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

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Primatech Inc.

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Outline

• Background
  ● Process Hazard Analysis (PHA)
  ● PHA methods

• Major Hazard Analysis (MHA)
  ● Description
  ● Approach
  ● Example

• Comparison of MHA and HAZOP Methods
  ● Applications
  ● Results

• Conclusions
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

Initiating event

Enabling events

Intermediate Events

Consequences

Process responses
Operator responses

Make possible another event

Equipment failure
Human failure
External events

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
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 |
| | | 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 |

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Comparison of the MHA and HAZOP Methods
Applications Used for Comparison

- Ammonia plant
- Urea handling process
- Other processes
**HAZOP**

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

<table>
<thead>
<tr>
<th>Parameter: Flow</th>
<th>Intention: 14 - 16MM SCFH</th>
</tr>
</thead>
</table>

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

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**MHA**

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

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</tr>
</thead>
<tbody>
<tr>
<td>1. Line leak due to corrosion</td>
<td>1.1. Loss of natural gas and process fuel flow to process during normal operation and release of hydrocarbons</td>
<td>1.1.1. Atmospheric release</td>
<td>ENV</td>
<td>1.1.1.1. Flow Alarms, FA-001 and FA-002</td>
<td>1.1.1.1. PM inspections not performed regularly</td>
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### HAZOP

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 - 16 MM SCFH

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</thead>
<tbody>
<tr>
<td>No</td>
<td>No / Low Flow</td>
<td>7. Freezing conditions due to severe winter weather resulting in blocked inlet line</td>
<td>7.1. Potential release of hydrocarbons to atmosphere due to activation of PSV-002 on plant upset</td>
<td>ENV</td>
<td>7.1.1. Same As 1.1.1 to 1.1.3</td>
</tr>
<tr>
<td></td>
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<td>7.2. Potential fire from release of hydrocarbons and exposure to operators</td>
<td></td>
<td>SAF</td>
<td>7.2.1. Same As 1.1.1 to 1.1.3, 1.2.2, 1.2.3, and 7.1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.3. Potential plant shutdown due to reduced flow of natural gas and process fuel to process</td>
<td></td>
<td>OPR</td>
<td>7.3.1. Same As 1.1.1 to 1.1.3, and 7.1.2</td>
</tr>
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### MHA

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

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<th>ENABLERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Freezing conditions due to severe winter weather resulting in blocked inlet line</td>
<td>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</td>
<td>6.1.1. Atmospheric release</td>
<td>ENV</td>
<td>6.1.1.1. Same As 1.1.1, 1.1.3</td>
<td>6.1.1.1. Ambient temperature indicator in the control room is out of service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.1.2. Potential fire and exposure to operators</td>
<td>SAF</td>
<td>6.1.2.1. Same As 1.1.1, 1.1.3, 1.1.2.2, 1.1.2.3, 6.1.1.2</td>
<td>6.1.2.1. Ignition source from vehicles in the area</td>
</tr>
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<td>6.1.2.2. Presence of operators in the area</td>
</tr>
</tbody>
</table>
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:
  www.primatech.com

- Contact info:
  paulb@primatech.com