A COMPARISON OF THE HAZARD AND OPERABILITY (HAZOP) STUDY WITH MAJOR HAZARD ANALYSIS (MHA)

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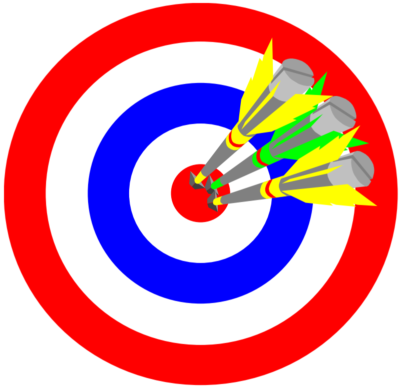
Background

PHA Objectives

- Identify hazard scenarios
- Determine if risk reduction is needed
- Develop recommendations for new or improved safeguards



Elements of PHA

Subdivide process

Identify initiating events (causes)

Identify scenarios

Identify consequences

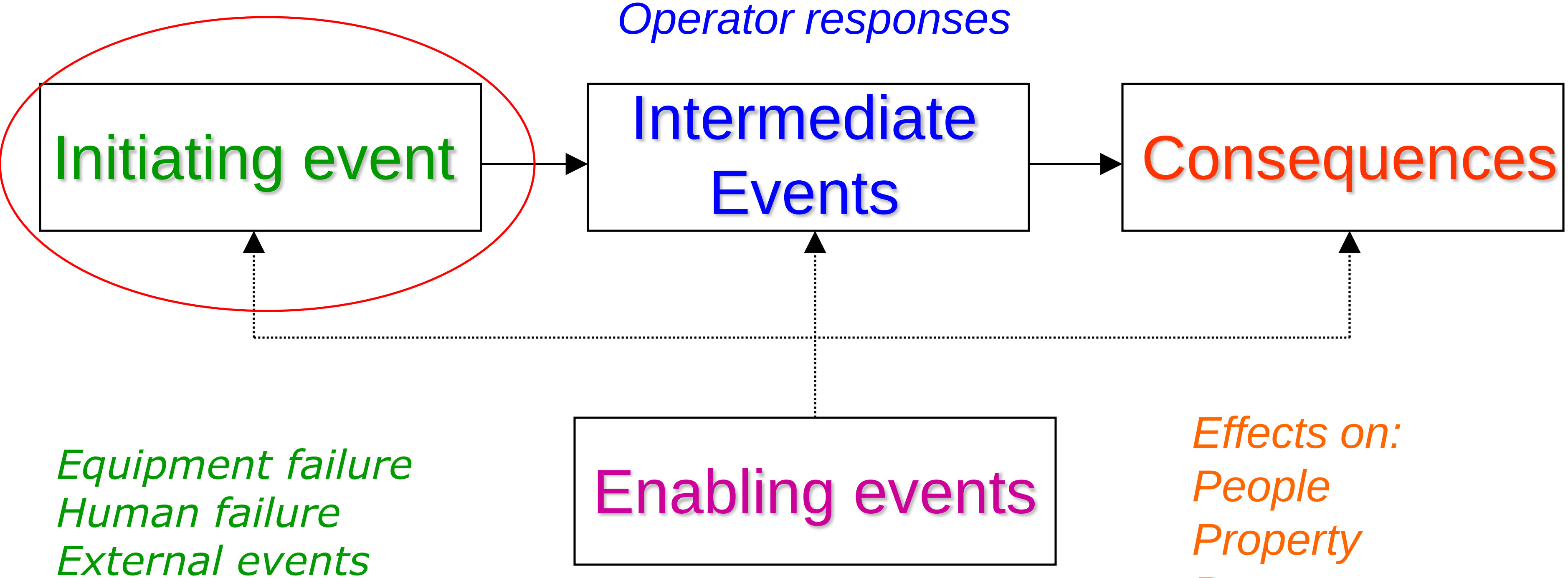
Identify safeguards

Perform risk ranking

Develop recommendations

Elements of a Hazard Scenario

Process responses
Operator responses



Equipment failure
Human failure
External events

Make possible another event

Effects on:
People
Property
Process
Environment
Etc.

Acceptable PHA Methods (OSHA PSM Standard)

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

Problems with HAZOP Method

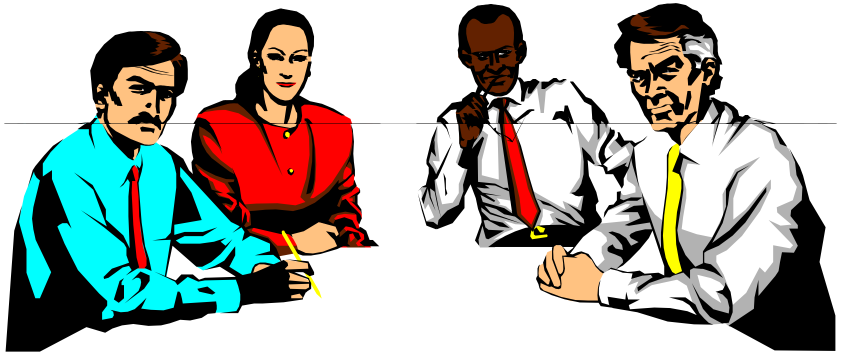
- Addresses both safety and operability scenarios
  - Some companies do not want to spend time identifying operability scenarios (typically at least half the time)
    - Difficult to divorce their identification from the identification of safety scenarios

Problems with HAZOP Method (Contd.)

- Difficult for teams to select only the important aspects of design intent
  - Effort is expended on issues that turn out to be unimportant
- Identifies initiating events for hazard scenarios in an indirect way
  - Novice team members have difficulty understanding this approach

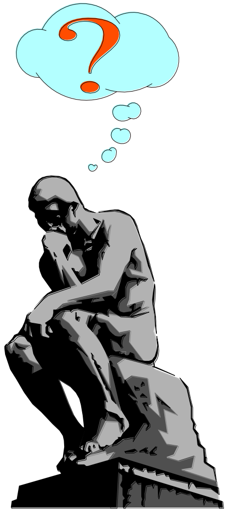
Problems with HAZOP Method (Contd.)

- Studies tend to be tedious and time-consuming
  - Can compromise the quality of the work performed
- Plant personnel are often reluctant to participate in HAZOP studies



Problems with What-If Method

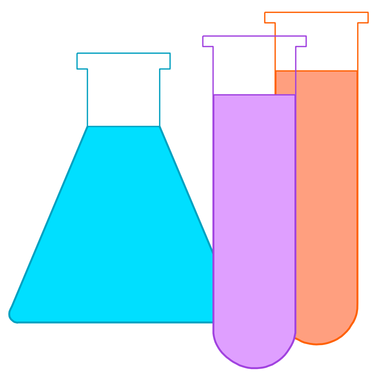
- Results are typically less-detailed than with the HAZOP method
- Little structure or guidance provided
- Addresses all types of accident causes
- Does not constrain brainstorming

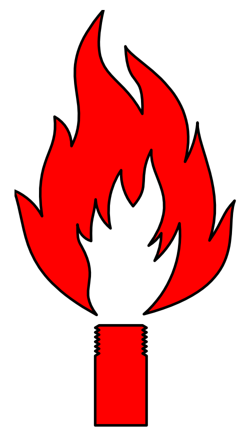


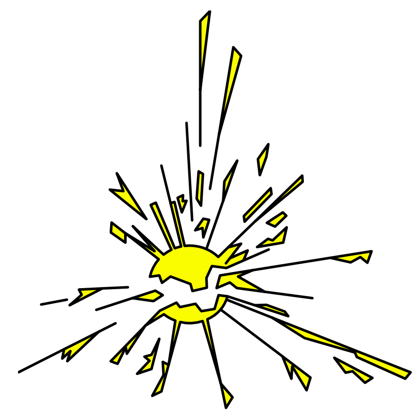
Major Hazard Analysis (MHA)

Description of Major Hazard Analysis

- Developed to overcome the disadvantages of other methods
- Focuses on major hazards
  - Toxicity, reactivity, flammability and explosivity







Purpose of Process Safety and Risk Management (OSHA and EPA)

- Prevent or minimize the consequences of catastrophic releases of *toxic, reactive, flammable, or explosive* chemicals
  - These releases may result in *toxic, fire or explosion* hazards

Major Hazard Analysis Approach

- Directly identifies initiating events (causes)
- Uses a structured framework of specific categories and common initiating events (causes) that can result in loss of containment
  - Focuses the team's brainstorming without narrowing their vision
  - Provides guidance to the team and helps assure completeness

MHA Initiating Event Categories

- Leaks / ruptures
  - Fracture
  - Relief device stuck open
  - Seal / gasket / flange failure
  - Corrosion / erosion
  - …
- Incorrect actions or inactions by people
  - Errors of omission
  - Errors of commission
  - Extraneous acts
  - …
- Exceeding process limits
  - Over / under pressuring
  - Over / under heating
  - …
- Control systems failures
  - Instrumentation
  - Signal and data lines
  - …
- Reactivity
  - Loss of control of an intended reaction
  - …
- Structural failures
  - Equipment supports
  - …
- Utility failures
  - Electric power
  - …
- Natural external events
  - Flooding
  - …
- Human external events
  - Vehicle impacts
  - …
- Knock-on effects
  - Incidents within the process
  - …
- Incorrect location / position / elevation
- Incorrect timing / sequence / order
- Others

Major Hazard Analysis Approach (Contd.)

- Categories and causes can be customized for specific facilities and/or types of processes
- MHA prompts consideration of items not included in the lists
- Team is not overburdened
  - Limited number of categories and causes of initiating events

Major Hazard Analysis Approach (Contd.)

- Other elements of the hazard scenarios are identified in the same way as for other PHA methods
  - Recorded in similar worksheet columns
- Scenario and enabler worksheet columns can be added to:
  - Clarify the scenario
  - Provide information for use in LOPA or QRA

Example of MHA

NODE: (1) INLET LINE TO HEXANE STORAGE TANK, TK-101

INITIATING EVENTS	SCENARIO	CONSEQUENCES	SAFEGUARDS	ENABLERS
1. Line leak at flange	Release of hexane into sewer system	1.1. Possible environmental contamination	Periodic walk-throughs by operators per procedure SOP-99-005	Failure of water treatment system
2. Mechanic leaves drain valve, MV-78, open	Release of hexane into dike and sewer	2.1. As for 1.1	Mechanic check	Failure of water treatment system
		2.2. Possible fire and exposure of operators	Deluge system	Presence of operators Ignition source
		2.3. Possible explosion impacting process personnel	Personnel are restricted in tank farm	Ignition source
		2.4. Possible explosion impacting public	Buffer zone around plant	Ignition source

Comparison of the MHA and HAZOP Methods

Applications Used for Comparison

- Ammonia plant
- Urea handling process
- Other processes

H A Z O P

Node: (1) Gas line from Pressure Controller, PIC-1, to Desulfurizers, V-101 and V-102, including steam heater E-001.

Parameter: Flow **Intention:** 14 - 16MM SCFH

GW	DEVIATION	CAUSES	CONSEQUENCES	CAT	SAFEGUARDS
No	No / Low Flow	1. Line leak due to corrosion	1.1. Release of hydrocarbons to atmosphere	ENV	1.1.1. Flow Alarms, FA-001 and FA-002 1.1.2. Low flow and low pressure DC alarms from Flow Transmitter, FT-1, and Pressure Transmitter, PT-1 1.1.3. Emergency Shutdown Procedure for Ammonia Plant, ERP-001 1.1.4. Cathodic protection of gas line

M H A

Node: (1) Gas line from Pressure Controller, PIC-1, to Desulfurizers, V-101 and V-102, including steam heater E-001.

INITIATING EVENTS	SCENARIOS	CONSEQUENCES	CAT	SAFEGUARDS	ENABLERS
1. Line leak due to corrosion	1.1. Loss of natural gas and process fuel flow to process during normal operation and release of hydrocarbons	1.1.1. Atmospheric release	ENV	1.1.1.1. Flow Alarms, FA-001 and FA-002 1.1.1.2. Low flow and low pressure DCS alarms from Flow Transmitter, FT-1, and Pressure Transmitter, PT-1 1.1.1.3. Emergency Shutdown Procedure for Ammonia Plant, ERP-001 1.1.1.4. Cathodic protection of gas line	1.1.1.1. PM inspections not performed regularly

H A Z O P

Node: (1) Gas line from Pressure Controller, PIC-1, to Desulfurizers, V-101 and V-102, including steam heater E-001.						
Parameter: Flow			Intention: 14 - 16MM SCFH			
GW	**DEVIATION**	**CAUSES**	**CONSEQUENCES**	**CAT**	**SAFEGUARDS**	**S**
No	No / Low Flow	7. Freezing conditions due to severe winter weather resulting in blocked inlet line	7.1. Potential release of hydrocarbons to atmosphere due to activation of PSV-002 on plant upset	ENV	7.1.1. Same As 1.1.1 to 1.1.3 7.1.2. Internet access available in the control room to monitor severe weather	
			7.2. Potential fire from release of hydrocarbons and exposure to operators	SAF	7.2.1. Same As 1.1.1 to 1.1.3, 1.2.2, 1.2.3, and 7.1.2	
			7.3. Potential plant shutdown due to reduced flow of natural gas and process fuel to process	OPR	7.3.1. Same As 1.1.1 to 1.1.3, and 7.1.2	

M H A

Node: (1) Gas line from Pressure Controller, PIC-1, to Desulfurizers, V-101 and V-102, including steam heater E-001.					
INITIATING EVENTS	**SCENARIOS**	**CONSEQUENCES**	**CAT**	**SAFEGUARDS**	**ENABLERS**
6. Freezing conditions due to severe winter weather resulting in blocked inlet line	6.1. Reduced flow of natural gas and process fuel to process and release of hydrocarbons due to activation of PSV-002 on plant upset	6.1.1. Atmospheric release	ENV	6.1.1.1. Same As 1.1.1.1 to 1.1.1.3 6.1.1.2. Internet access available in the control room to monitor severe weather	6.1.1.1. Ambient temperature indicator in the control room is out of service
		6.1.2. Potential fire and exposure to operators	SAF	6.1.2.1. Same As 1.1.1.1 to 1.1.1.3, 1.1.2.2, 1.1.2.3, 6.1.1.2	6.1.2.1. Ignition source from vehicles in the area 6.1.2.2. Presence of operators in the area

Results of Comparison

- More hazard scenarios are usually identified using the MHA method
- Time required for an MHA study is substantially less
- MHA method provides flexibility
- Less ambiguity in MHA
- All hazard scenarios for a node appear in a single worksheet in MHA

Results of Comparison (Contd.)

- MHA can be conducted at different levels of detail (process subdivision)
  - Systems and subsystems typical of What-If studies
  - Nodes used in the HAZOP method
- MHA method is more readily understood by PHA teams
  - Follows the elements of a hazard scenario
- People are more willing to participate in the study
  - Immediate dividends are evident from their work

Extension of MHA to Other Types of Hazards

- MHA was developed to address major hazards
  - Toxicity, reactivity, flammability and explosivity
- Direct Hazard Analysis (DHA) is an extension of MHA to address other hazards
  - E.g. over-pressurization, entrapment by moving equipment
  - Each hazard type uses a structured list of categories of initiating events and ways they can occur
  - Used in combination with the Hazard Identification (HAZID) method

Conclusions

- MHA is a more efficient way of addressing major hazards
- Structured approach provides confidence in the completeness of the method
- Existing PHA studies can be converted easily into MHA format
  - E.g. when PHAs are revalidated
- Existing PHA recording tools can be used to perform MHA studies
  - E.g. PHAWorks®

Further information

- Technical papers on process safety and the Major Hazard Analysis (MHA) method:

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