - ▶ Facility/Equipment Drawings
 - ▶ Operating Procedures
 - ▶ Control System Descriptions

- ▶ Other Information
 - ▶ Life Cycle of Facility
 - ▶ Regulatory Requirements
 - ▶ Definitive Questions

- ▶ Ideally Information Provided to Team Prior to Workshop



Preparing for Review

- ▶ Complete Site Visits & Interviews Prior to Workshop
 - ▶ Ideally Operations, Maintenance, & Utilities Included in Workshop

- ▶ Develop “Seed” What If Questions
 - ▶ Based on Previous Analysis
 - ▶ Down and/or Across

- ▶ Strength of Process
 - ▶ Depth of Team Knowledge & Experience
 - ▶ Questions Developed by Team



Preparing for Review

- Hybrid Checklist Method (Section 4.4 Checklist Analysis)
 - More Systematic Approach

- Develop Checklist
 - Hazard Based
 - Process Based
 - Facility Based
 - Equipment Based
 - Event Based



Preparing for Review

- ▶ Set-up Checklist Approach
 - ▶ Facility/Process versus Hazards
 - ▶ May Dictate When SMEs at HE

- Facility

- Process Area
 - Process/Activity
 - Hazard
 - » Initiating Event

- Facility

- Hazard
 - Facility/Process Area
 - Process/Activity

- Hazard

- Facility
 - Process Area
 - Process/Activity

- Hazard

- Facility/Process Area
 - Process/Activity



Performing the Review

- ▶ What-If/Checklist Workshop Team
 - ▶ Facilitator/Team Leader*
 - ▶ Scribe
 - ▶ Operations Personnel*
 - ▶ Maintenance Personnel*
 - ▶ Other Subject Matter Experts (SMEs)
 - ▶ Fire Protection
 - ▶ Industrial Hygiene
 - ▶ Structural/Civil Engineers
 - ▶ Mechanical Engineers
 - ▶ Occupational Safety
 - ▶ Management



Performing the Review

- Workshop Length No More Than 4 – 6 Hours
- Provide What If Training and Ground Rules to Team
- Basic Explanation of Process/Facility
- Discuss Scope of Review
- Determine How Workshop Flows
 - Across Versus Down
 - Down Preferred ~ Gets to the Questions



Performing the Review

- ▶ Either/Or ~ Both
 - ▶ Use Checklist to Order Workshop
 - ▶ Use Checklist to Ensure Completeness of Workshop

- ▶ Order What If Workshop Using Checklist
 - ▶ Address Hazards Identified for Given Process in Given Area
 - ▶ Chemical Hazards for Handling in Storage Area
 - ▶ Pressure Hazards for Handling in Storage Area
 - ▶ Chemical Hazards for Handling in Reactor Area
 - ▶ Pressure Hazards for Handling in Reactor Area

- ▶ Ensure Workshop Completeness Using Checklist

- ▶ Don't Use to Restrict Creativity & Imagination of Team



Inherent Safety Reviews

- Evaluate Hazards As Inherent Safety Review

- Identify Inherent Safety Improvements for Reducing or Eliminating the Potential for Scenario to Develop
 - Substitution
 - Minimization
 - Moderation
 - Simplification



Documenting Results

- Documentation is Key to Transforming Team's Findings into Measures for Hazard Elimination or Reduction
- Findings Documented in What If Worksheet
- List of Suggestions for Improving Safety of Process
- Narrative Report with Attached Worksheets
- Results of the What-if Analysis May Provide Input into More Refined Hazard Evaluation Analysis



Documenting Results

Example

	What-if	Hazard(s)	Consequence	Safeguards	Recommendations & Actions
1.	Wrong feed material is delivered instead of Phosphoric acid?	Contaminant incompatibility	Potentially hazardous phosphoric acid or ammonia reactions with contaminants or production of off-specification product	<ul style="list-style-type: none">• Reliable Vendor• Plant material handling procedures	<ul style="list-style-type: none">• Ensure adequate material handling and receiving procedures and labeling exists
2.	Phosphoric acid concentration is too low?	Ammonia inhalation toxicity	Unreacted ammonia carryover to the DAP storage tank and release to the work area	<ul style="list-style-type: none">• Reliable Vendor• Ammonia detector and alarm	<ul style="list-style-type: none">• Verify phosphoric acid concentration before filling tank



What-if/Checklist Analysis Used for Further Scenario Evaluation

- ▶ When Used As A Starting Point For **Risk Evaluation** Or For **Layer Of Protection Analysis (LOPA)**, More Explicitly Structured Output Required
 - Scenarios (The What-if Conditions) Should Represent An Initiating Cause
 - Initiating Cause/Event (pg xxv): 1st Event Marking Transition from Normal to Abnormal
 - Consequence Should Be A Description Of The Events That Would Unfold If The Initiating Cause Occurred And No Safeguards (Preventative) Intervened - Up To The Loss Event
 - Loss Event (pg xxv): Irreversible Physical Event with Potential for Loss/Harm
 - Safeguards (Preventative) Only Those Controls That Come Into Effect After the Initiating Cause But Before the Loss Event
 - Separate Containment/Mitigative Controls After Loss Event



Module 5

Exercise/Discussion

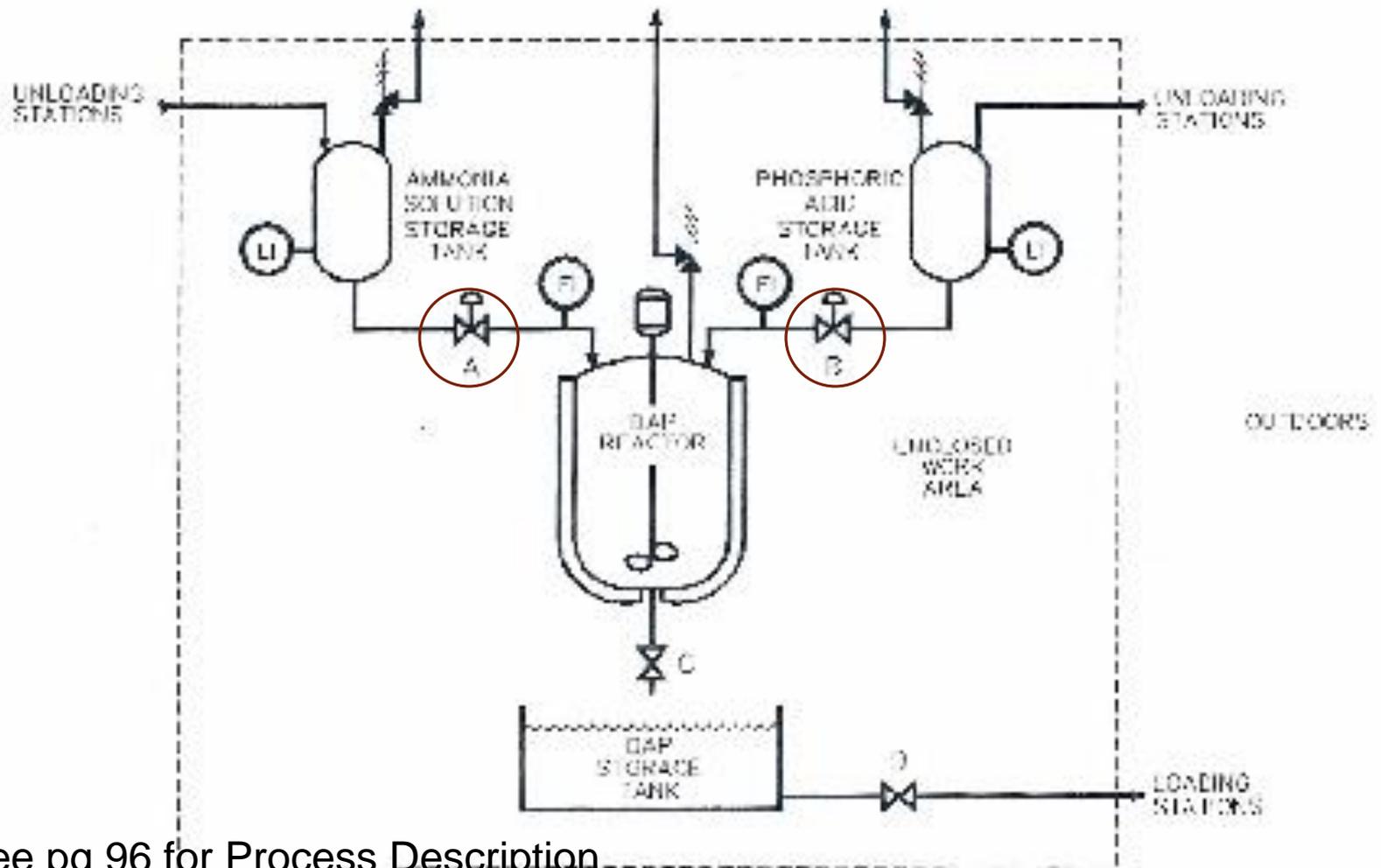


What-If/Checklist Analysis Exercise

- DAP Process Example (pg 97)



Redbook DAP Example



See pg 96 for Process Description



Redbook DAP Example

DAP Production System Component List

Ammonia Subsystem

- Ammonia Unloading Station
- Ammonia Storage Tank
- Ammonia Tank Level [L1]
- Ammonia Line Valve [A]
- Ammonia Line Flow Meter [F1]
- Ammonia Lines

Phosphoric Acid Subsystem

- Phosphoric Acid Unloading Station
- Phosphoric Acid Storage Tank
- Phosphoric Acid Tank Level [L2]
- Phosphoric Acid Line Valve [B]
- Phosphoric Acid Line Flow Meter [F2]
- Phosphoric Acid Lines

DAP System

- DAP Reactor
- DAP Mixer
- DAP Reactor Valve [C]
- DAP Storage Tank
- DAP Storage Tank Valve [D]
- DAP Loading Station



What-If/Checklist Analysis Exercise

- Identify Hazards



What-If/Checklist Analysis Exercise

- ▶ Identify Hazards
- ▶ Determine Checklist
 - ▶ Facility, Process Area, Process, Activity, Hazard



What-If/Checklist Analysis Exercise

- ▶ Identify Hazards
- ▶ Determine Checklist
 - ▶ Facility, Process Area, Process, Activity, Hazard
- ▶ Complete HE Table
 - ▶ Determine Across vs Down



What-If/Checklist Analysis Exercise

- ▶ Identify Hazards
- ▶ Determine Checklist
 - ▶ Facility, Process Area, Process, Activity, Hazard
- ▶ Complete HE Table
 - ▶ Determine Across vs Down
- ▶ Document/Review Results



Module 6

Lessons Learned



Instructor Lessons Learned

- Stakeholder Buy In
 - Scope
 - Schedule
 - Budget
- Never Enough Time to Complete
 - Preparation, Analysis, & Documentation
- Use Dedicated Workshop Facilitator
- Respect Team Leader Responsibilities
 - Required to Take On Process
 - Review, Documentation, Factual Accuracy, Comment Resolution & Concurrence
 - In Addition to Workshop/Meetings



Instructor Lessons Learned

- ▶ Adjust Team Members Based on Complexity of Operation
 - ▶ Minimum ~ Analyst with Operations/Peer Review
 - ▶ Maximum ~ Divide & Conquer

- ▶ Few Team Members With Prior HE / What-If Analysis Experience
 - ▶ Initial Training for Team on Technique & Expectations
 - ▶ Expect Re-Training/Calibration During HE
 - ▶ Hard for Team Members to Grasp Brainstorming with No Restrictions
 - ▶ Unmitigated Events



Instructor Lessons Learned

- ▶ Breakdown Workshop Into Facility/Process/Hazards
- ▶ Create Worksheets Based on Checklist
- ▶ Pre-populate (Seed) What-If Analysis Table
 - ▶ Recommend Few Across & Many Down
 - ▶ Facility/Process ~ Event, Hazards, Consequence, Controls
- ▶ Finish Brainstorming Events (Down) in Workshop
- ▶ Facilitator/Analyst Completion of Workshop Tables
 - ▶ Common Event Language ~ Develop Write Ups for Events
 - ▶ Common Control Terms ~ Develop Standard List
 - ▶ Ensure Consequences Are Comparable Throughout ~ Develop Standard List



Preferred PHA Methodology

- Formal HI Using Standard Checklist
- Screen HI for Hazards to Carry Forward into HE
- Typically Screen on SIH ~ Codes & Standards
- Preferred “Broad Brush” HE Method
 - What-If/Checklist ~ Not In Form of What-If Question (e.g., Event)
 - Use List of Hazards Carried Forward as Checklist
 - Use of Process Areas as Checklist
 - Use HE Worksheet with Process Area, Event, Cause/Initiating Event, Hazard, Consequence, & Frequency
- Perform Additional HE and/or Accident Analysis If Necessary
 - Higher/Unacceptable Residual Risk
 - Unclear Control Strategies
 - Better Definition of Frequency or Consequence



Preferred PHA Methodology

- Use of Risk to Determine Control Adequacy
 - Standard Frequency, Consequence, & Risk Tables
 - Qualitative Analysis
 - Analyze Unmitigated Consequence & Frequency ~ Inherent Risk
 - Apply Identified Preventative/Mitigative Controls
 - Determine Mitigated Consequence & Frequency ~ Residual Risk
- Perform Control Hierarchy Analysis
- Document "Safety Envelope"
- Initiate Management of Change
 - Identify Changes
 - Evaluate Potential Impact to Analysis & Subsequent Controls



Session Overview

- Purpose
 - Provided Redbook Guidelines for What-if/Checklist Analysis

- Objectives
 - Understand Use of Redbook as Standard
 - Understand Input into Process
 - Understand Steps to Complete Process
 - Understand Output from Process
 - Instructor Lessons Learned



Follow Up with Parvati

➤ Kelsey L. Forde, CIH, CHHM

➤ klforde@parvaticorp.com

➤ (505) 967-8917

➤ Timothy S. Stirrup, IH, REM

➤ tsstirrup@parvaticorp.com

➤ (505) 980-3743

➤ www.parvaticorp.com

➤ Facility/Worker Safety

➤ Redbook Training

➤ Redbook Overview

➤ Redbook HE Techniques

➤ What-If/Checklist

➤ Failure Modes & Effects Analysis

➤ Hazard & Operability Analysis

➤ Layer of Protection Analysis (LOPA)

➤ Risk Analysis

➤ Inherent Safety Reviews

➤ Perform Process Hazards Analysis

➤ Facilitate Hazard Evaluations

➤ Peer Review PHA (HI + HE)

➤ STAMP/STPA

➤ Traditional ES&H/IH Services