OPERATIONAL RISK MANAGEMENT IN CHEMICAL PROCESS INDUSTRIES

Engr. Nelia G. Granadillos
Chief, Environment Control Division
Occupational Safety and Health Center
OPERATIONAL RISK MANAGEMENT

Outline:

• Hazard and Operability Study or HAZOP
• Failure Mode Effect Analysis or FMEA
• Emergency Management
• Human Factor
Chemical Weapons Convention

• The Philippines is a signatory to the Chemical Weapons Convention

• OSH professionals have a responsibility to ensure that chemicals, equipment and facilities are protected and are not used for illegal, harmful or destructive purposes.

• As our obligation, toxic chemicals or precursors that can cause death, injury, or disease and the control of these hazards will always be their elimination as reasonably practicable.
Operational Risk Management

Objectives

• This takes into account international standards and Hazard and Operability Studies in Germany

• Focuses on the technique of Hazard and Operability Studies or HAZOP that can greatly assist in a proactive approach to identify hazardous deviations.

• The process hazard analysis aims to pinpoint the safety, health and environmental hazards in any business activity and ensuring control by hazard study

• This ensures that chemical industry projects are commissioned promptly and safely and that the need for late changes be minimized
Methodology

• The hazard study is a six stage process from project conception to final regular usage.
• It consists of the following steps:
  ▪ material hazards – identify the properties of materials and assess its use in the operation
  ▪ risk of people – the process design or control engineers and operators’ role in safe operation
  ▪ process study – identify hazard, operability problems
  ▪ end of construction stage - final check
  ▪ plant commissioning and review after hand over – confirmation of compliance with regulations
  ▪ Review operations after 3 to 6 months if consistent with the design intent
Hazop Study

• Determination of a process hazard
• Hazards or operability problems are seen in the detailed systematic examination through appropriate equipment, alarms, procedures to prevent and correct unwanted events

• Required documents:
  ✓ P & I Diagram
  ✓ Plant lay-out
  ✓ Trip and Control Information
  ✓ Safety Data Sheet
  ✓ Process Description
  ✓ Working Instructions
Hazard Assessment (Risk analysis)

- The FMEA (Failure Mode Effect Analysis) technique is not used to determine a hazard but a tool used to evaluate a hazard.
- FMEA aims to eliminate hazards affecting people and environment and can equally be applied to a production process or equipment of a chemical plant.
<table>
<thead>
<tr>
<th>SEVERITY</th>
<th>INJURY (SAFETY)</th>
<th>DAMAGE CAUSED TO THE ENVIRONMENT</th>
<th>DAMAGE ON PROPERTY OR PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0</td>
<td>No Injury</td>
<td>No damage to the environment</td>
<td>No damage on property or production</td>
</tr>
<tr>
<td>S1</td>
<td>Little injuries with no consequences</td>
<td>Little damage with no long term effect</td>
<td>Little damage on property or production, production loss – several hours</td>
</tr>
<tr>
<td>S2</td>
<td>Little injuries to the employees</td>
<td>Serious damage to the environment, but able to be corrected</td>
<td>Large damage on property or production, production loss – several days</td>
</tr>
<tr>
<td>S3</td>
<td>Mortal Danger</td>
<td>Large long term damage</td>
<td>Large damage on property or production, production loss – several weeks</td>
</tr>
<tr>
<td>S4</td>
<td>Massive accident with possible loss of life</td>
<td>Disaster</td>
<td>Massive destruction on property or production, result – production stop</td>
</tr>
<tr>
<td>PROBABILITY</td>
<td>CLASSIFICATION</td>
<td>FREQUENCY OF HAZARDOUS EVENT PER YEAR</td>
<td>EXPLANATION</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
<td>---------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>P0</td>
<td>Unlikely</td>
<td>$\leq 10^{-7}$</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>Very rare</td>
<td>$\leq 10^{-5}$</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>Rare</td>
<td>$\leq 10^{-2}$</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Possible</td>
<td>$\leq 10^{-1}$</td>
<td>Event, that arises once in 1000 years till once every 10 years</td>
</tr>
<tr>
<td>P4</td>
<td>Often</td>
<td>$&gt;10^{-1}$</td>
<td>Event, that arises more than once every 10 years</td>
</tr>
</tbody>
</table>
## Critical Matrix for the Evaluation of Hazop Study

<table>
<thead>
<tr>
<th>Probability</th>
<th>S0</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>P4</td>
<td>P4S0</td>
<td>P4S1</td>
<td>P4S2</td>
<td>P4S3</td>
<td>P4S4</td>
</tr>
<tr>
<td>P3</td>
<td>P3S0</td>
<td>P3S1</td>
<td>P3S2</td>
<td>P3S3</td>
<td>P3S4</td>
</tr>
<tr>
<td>P2</td>
<td>P2S0</td>
<td>P2S1</td>
<td>P2S2</td>
<td>P2S3</td>
<td>P2S4</td>
</tr>
<tr>
<td>P1</td>
<td>P1S0</td>
<td>P1S1</td>
<td>P1S2</td>
<td>P1S3</td>
<td>P1S4</td>
</tr>
<tr>
<td>P0</td>
<td>P0S0</td>
<td>P0S1</td>
<td>P0S2</td>
<td>P0S3</td>
<td>P0S4</td>
</tr>
</tbody>
</table>

- **Low Risk**
- **Severity Risk – Not Acceptable**
- **Area Requires Further Safety Arrangements in Order to Minimize the Risk**

---

**Department of Labor and Employment**

**Occupational Safety and Health Center**
Example of Hazop Study: FMEA
Filling operation of a storage tank B1

• Product – Ethyl Benzene
• Deviation of solvent flow pressure: - more than 6 bar pressure
• Cause – V3 closed
• Effect or hazard – Increased pressure, due to blockage in a pipe
  – Seal damage
  – Leakage
  – Fire and explosion
Take over and supply ethyl benzene as solvent into B1

Hazard, when V3 is closed

Fig 1 HAZOP / FMEA – Leakage of valve V3 during filling operation of a Storage Tank B1
Hazard Analysis
HAZOP Technique

• Determination of severity : S2
• Determination of probability: P3
• Application of S2 and P3 using the critical matrix - showed that it is in the yellow area, which means that in order to minimize the risk, further safety arrangement is required
Corrective Action

• Adding a flow gauge with a switch off device for pump p1, an additional safety equipment in order to be in safe condition.
• Due to the fact that the severity never changes, the severity S2 will not change, however probability P3 will change to P2. From the critical matrix, you may see that the relation P2 vs S2 are in the “acceptable area”
To determine the safety of new or existing equipment

• apply the hazop study
• have resources available
• acquire external support
• Make clear priority decisions
• include the SHE mgt system
• ensure competencies of the team members
Emergency Management

• Emergency is a situation which is out of control and potentially a threat the system to total destruction
• Crisis is triggered by an emergency
• Requires an emergency plan which includes the procedures in emergency situation, trained emergency team, material and resources
• description of scenarios
Human Factors

• The goal of human factors is to apply knowledge in designing systems that work and minimizing limits of human performance.

• 80 to 90% of all errors are due to human factors and team work failure thus human behavior dominates the risk to the system

• The knowledge of accident causation is a precondition to design safer systems. There is the opportunity to learn from errors and the consideration and analysis of incidents are crucial for safety
Conclusion

• Operational Risk Management is necessary to protect the people and environment from destruction brought about deficiency in design, human error and inadequacy of maintenance.

• This can be carried out by the hazop technique to pinpoint the process hazard and evaluated through failure mode effect analysis or FMEA.

• Risk management is not enough, a robust emergency management and human factor is crucial to ensure safety
Thank you!