

CE 400 / CE 500

Process Safety Management

Lecture 19 Hazard Evaluation Methods I

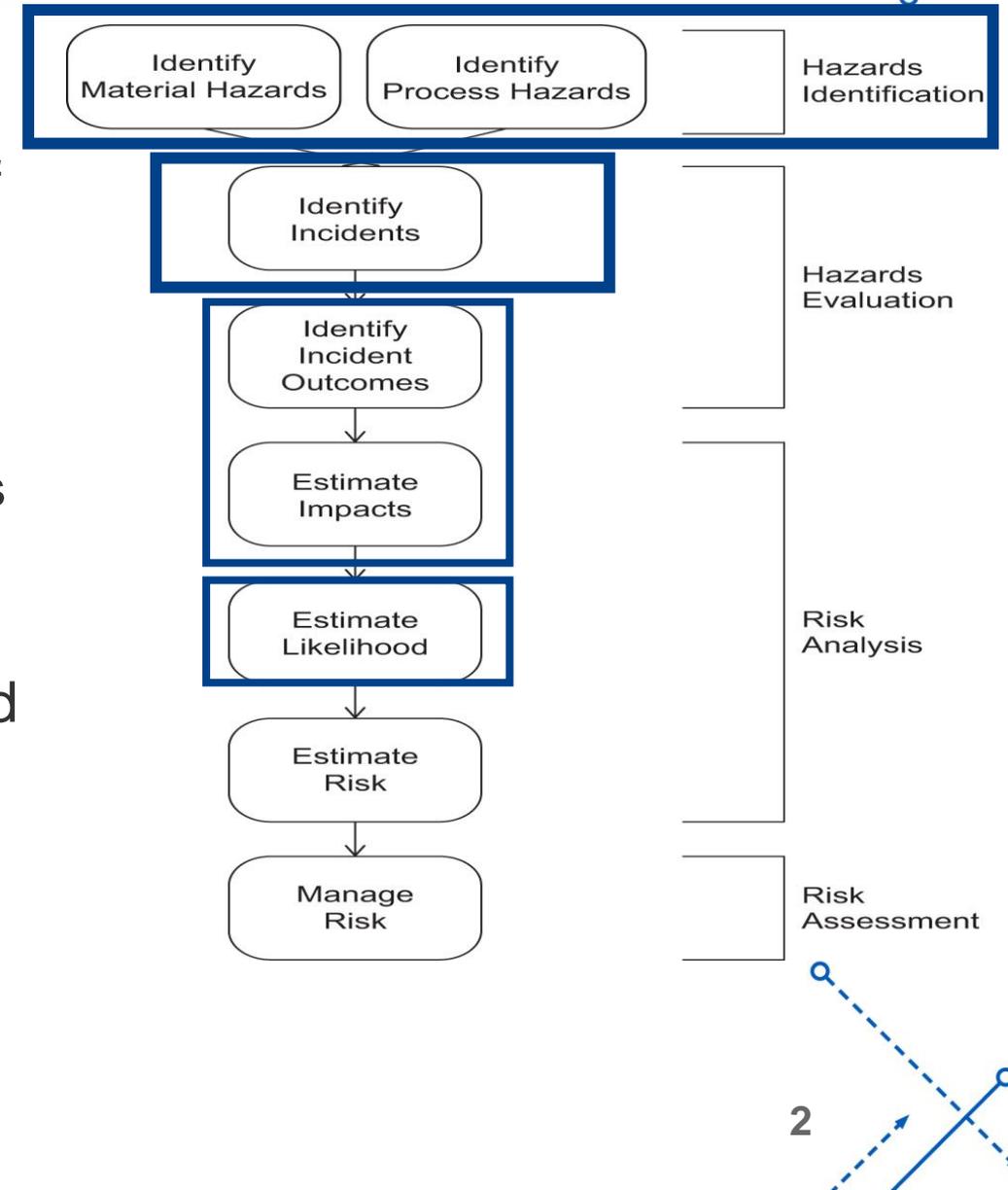
Instructor: David Courtemanche



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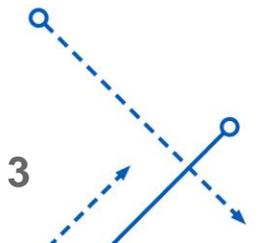
Where the Rubber Hits the Road...

- Hazards Evaluation is what most people think of when they think of a PHA
- Last lecture we discussed identifying what the hazards of our process are
 - We can't protect ourselves from these hazards until we determine what kind of events can lead them to express themselves
- We must attempt to identify everything that could go wrong
 - How does it occur?
 - Which hazard does it allow?
 - How bad is it really?
 - What safeguards are in place?
 - How likely is it to happen?



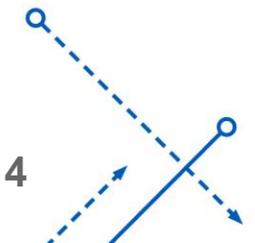
How Is It Done?

- Most Common Methods:
 - What If? / Checklist
 - Either one is sometimes done on its own
 - Usually done together
 - Failure Mode and Effects Analysis
 - Hazards and Operability Analysis (HAZOP)



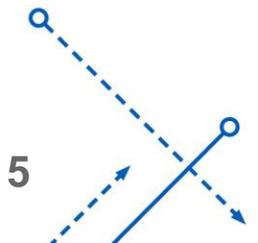
What If? / Checklist Methods

- Somewhat open ended method of asking questions about what could happen in your process
 - Typically still break down the process into small enough process units (or steps) that you can have some confidence that you have covered everything
 - Document what would happen, what safeguards are in place, and what is the likelihood of this happening
- Checklists can be created (or found) which generate ideas for questions
- Advantages
 - Open ended approach may lead team to think of things other methods might miss
- Disadvantages
 - Hard to say when you are done – are there other questions?



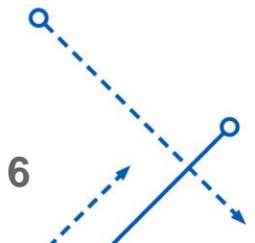
Failure Mode and Effects Analysis (FMEA)

- Break down the process into Nodes
 - Individual equipment pieces
 - Valves, temperature sensors, pumps, everything
- Evaluate the various ways that each node can fail
- Document what the effect on the process will be
- Document the Consequence Level of those effects
- Document the safeguards that are in place
- Document your estimate of the frequency
- Calculate Risk Factor
- Mitigate unacceptable Risk Factors



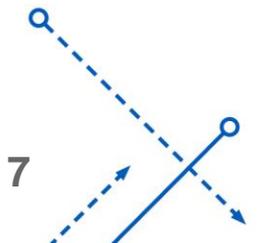
FMEA Failure Modes, examples

- **Valve**
 - Open when should be closed
 - Closed when should be open
 - Plugged
 - Partially Open
 - Leaking
- **Pump**
 - Running too fast
 - Running too slow
 - Not running
 - Running in reverse
- **Temperature Sensor**
 - Reading too high
 - Reading too low
 - Not reading
 - Not updating value
- **Pressure Sensor**
 - Reading too high
 - Reading too low
 - Not reading
 - Not updating value



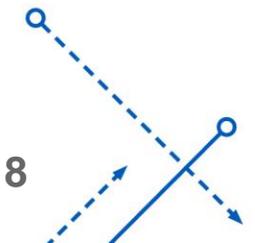
Hazards and Operability Analysis (HAZOP)

- Break down the process into Nodes
 - Individual Process Units
 - Flow Lines, Tanks, etc
- Evaluate the various Aspects of each Node that can be Off Target
- Document what the effect on the process will be
- Document the Consequence Level of those effects
- Document the safeguards that are in place
- Document your estimate of the frequency
- Calculate Risk Factor
- Mitigate unacceptable Risk Factors



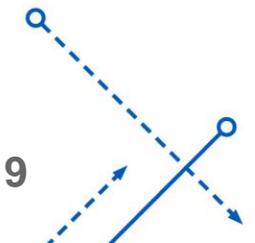
HAZOP Questions, examples

- **Flow**
 - No flow
 - Flow too low
 - Flow too high
 - Reverse Flow
- **Pressure**
 - Pressure too high
 - Pressure too low
- **Temperature**
 - Temperature too high
 - Temperature too low
- **Composition**
 - Concentration too high
 - Concentration too low
 - Wrong chemical



FMEA and HAZOP Pros and Cons

- Pros
 - Very thorough
 - Leads to a definitive feeling of being “finished”
- Cons
 - **AGONIZINGLY** time consuming
 - You have to be careful not to let things slip between the nodes
 - There may be manual steps that don't appear on the P&ID
 - NO METHOD IS PERFECT nor will it do your work for you
 - You still need to understand your process to properly answer the questions of what the consequence and frequency will be
 - Things can be missed



Fault Trees

- Works in reverse of an FMEA
- Start with a well defined incident, known as a **Top Event**, and then works backwards to identify various scenarios that could cause it.
- Drive down to Basic or Intermediate Events
 - Intermediate Event can be broken down further into various causes
 - Basic Event is a stopping point
- Sometimes you will see this listed as a Hazards Evaluation Methodology
 - I disagree – it starts with the hazardous event and then works back to find root causes
 - How do you identify the event?
 - Use the previous methods discussed in this lecture
 - This is a great tool in estimating event frequencies
 - We will return to it in a later lecture

