

Fault Tree Analysis (FTA)

- Chapters in Chemical Process Safety
- 1 Toxicology
 - 2 Industrial Hygiene
 - 3 Chemical Exposure
 - 4 Source Models
 - 5 Dispersion
 - 6 FMEAs & Explosions
 - 7 Concepts to Prevent Fires/Explosions
 - 8 Chemical Reactivity - Laboratory
 - 9 Intro to Reliefs
 - 10 Relief Sizing
 - 11 Hazards ID & Eval
 - 12 Risk Analysis & Assessment
 - 13 Safety Strategies
 - 14 Case Histories

Top Level Events

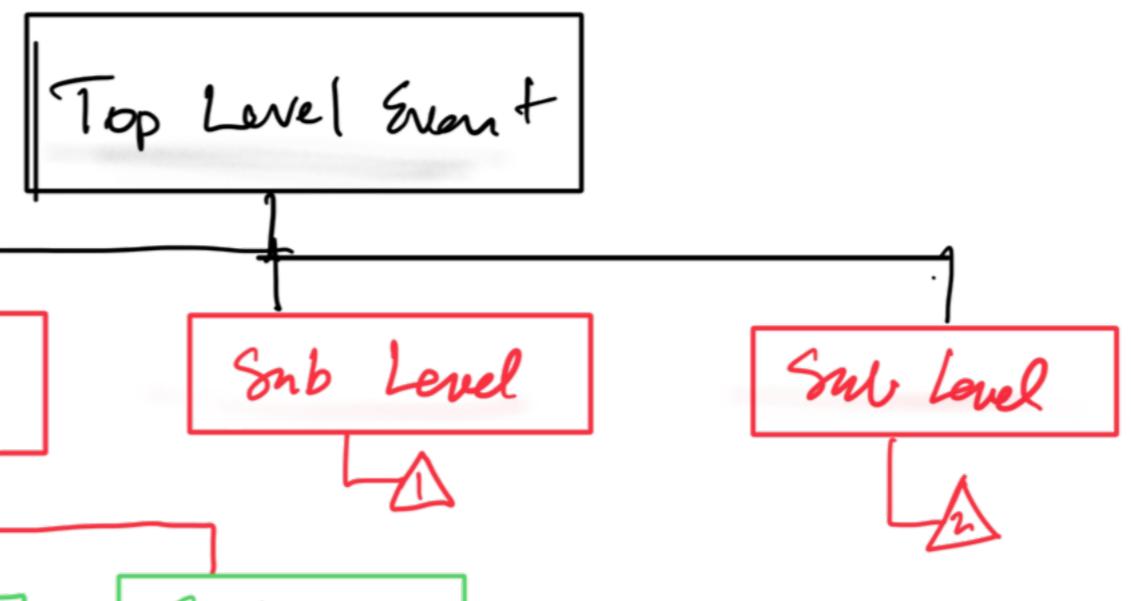
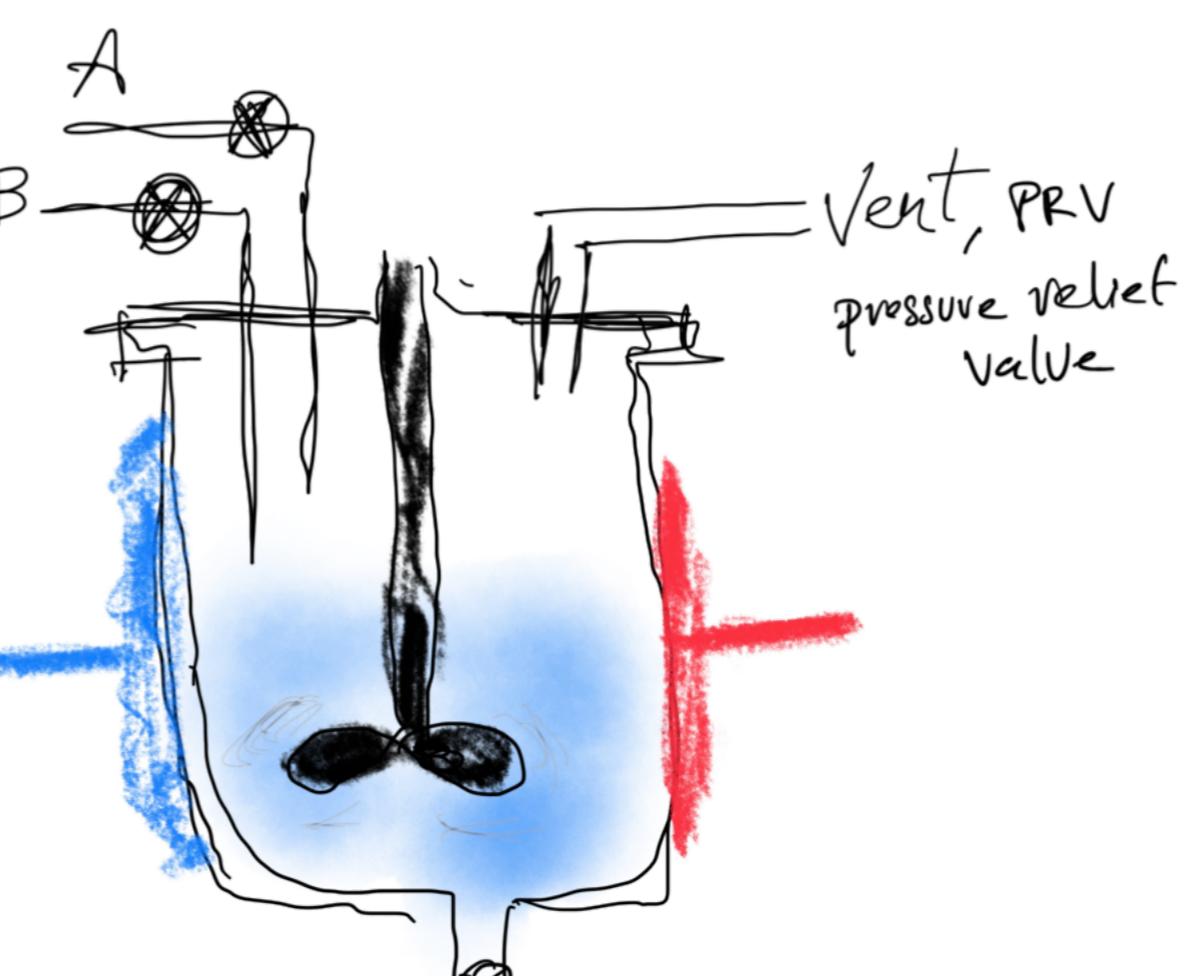
- Reactor Explodes
- Hazardous Chemical Spill
- Hazardous Release
- Public Exposed
- Equipment Failure

Sub Events

- How could top level Event happen?
- Temperature
- Pressure
- Sub equipment failure
- Electrical failure
- Mechanical failure

Sub-Sub Events

- How could the subevent happen
- what could cause the deviation
- Are there multiple events that must happen together?



FMEA / HAZOP

Operation	Hazard	Consequence	Safeguards	Pot.Phy	Rew.Inds.
On	Overheat	Explosion		Red	
Off	Overheat	Explosion		Orange	
Start Up	Failure	Failure		Yellow	

- These steps ideally implemented
- @ Design - DHA or Design Hazards Analysis
 - * 10%, 25%, 50% ...
 - @ Construction & Startup
 - @ Operation
 - @ Decommissioning
 - @ Accident Investigation

EFFECTIVE

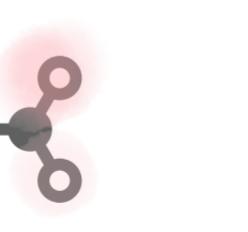
Hazard Identification & Evaluation with Risk Analysis & Assessment

- 1 - Define Process
- 2 - Identify Analysis Method
- 3 - Identify Top level Events and Contributing factors using
 - Fault Tree Analysis with FMEA
 - Deductive w/ Inductive Logic
 - HAZOP (Hazards & Operability Study)
 - Use Guide words @ PSM
- 4 - Complete Line Items on FMEA or HAZOP to identify:
 - Consequences
 - Risk Rating
 - Failure Mode
 - Safeguards
 - Recommendations
- 5 - Potentially complete & Quantitative Analysis for highest hazards
- 6 - Incorporate other PSM factors to reduce risk (14 items)

NEEDED INFORMATION FOR EFFECTIVE HAZARDS ANALYSIS

Chemical Information

- Flammability
- Toxicity
- Reactivity

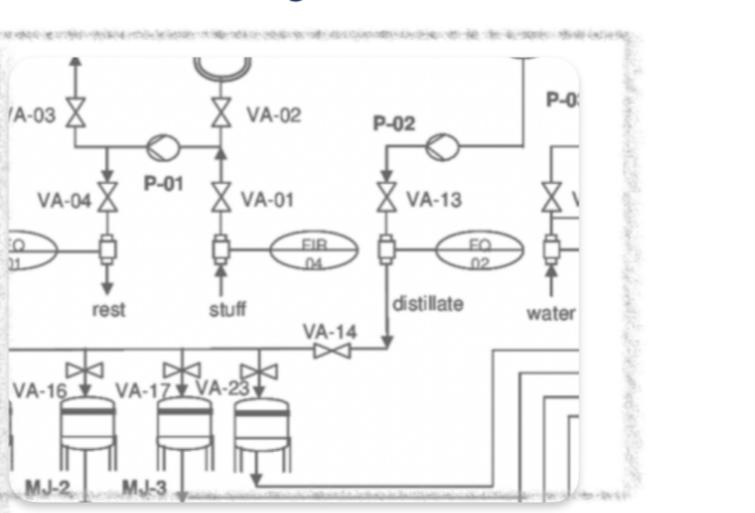


Process Information

- PFD (Process Flow Diagrams)
- P&ID (Piping & Instrumentation Diagrams)

Equipment Details

- Procedures
 - Start-up
 - Operation
 - Shut-down



Other Important Info

- Near Miss Details
- Accident History

1st Parts of PSM DHA 190.119

- PHA
- PSI
- Management of Change
- Training
- etc...

Process Hazards Analysis (PHA)

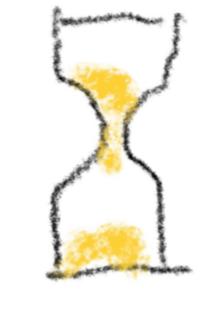
- Any # of methods to identify & control hazards
- Recommended ways:
 - FTA with FMEA (Fault Tree with Failure Modes & Effects Analysis)

HAZOP

Hazards & Operability

Hazards & Operability

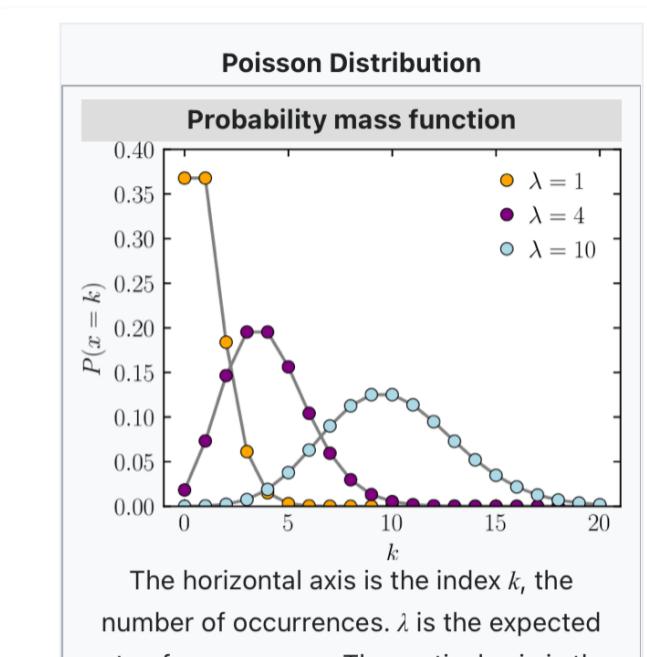
Event Probability



Poisson Distribution

$$P = \frac{k^k e^{-\lambda}}{k!}$$

λ is the rate of occurrences
 k is the # of occurrences/events
 The probability of k or more events is
 $P = 1 - e^{-\lambda} (k=0)$



Here the rate of occurrences/events is 1 event in a given time frame.
 If we incorporate that time frame $P(\text{at least 1 event}) = 1 - e^{-\lambda t}$

As time increases, the probability of at least one event occurring increases to 1 or certainty. There will be at least one event. And conversely, short time yields a probability vanishingly small.