Hazards Analysis

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Learning Outcomes

- Outline the systematic steps for conducting a hazards analysis: Define process, Identify method, Identify top events, and Document findings.
- Compare and select appropriate analysis methods (e.g., What-If, HAZOP, FMEA, FTA) based on process complexity.
- Understand the importance of performing analysis early in the design phase to effectively reduce risk.

Reading

- Foundations of Spiritual and Physical Safety: with Chemical Processes; Chapter 5, Sections 2 (Intro, up to Section 2.1)
- Job Hazards Analysis Template: https://uolab.groups.et.byu.net/files/safety/JHATemplate.docx

1 Effective Hazards Analysis Steps

Hazard Identification and Evaluation with Risk Analysis and Assessment

1. Define the process

This step can involve collecting documentation such as a process flow diagram (PFD), piping and instrumentation diagram (P&ID), operating procedure and other relevant information. It is also important to gather information about the process, such as the materials used, and the operating conditions among other things.

2. Identify the hazards analysis method to use

Hazards analysis methods include HAZOP, FMEA, and fault tree analysis (FTA). The choice of method will depend on the specific process and the goals of the analysis.

3. Identify the Hazardous Top Level Event and contributing factors with

- a Fault Tree Analysis (FTA)
  - Including deductive and inductive reasoning
- a HAZOP (Hazards and Operability Study)
  - Including guide words and deviations

4. Fill out a Hazards Analysis (HA) Table

For each failure mode (the lower level events in your falut tree anlaysis), fill out the hazards analysis table including the following information:

- Task description or process step
- Hazard type
- Hazard description
- Event consequence
- Safeguards currently present to mitigate the hazard
- Rank (1A to 5E) for severity and likelihood of the hazard
- Recommendations to reduce the risk of the hazard

5. Potentially complete a quantitative risk analysis for those hazards with a high risk ranking
6. Incoporate other PSM elements per the OSHA 1910.119 standard

2 Hazards Analysis Methods

Some of the possible methods that can be used include:

- Checklists
- What If
- Five (5) Why's
- Fishbone
- Bowtie
- JHA (Job Hazard Analysis)
- HAZOP (Hazard and Operability Study)
- FTA (Fault Tree Analysis)
- FMEA (Failure Mode and Effects Analysis)

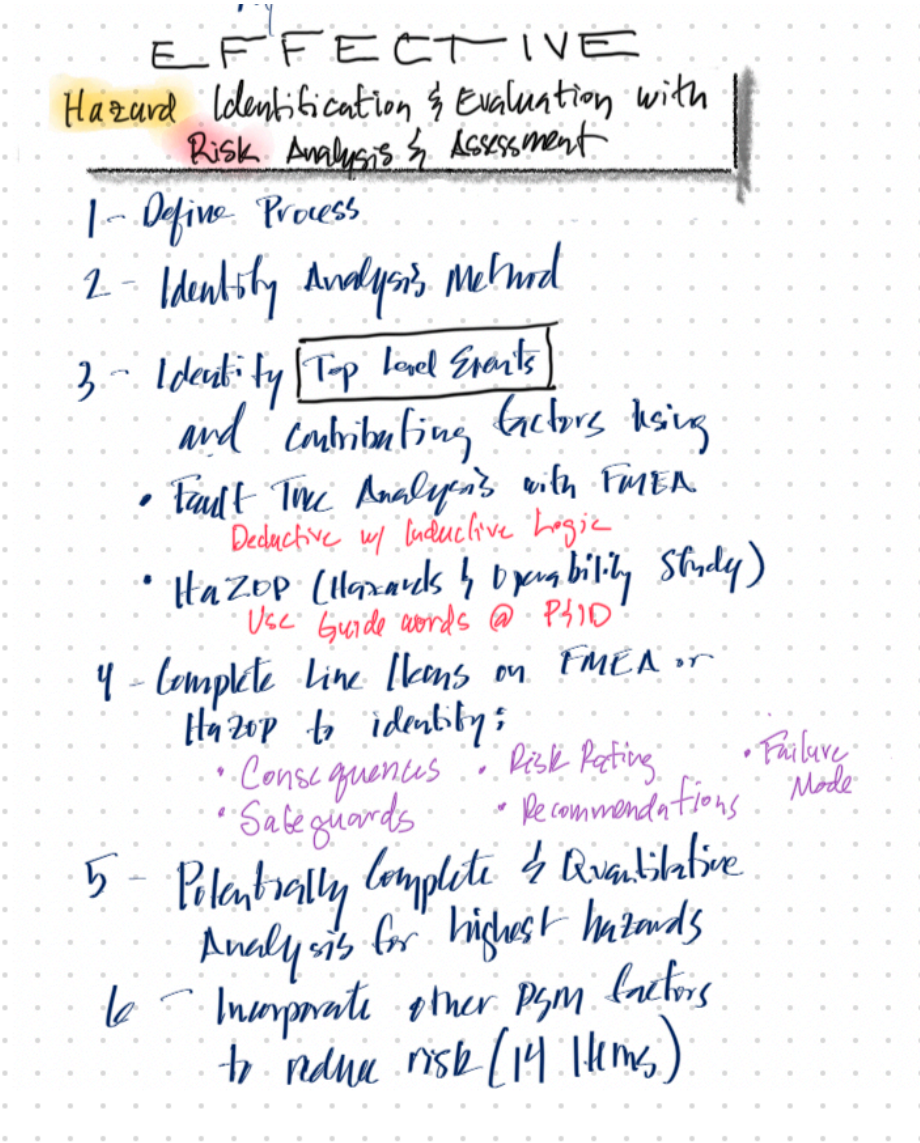

Figure 1: Effective Hazards Analysis Steps

Figure 2: Bowtie Example

2.1 Bowtie

```
import graphviz

# Create a new directed graph
dot = graphviz.Digraph('Bowtie', comment='Process Safety Bowtie', format='png')
dot.attr(rankdir='LR', size='12,5')

# Define Styles
dot.attr('node', shape='box', style='filled', fontname='Arial')

# - - - THE CENTER (Top Event) - - -
dot.node('TopEvent', 'LOSS OF CONTAINMENT\n(Exothermic Runaway)',
         fillcolor='red', fontcolor='white', width='2.5')

# - - - LEFT SIDE (Threats & Preventative Barriers) - - -
with dot.subgraph(name='cluster_threats') as t:
    t.attr(label='THREATS', color='blue')
    t.node('T1', 'Cooling System Failure', fillcolor='lightblue')
    t.node('T2', 'Reactant Overcharge', fillcolor='lightblue')

    t.node('B1', 'Redundant Pumps', shape='diamond', fillcolor='lightgray')
    t.node('B2', 'Auto Feed -Cut', shape='diamond', fillcolor='lightgray')

# - - - RIGHT SIDE (Consequences & Mitigative Barriers) - - -
with dot.subgraph(name='cluster_consequences') as c:
    c.attr(label='CONSEQUENCES', color='orange')
    c.node('C1', 'Vessel Rupture', fillcolor='peachpuff')
    c.node('C2', 'Toxic Release', fillcolor='peachpuff')

    c.node('M1', 'Pressure Relief Valve', shape='diamond', fillcolor='lightgray')
    c.node('M2', 'Scrubber System', shape='diamond', fillcolor='lightgray')

# - - - CONNECTIONS - - -
# Left to Center
dot.edge('T1', 'B1')
dot.edge('B1', 'TopEvent')
dot.edge('T2', 'B2')
dot.edge('B2', 'TopEvent')

# Center to Right
dot.edge('TopEvent', 'M1')
dot.edge('M1', 'C1')
dot.edge('TopEvent', 'M2')
dot.edge('M2', 'C2')

# Render the diagram
dot.render('reactor_bowtie', view=True)
print("Bowtie diagram generated as 'reactor_bowtie.png'")
```

```
Bowtie diagram generated as 'reactor_bowtie.png'
```

2.2 Fishbone and Five (5) Why

```
# Create a directed graph
```

Figure 3: Fishbone and Five Why Example

```
fish = graphviz.Digraph('Fishbone', comment='Root Cause Analysis', format='png')
fish.attr(rankdir='LR', size='12,8')

# Define Global Styles
fish.attr('node', fontname='Arial', style='filled')

# - - - THE HEAD (The Effect/Problem) - - -
fish.node('Effect', 'PUMP SEAL FAILURE\n& LEAK',
          shape='deeppink', fillcolor='salmon', width='2.5')

# - - - THE MAIN BONES (Categories: The 6 Ms) - - -
categories = {
    'Machine': ['Worn Bearings', 'Improper Alignment'],
    'Method': ['Inadequate PM Schedule', 'Incorrect Startup Procedure'],
    'Material': ['Incompatible O -ring Elastomer', 'Abrasive Particles in Fluid'],
    'Manpower': ['Lack of Training', 'Fatigue / Overtime'],
    'Measurement': ['Faulty Pressure Gauge', 'No Vibration Monitoring'],
    'MotherNature': ['Extreme Ambient Heat', 'Corrosive Atmosphere']
}

# - - - BUILDING THE STRUCTURE - - -
for cat, causes in categories.items():
    # Create the category node (the large bones)
    fish.node(cat, cat, shape='ellipse', fillcolor='lightblue')
    fish.edge(cat, 'Effect', penwidth='3') # Thick line for main bones

    # Create the individual causes (the small bones)
    for cause in causes:
        fish.node(cause, cause, shape='none', style='none', fontsize='10')
        fish.edge(cause, cat)

# Render the diagram
fish.render('pump_fishbone', view=True)
print("Fishbone diagram generated as 'pump_fishbone.png'")

Warning: using box for unknown shape deeppink
Warning: gvrender_set_style: unsupported style none - ignoring
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Fishbone diagram generated as 'pump_fishbone.png'
```

3 Recommended Methods

The recommended methods for hazards analysis that we used effectively in evaluating explosive, pyrotechnic, and propellant based processes included:

- Fault Tree Analysis (FTA) with deductive and inductive reasoning followed by Failure Mode and Effects Analysis (FMEA) where the HA table is filled out for each failure mode.
- HAZOP (Hazards and Operability Study) with guide words and deviations

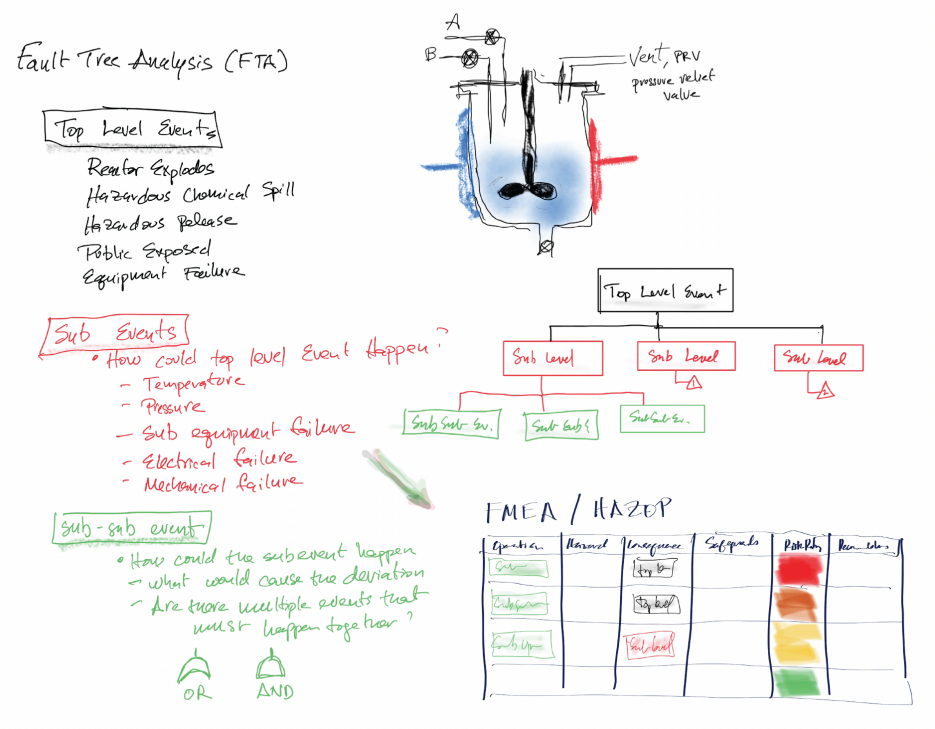

Figure 4: Fault Tree Analysis to Hazards Analysis Table

4 When Should you Conduct a Hazards Analysis? As early in the process as feasible.

Many complex processes have been designed and built prior to completion of a hazards anlysis (FTA with a FMEA, or HAZOP). This makes integration of engineering controls into the process very difficult or costly or both. Ideally you complete a hazards anlysis at the design stage and other stages including:

- Design (a Design Hazards Analysis)
- Construction and Startup
- Operation
- Decomissioning
- Accident Investigation

5 Process Safety Information (PSI) is Critical

Process safety information including details of the process, the materials used, and the operating conditions is critical to completing a hazards analysis. We'll talk a lot more about PSI.

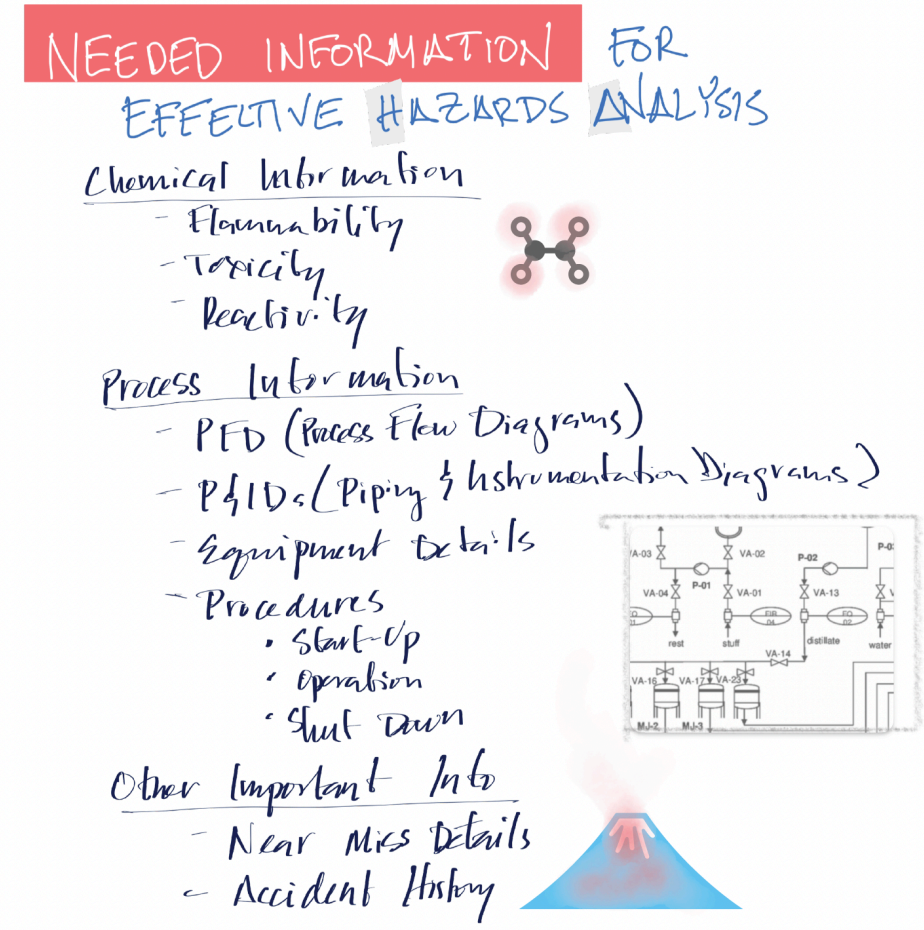

Figure 5: Needed Information for Effective Hazards Analysis

Other helpful graphics for hazards analysis and review download pdf: physical/supportfiles/FTAwRev1.pdf

Action Items

1. Following the "Canning Green Beans Procedure,"Example Scenario: Canning Green Beans complete a Hazards Analysis (HA) table for the first five steps of the process, identifying the hazard type, consequence, and current safeguards. Use this template https://uolab.groups.et.byu.net/files/safety/JHATemplate.docx
2. Explain why it is critical to conduct a hazards analysis as early as feasible in the design process. Write 1 or 2 complete sentences.