REQUIREMENTS FOR IMPROVED PHA METHODS

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OVERVIEW

- PHA weaknesses
- HAZOP study weaknesses
- Criteria for new and improved methods
- Possible ways forward

PHA WEAKNESSES

- Current PHA methods suffer from two types of weaknesses
  - Inherent weaknesses
  - Weaknesses in how PHA is practiced
    - E.g. inadequate team composition
- Focus here is on the former
- Individual PHA methods offer different advantages and disadvantages
- Current PHA methods share a number of weaknesses

PHA WEAKNESSES (CONTD.)

- Identifying and understanding these weaknesses assists in the development of new and improved approaches
- Knowledge of weaknesses also allows PHA teams to compensate for them
  - To the extent possible

WEAKNESSES IN PHA METHODS

- Subjective judgment
- Only departures from design intent are addressed
- Ability to address all aspects of design intent
- Scenario detail
- Identification of human failures
- Root causes of hazard scenarios
- Ability to identify multiple failures
- Consideration of dependent failures
- Consideration of domino effects
- Identification of worst-consequence rather than worst-risk scenarios
- Focus on individual parts of a process
- Uniqueness of process subdivision
- Utility and support system failures
- Treatment of modes of operation
- Treatment of non-steady-state processes
- Addressing human factors issues
- Addressing facility siting issues
- Interactions between processes
- Conservative assumptions
- Prediction of real-world accidents

DEPARTURES FROM DESIGN INTENT

- PHA focuses on looking for ways the process may deviate from the design intent
- Does not evaluate the adequacy of the design intent itself
- Verification of the design intent is part of a formal design review
  - Outside the scope of PHA studies
- New designs may be hazardous
  - Even within the envelope of the design intent

ADDRESS ALL ASPECTS OF DESIGN INTENT

- Hazard scenarios arise when there is a deviation from the design intent for a process
- There are many aspects of design intent
- Significant challenge to identify those aspects for which deviations will result in scenarios of concern

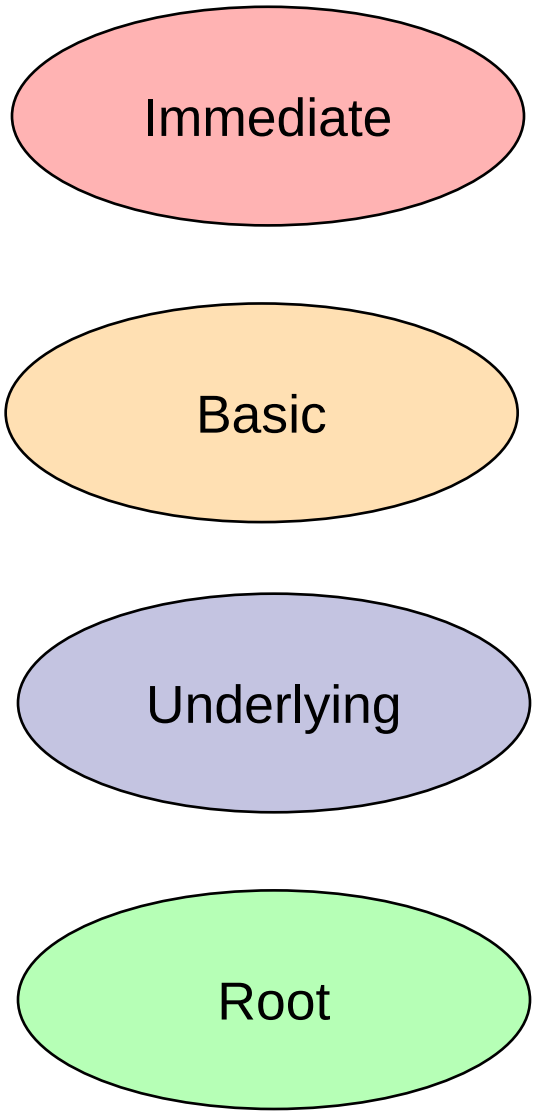
ASPECTS OF DESIGN INTENT

- Equipment
- Process materials
- Materials of construction
- Conditions
- Properties
- Operations
- Actions
- Reactions
- Functions
- Specifications
- Environment
- Locations
- Positions
- Elevations
- Measurements
- Controls
- Software
- Maintenance
- Calibration
- Testing
- Sampling
- Services / utilities
- Communications
- Timing
- Sequence and order

ROOT CAUSES OF HAZARD SCENARIOS

- Usually, PHA does not address root causes of scenarios
  - Such as human and organizational factors
- Typically, practitioners identify immediate or basic causes
- No consistent practices on the level of causality that should be used
- Deeper that PHA teams probe the cause hierarchy, the more time-consuming the study becomes
- Key issue is how deep should teams go in order to identify needed risk reduction measures

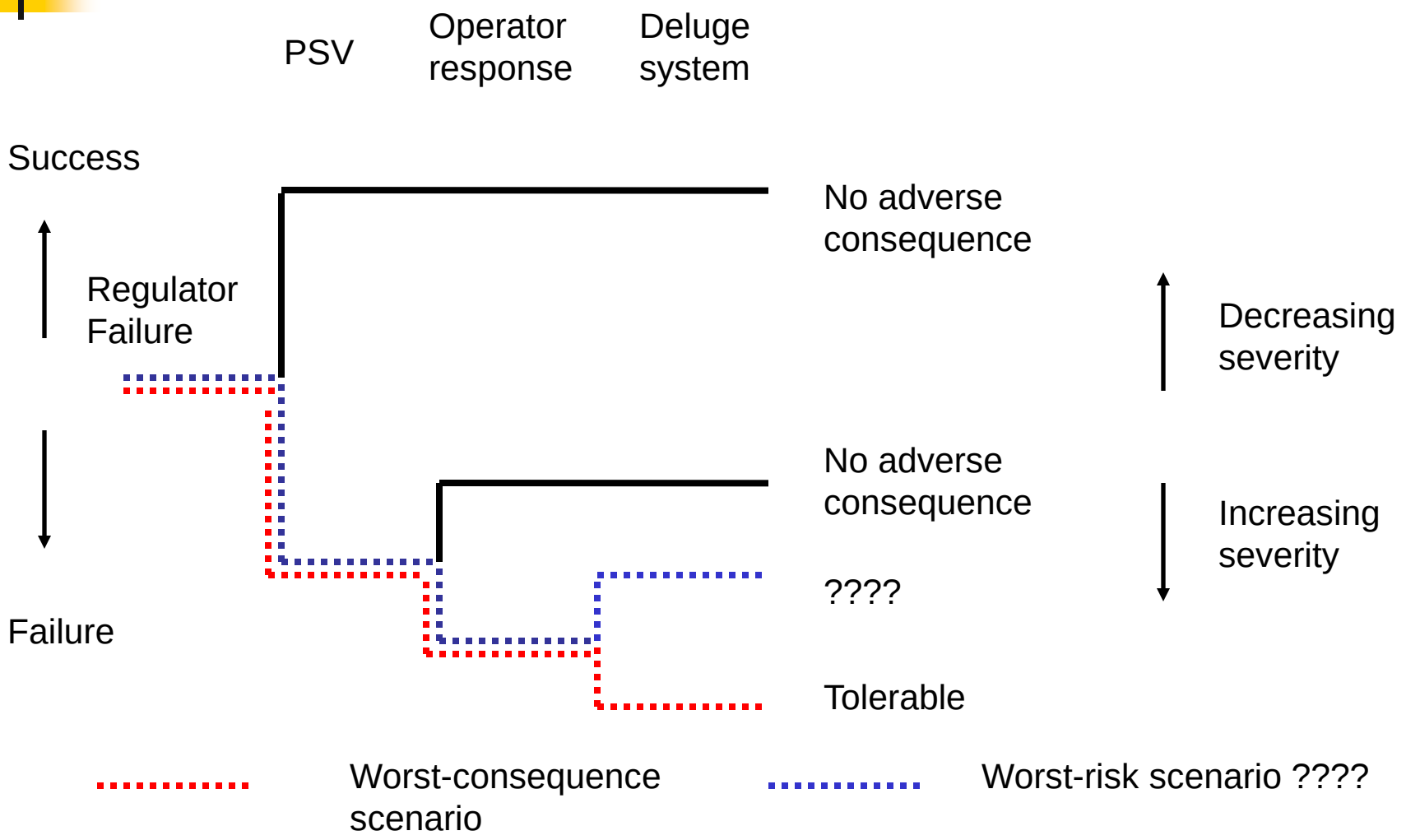
HIERARCHY OF CAUSALITY



IDENTIFICATION OF WORST-CONSEQUENCE RATHER THAN WORST-RISK SCENARIOS

- Usually, scenario severity values are estimated assuming all safeguards fail
  - Worst-consequence scenario
- Worst-consequence scenario may not be the worst-risk scenario for the same initiating event
  - Often, practitioners implicitly assume the two are the same

EXAMPLE OF WORST-CONSEQUENCE VERSUS WORST-RISK SCENARIO



FOCUS ON INDIVIDUAL PARTS OF A PROCESS

- Usually the process is divided into sections
  - Focus the analysis
  - Make the study manageable
- Such process subdivision may result in missing scenarios that involve multiple parts of the process
  - E.g. Simultaneous failure of two valves in different nodes
- Some initiating events may affect the entire process producing a global or system scenario
  - E.g. flooding and the loss of utilities such as electric power

HAZOP STUDY METHOD

- Most commonly-used PHA method
- Viewed by many practitioners as the most thorough and complete PHA method
- HAZOP shares the weaknesses described
  - Also has its own weaknesses

HAZOP STUDY WEAKNESSES

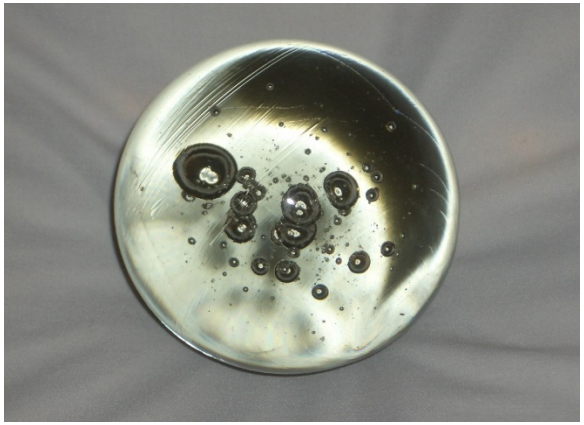
- Incomplete consideration of design intent
- Compound deviations
- Counter-intuitive inductive / deductive starting point
- Operability issues are included
- Difficulty in focusing on specific hazard types
- Equipment focus
- Technical vocabulary
- Studies are lengthy
- Presentation of results

INCOMPLETE CONSIDERATION OF DESIGN INTENT IN HAZOP

- HAZOP shares with other PHA methods the difficulty of addressing all key aspects of design intent
- Use of a short checklist in HAZOP to select parameters to generate deviations exacerbates the problem
  - Inhibits consideration of other aspects of node intention
- Unfortunately, practitioners may not consider parameters that are not on the checklist

INCOMPLETE CONSIDERATION OF DESIGN INTENT IN HAZOP (CONTD.)

- Consideration of additional aspects of design intent is difficult
  - Like gazing into a crystal ball and trying to predict the future
    - Which aspects of design intent, if addressed, will generate scenarios of concern



HAZOP STUDIES ARE LENGTHY

- HAZOP studies take more time than other methods
- HAZOP inefficiencies include:
  - Identification of operability scenarios when they are not desired
  - Consideration of process deviations that do not result in scenarios of concern
- Lengthy studies have an adverse impact on team performance
  - Participants become fatigued and jaded
- HAZOP is theoretically attractive but practically limited

ADMINISTRATIVE CRITERIA FOR NEW AND IMPROVED METHODS

- Appropriate for the process industries
- Meet regulatory requirements and industry practices, codes and standards
- Non-proprietary
- Ease of understanding and application by participants
- Team approach
- Facilitator
- Brainstorming scenarios
- Consistency
- Structure
- Logical
- Presentation of results
- Ease of updating and revalidating studies
- Ease of use for other process safety purposes
- Conversion of previous studies
- Continuous improvement

TECHNICAL CRITERIA FOR NEW AND IMPROVED METHODS

- Able to address all types of hazards
- Tailored to hazards of interest
- Exclusion of extraneous scenarios
- Adjustable to the complexity and circumstances of the process
- Reliance on subjective judgment
- Completeness of scenario identification
- Coverage of design intent
- Level of detail
- Sequential order of events
- Robust to team inadequacies
- Efficiency of scenario identification
- Robust and meaningful scenario risk estimation
- Specific measures for risk reduction
- Use throughout the process life cycle
- Analysis of process changes

RELIANCE ON SUBJECTIVE JUDGMENT

- Engineering judgment is a key aspect of PHA studies
- Subjectivity introduces uncertainty and often conservatism into the analysis
- PHA methods should minimize the need for subjective judgment
  - Reduce uncertainty in results
  - Avoid overly-conservative conclusions

RELIANCE ON SUBJECTIVE JUDGMENT (CONTD.)

- Attempts have been made to automate HAZOP studies using computer software
  - No completely successful approach has yet been devised
  - Questionable whether the creativity of people can be replaced by computer algorithms
    - At least at this time
  - Regulatory acceptance of such studies is likely to be an issue

ROBUST TO TEAM INADEQUACIES

- PHA study results are subject to team member bias, motivation, experience, knowledge and creativity
- Study success depends on the interactions of the team members
- Unrealistic to expect that a PHA team will function in a perfect way
  - Owing the nature of people

POSSIBLE WAYS FORWARD – SEMI-AUTOMATED STUDIES

- Program PHA software:
  - Use a database of information from studies that have been conducted
    - Suggest worksheet entries
    - Identify missing entries
  - Check worksheet entries for compliance with study guidelines

POSSIBLE WAYS FORWARD – TEAM TRAINING

- Train team members in scenario recognition
  - Not just the mechanics of PHA
- Be able to relate what they know of incidents they have experienced to the format in which hazard scenarios are identified and recorded
- Real-world examples should be used
  - Preferably from the facility where participants work
  - Videos from the CSB can be used to bring scenarios to life

POSSIBLE WAYS FORWARD – TEAM TRAINING (CONTD.)

- Participants must understand important concepts for hazard scenarios in the context of real-life incidents such as:
  - Multiple failures
  - Domino effects
  - Dependent and common cause failures
  - Latent failures and enablers
- Otherwise PHA studies can seem like theoretical exercises

CONCLUSIONS

- Current PHA methods suffer from a variety of weaknesses
  - Almost certainly results in incomplete studies with hazard scenarios being missed
- HAZOP shares these weaknesses
  - Also has weaknesses of its own
- Criteria proposed for new and improved methods
- Suggestions made for the way forward