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
  - 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 - 3rd 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 - 3rd 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

Chapter 1
Understand HE terminology, purpose, & limitations

Chapter 2
Prepare for HE

Chapter 3
Identify hazards

Chapter 4 & 5
Evaluate Hazards

Chapter 6
Select an appropriate HE method

Part II
Worked Examples

Chapter 7
Control evaluation

Chapter 8
Complete HE

Appendices
Checklists & forms
Drawing Symbols
Software Aids
Chemical Compatibility
Process Safety Resources

Conduct Inherent Safety Reviews (Section 3.7)

Chapter 9
Extensions & special applications
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