

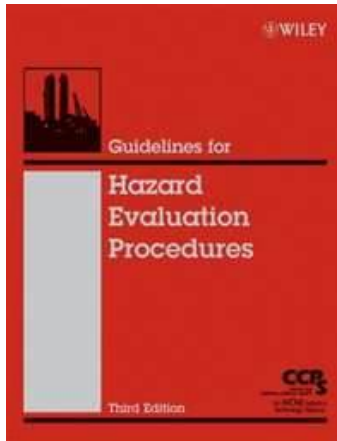
**AHMP** 30 1987-2017  
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## Redbook: Guidelines for Hazard Evaluation Procedures

## Redbook Overview



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# Historical Perspective

- ▶ Published By Center for Chemical Process Safety (CCPS)
  - ▶ Established in 1985 by American Institute of Chemical Engineers
  - ▶ Develop & Disseminate Technical Information Supporting HE
  - ▶ Prevention of Major Chemical Accidents
  - ▶ Guidelines 1st Published in 1985
- ▶ Current (3rd Ed) Guidelines Encompass
  - ▶ Lessons Learned from Industry Accidents
  - ▶ US Chemical Safety & Hazard Investigation Board (CSB)
    - ▶ Recommendations for Hazard Evaluations
    - ▶ <http://www.csb.gov/>
  - ▶ Process Safety Management Implementation
  - ▶ Laws & Regulations
  - ▶ International Standards
  - ▶ Experience Gained Since 1985 with Performing Hazard Evaluations

# Redbook Sum of Parts

- ▶ Part I - Hazard Evaluation Procedures
  - ▶ “Guidelines”
  - ▶ Describes Methods Used to Identify & Assess Hazards
  - ▶ Management Overview
  - ▶ Nine Chapters
    - ▶ Follow Flow of Performing Hazards Analysis
- ▶ Part II - Worked Examples and Appendices
  - ▶ Companion to the “Guidelines”
  - ▶ Examples for Novice Analyst
  - ▶ Examples for Training

# Redbook Do's & Don'ts

## ▶ Guidelines Do Provide

- ▶ Insights To Be Considered When Making Risk Management Decisions & Designing Risk Management Programs
- ▶ Expectations for High Quality Hazard Evaluations
- ▶ Aid for Initial Training of Hazards Analysts
- ▶ Reference Material for Experienced Hazard Analysts

## ▶ Guidelines Don't Provide

- ▶ A Complete Hazards Analysis Program
- ▶ Specific Advice On How to Establish HA Program
- ▶ Replace Hazards Evaluation Experience of Qualified Analysts

# Redbook Improvements - 3<sup>rd</sup> Edition

- ▶ In Depth Discussion Inherent Safety Reviews & HE Concepts
- ▶ HE Methods Divided
  - ▶ Non-Scenario Based
  - ▶ Scenario Based
- ▶ Scenario Risk Estimation To Determine Adequacy of Controls

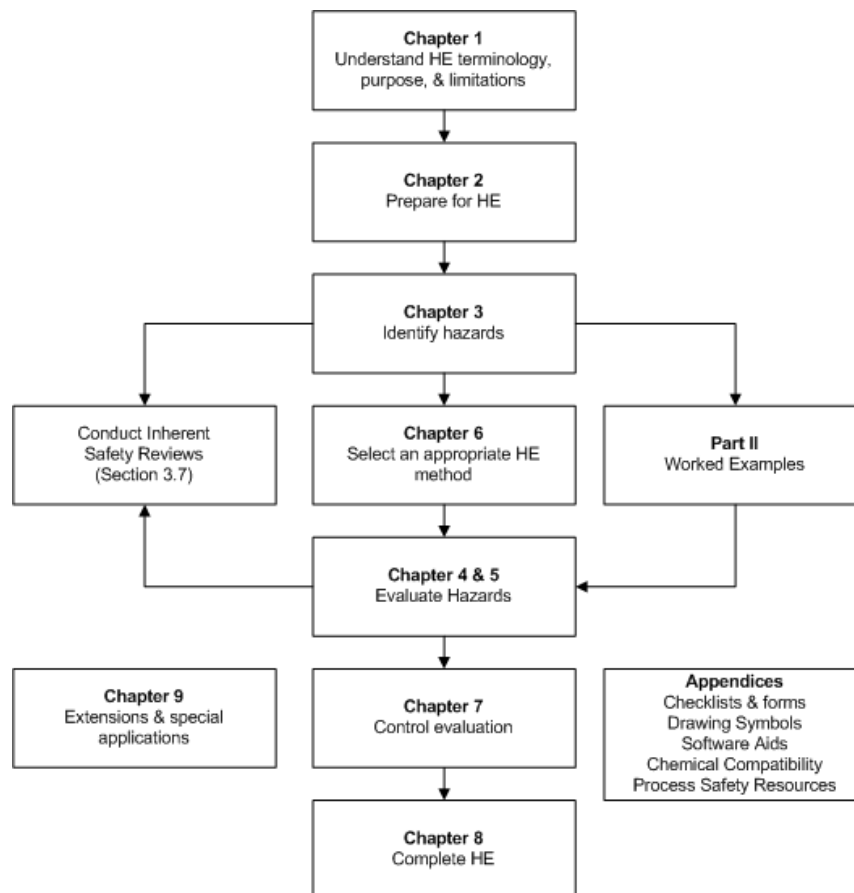
# Redbook Improvements - 3<sup>rd</sup> Edition

## ▶ New Sections

- ▶ HE with Layer of Protection Analysis (LOPA)
- ▶ Evaluating Procedure Based Operations
- ▶ Evaluating Programmable Systems
- ▶ Facility Siting Issues
- ▶ Human Factors Added to Human Reliability Analysis
- ▶ HE Reviews for Management of Change
- ▶ Integration of HE with Reliability & Security

## ▶ Additional Checklists & Forms In Chapters & Appendix A

# Redbook Outline & Flow



RB - Page 9

## Guidelines - Overview

- ▶ Summarizes the Use of HE Techniques as Integral Part of a Process Safety Management Program
- ▶ Describes How HE Techniques Used Throughout Life of Process/Facility
- ▶ Realistic Expectations for Managers
  - ▶ What HE Provides
  - ▶ Limitations of Common Techniques



## Guidelines - Overview

- ▶ HE Organized Effort to Identify & Analyze the Significance of Hazards/Hazardous Situations with a Process or Activity
- ▶ HE Used to Pinpoint Weaknesses in Design & Operation of Facilities that Could Lead to Impact from Hazards
- ▶ HE Information to Aid in Decisions for Improving Safety & Managing Risk of Operations
- ▶ HE Focus on Process Safety Issues With Workers & Public
- ▶ HE Complement Traditional Health & Safety Worker Assessments

## Guidelines - Overview

- ▶ HE Performed Throughout Life of Process
- ▶ Lifecycle Approach
  - ▶ Early Stages of R&D
  - ▶ Detailed Design & Construction
  - ▶ Periodically Throughout Operation
  - ▶ Decommissioning & Dismantlement
- ▶ Efficiently Reveal Deficiencies In Design & Operation

# Guidelines - Overview

- Non-Scenario Based
  - Preliminary Hazards Analysis
  - Safety Review
  - Relative Ranking
  - Checklist Analysis
- Scenario Based
  - What-If Analysis
  - What-If/Checklist Analysis
  - Hazard & Operability (HazOp) Studies
  - Failure Modes & Effects Analysis (FMEA)
  - Fault Tree Analysis (FTA)
  - Event Tree Analysis (ETA)
  - Cause Consequence Analysis (CCA) & Bow Tie Analysis
  - Other Techniques

## Guidelines - Overview

- ▶ Redbook Part I - Guidance on Process Safety Management Program
- ▶ Redbook Part II - Aid in Training & Experience
- ▶ Redbook Part I & Part II
  - ▶ Analyst Understand Basics of HE
  - ▶ Performing HE of Simple Processes Using Simple HE Methods
- ▶ Redbook Part I & Part II Together with Experience
  - ▶ Analyst Scope, Organize, Lead, & Document HE
  - ▶ Facilitator Role for Analyst

## Guidelines - Overview

- ▶ Benefits of HE Program
  - ▶ Fewer Incidents Over Life of Process
  - ▶ Reduced Consequences of Incidents
  - ▶ Improved Emergency Response (Understanding of Hazards)
  - ▶ Improved Training & Understanding of Process
  - ▶ More Efficient & Productive Operations
  - ▶ Improved Regulatory & Community Relations

# Guidelines - Overview

- ▶ HE Program Requires Significant Investment
  - ▶ Completion of HE Requires Time (Hours to Months)
  - ▶ Documentation, Training, & Staff/Material Resources
- ▶ Need Strategy to Use Properly Trained/Skilled Analysts
- ▶ Select Appropriate HE Technique
  - ▶ Technique Commensurate with Problem
    - ▶ Available Information
    - ▶ Consequence/Risk
  - ▶ Ensure Effort Not Wasted by Over-Studying a Problem with a More Detailed Approach than Necessary

# Guidelines - Overview

## ▶ HE Limitations

- ▶ Never 100% Certainty for Identification of All Hazards, Events, Causes, and Effects
- ▶ Results & Benefits Cannot Be Directly Verified
- ▶ Based on Existing Knowledge or Process/Operation
  - ▶ Quality Reflected in Drawing Accuracy, Procedure Accuracy, & Process Knowledge
- ▶ Dependent on Subjective Judgment, Assumptions, & Experience of Analysts
- ▶ Cannot Guarantee Incidents Will Not Occur

## ▶ Limitation Provides Justification

- ▶ Periodic HE Throughout Lifecycle
- ▶ Justification for Management of Change (MOC)

# Guidelines - Overview

- ▶ HE Provides Valuable Input for Risk Reduction
- ▶ Four Pillars Establish Risk Based Process Safety
  - ▶ Understanding Hazards and Risks
  - ▶ Committing to Process Safety
    1. Developing and Sustaining a Culture that Embraces Process Safety
    2. Identifying, Understanding, & Complying With Codes, Standards, Regulations, and Laws
    3. Establishing and Continually Enhancing Organizational Competence
    4. Soliciting Input from Stakeholders - Employees, Contractors, & Neighbors
  - ▶ Manage Risks
  - ▶ Learn from Experience



# Chapter 1

## Introduction to Guidelines

- ▶ Describes How HE Techniques Fit Into PSM Program
- ▶ Relates Use of HE Techniques to Risk Management
- ▶ Introduces Terminology Used for Evaluating Process Hazards In Context of a Typical Incident Sequence of Events
- ▶ Introduces Role of Safeguards in Preventing & Protecting Against Upsets & Mitigating the Impacts of Loss Events
- ▶ How HE Techniques can be Used Throughout Lifetime
- ▶ Outlines Important Theoretical & Practical Limitations of HE Techniques
- ▶ Summarizes Expectations from Use of HE Techniques

# Chapter 2

## Preparation of Hazard Evaluations

- ▶ Describes Infrastructure Needed to Support HE Program
- ▶ Gives Examples of Scope Statements for HE
- ▶ Outlines the Skills & Information for HE
- ▶ Addresses Schedule & Logistical Considerations for HE

# Chapter 3

## Hazard Identification Methods

- ▶ Importance of Identifying Hazards
- ▶ Contemporary Approaches for HI
- ▶ Use of Experience in Analyzing Material Properties & Process Conditions
- ▶ Several Structured Approaches for HE (with Examples)
- ▶ Describes Types of Results Expected from HI

# Chapter 4 & 5

## Hazard Evaluation Techniques

- ▶ Difference Between Scenario & Non-Scenario Based HE
- ▶ Non-Scenario Based
  - ▶ Experienced Based on Facility/Team Experience
  - ▶ Efficient at Broad Brush for Hazards Review
  - ▶ Applied Early in Design/Operation for Safety Improvement Efforts
- ▶ Scenario Based
  - ▶ Predictive & Analytical
  - ▶ Systematically Determine What Can Go Wrong
  - ▶ Systematically Determine Safeguards
  - ▶ Applied Throughout Process Lifecycle
  - ▶ Divided Into 2 Groups
    - ▶ Wide Range of Hazards
    - ▶ Specific Use in Special Situations

# Chapter 4

## Non-Scenario Hazard Evaluations

- ▶ Non-Scenario Based HE Techniques
  - ▶ Purpose, Description, Types of Results, Resource Requirements, & Analysis Procedure For Each Technique
- ▶ 4 Non-Scenario Based HE Techniques
  - ▶ Preliminary Hazards Analysis (PHA/PreHA)
  - ▶ Safety Review
  - ▶ Relative Ranking
  - ▶ Checklist Analysis
- ▶ Illustrates Each Method with a Brief Example

# Chapter 5

## Scenario Hazard Evaluations

- ▶ Scenario Based HE Techniques
  - ▶ Purpose, Description, Types of Results, Resource Requirements, & Analysis Procedure For Each Technique
- ▶ 8 Scenario Based HE Techniques
  - ▶ What-If Analysis
  - ▶ What-If/Checklist Analysis
  - ▶ Hazard & Operability (HazOp) Studies
  - ▶ Failure Modes & Effects Analysis (FMEA)
  - ▶ Fault Tree Analysis (FTA)
  - ▶ Event Tree Analysis (ETA)
  - ▶ Cause Consequence Analysis (CCA)
  - ▶ Human Reliability Analysis (HRA)
- ▶ Illustrates Each Method with a Brief Example

# Chapter 6

## Selection of HE Techniques

- ▶ Factors Influence Selection of Appropriate HE Technique
- ▶ Question Based Flowchart to Choose HE Technique
- ▶ Selection Criteria

# Selection of HE Techniques

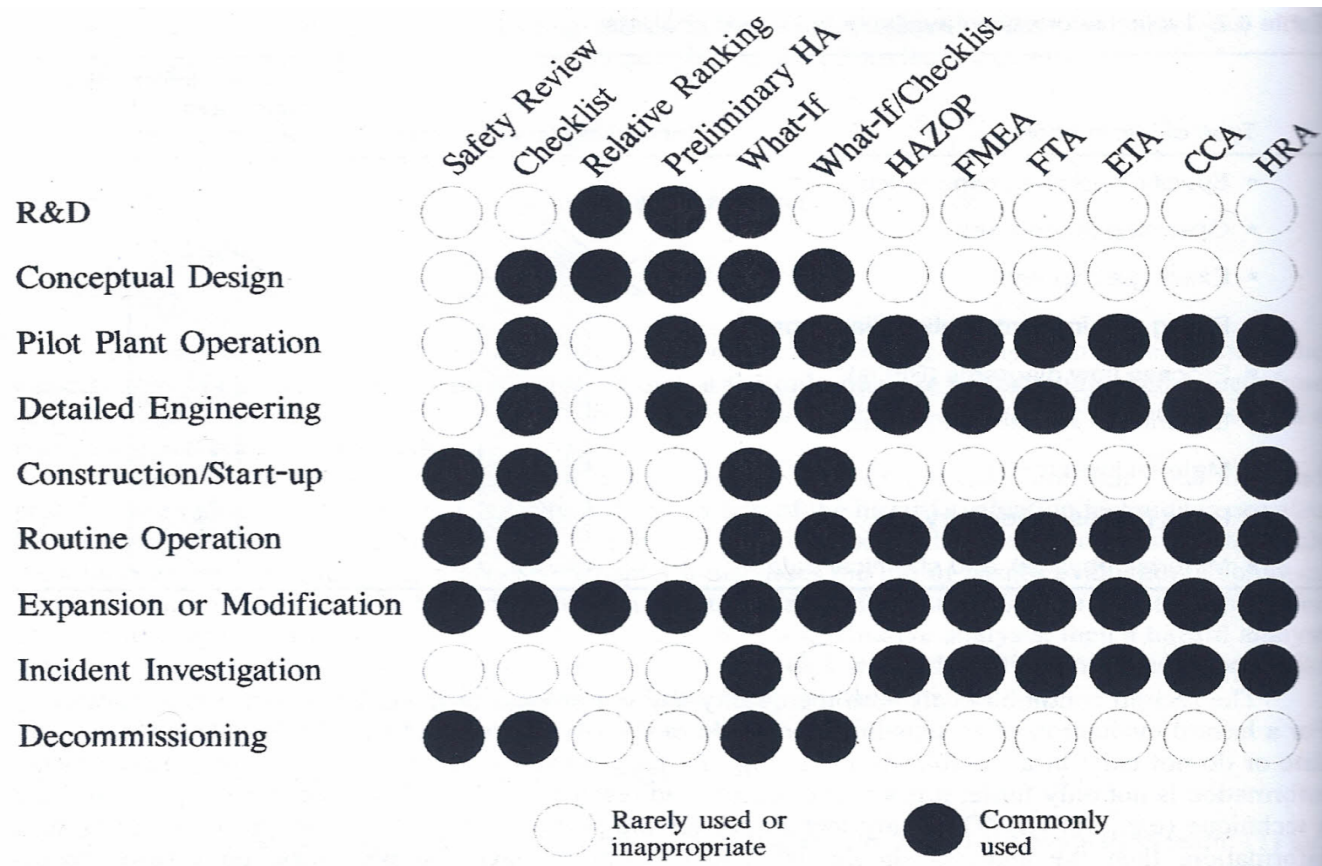


Figure 6.1 Typical uses for hazard evaluation techniques



# Chapter 7

## Risk Based Determination

- ▶ Guidelines for More Detailed Evaluation of Scenario Risks
- ▶ Basic Concepts of Estimating Loss Event Impacts, Initiating Frequency, and Safeguard Effectiveness
- ▶ Examples Comparing Risks for Determining Adequacy of Safeguards
- ▶ Use of Layer of Protection Analysis (LOPA)

# Chapter 8

## Analysis Follow-Up

- ▶ Importance of Prioritizing Results
  - ▶ List of Identified Hazards
  - ▶ Description of Significance of Events/Hazards
  - ▶ Recommendations for Reducing/Eliminating Issues
  - ▶ Ideally Rank Solutions Versus Rank Problems
  - ▶ Rank Via Immediate Actions, Planned Actions, & Further Evaluations
- ▶ Importance of Documenting Results
  - ▶ Consolidate & Preserve Results for Future Use
  - ▶ Provide Evidence Performed Per Sound Engineering Principles
  - ▶ Support Other PSM Activities
- ▶ Guidelines for Communicating Results
- ▶ Strategies for Management of Change

# Chapter 9

## Extensions/Special Applications

- ▶ Combining Tools
  - ▶ HazOp with LOPA
  - ▶ What-If with LOPA
- ▶ Special Topics
  - ▶ Evaluating Hazards for:
    - ▶ Procedure Based Operations
    - ▶ Programmable Control Systems
    - ▶ Reactive Chemical Systems
  - ▶ Human Factors
    - ▶ Consideration of Human Factors
    - ▶ Completing Human Reliability Analysis
  - ▶ Facility Siting, Layout, & Facility-Based Personal Protection

## Part II - Worked Examples

- ▶ Example Description of Facility & Process
- ▶ Example HI
- ▶ Example HE Techniques
  - ▶ R&D: What-If Analysis
  - ▶ Conceptual Design: PreHA
  - ▶ Pilot Plant: HAZOP
  - ▶ Detailed Engineering: FTA/ETA
  - ▶ Construction/Start-up: Checklist Analysis & Safety Review
  - ▶ Routine Operation: Safety Review for Management of Change
  - ▶ Routine Operation: HAZOP Study for Cyclic Review
  - ▶ Plant Expansion: Relative Ranking & HAZOP for Batch Process
  - ▶ Incident Investigation: FMEA & HRA
  - ▶ Decommissioning: What-If/Checklist Analysis

# Guidelines - Appendices

- ▶ Example Checklists & Forms for HE
- ▶ Legend of Symbols & Abbreviations for Drawings
- ▶ Commercially Available Software Aids for Performing Hazard Evaluations
- ▶ Chemical Compatibility Chart
- ▶ Process Safety Enhancement Resources

# Follow Up with Parvati



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## ▶ 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