Event Tree Analysis

FPST 4333

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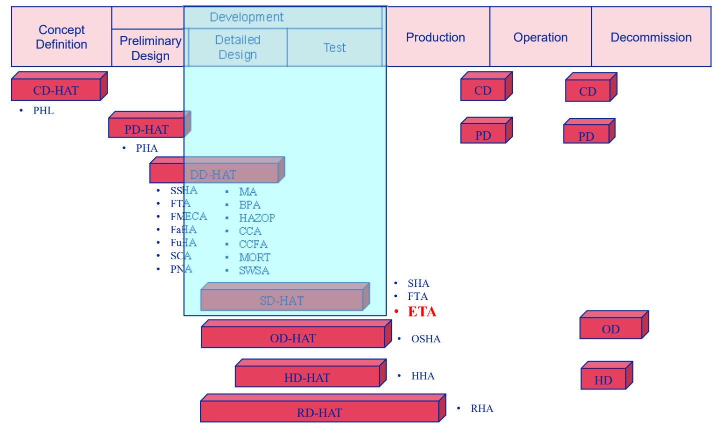
Life Cycle Phase



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EVENT TREE Analysis

- **Event Tree Analysis (ETA):**
  - ⇨identify and evaluate sequence of events stemming from an initiating event.
  - ⇨*bottom-up, deductive*
  - ⇨human operators or automated systems
- Complementary to other techniques, e.g.,
  Fault Tree Analysis

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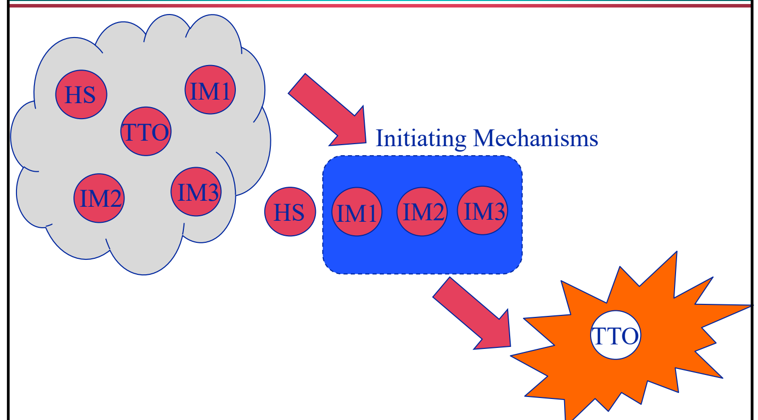
ETA - Intiating Event



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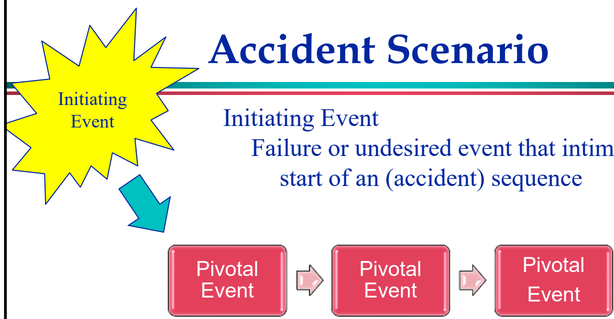
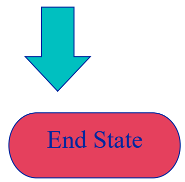
Accident Scenario



Initiating Event
Failure or undesired event that intimates the start of an (accident) sequence

Pivotal Event
Intermediary events that the failure or success of determine the progress to undesired outcomes



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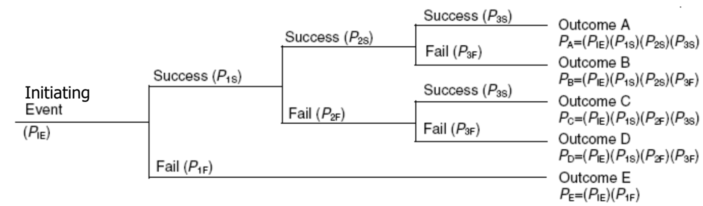
Event Tree Structure

Initiating Event	Safety Functions			Outcomes
	Event 1 (P_1)	Event 2 (P_2)	Event 3 (P_3)	



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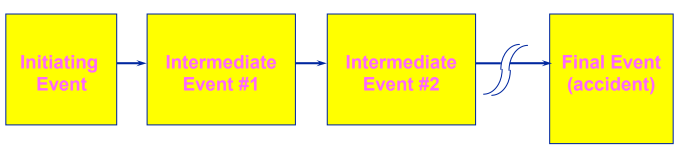
Anatomy of an Accident

An accident is a series of interconnected events that leads to an undesirable outcome.



This diagram represents a "look back" at an accident that might be developed as part of an incident investigation.

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Event Tree Method

Identify an initiating event

Pipe of vessel burst;	Ignition of combustibles	Utility system failure;	Outbreak of epidemic

Identify the safety functions designed to respond to the initiating event.

Construct an event tree

Describe the event sequence following the initiating event.

Assign probabilities to each event

Determine probabilities of event sequence.

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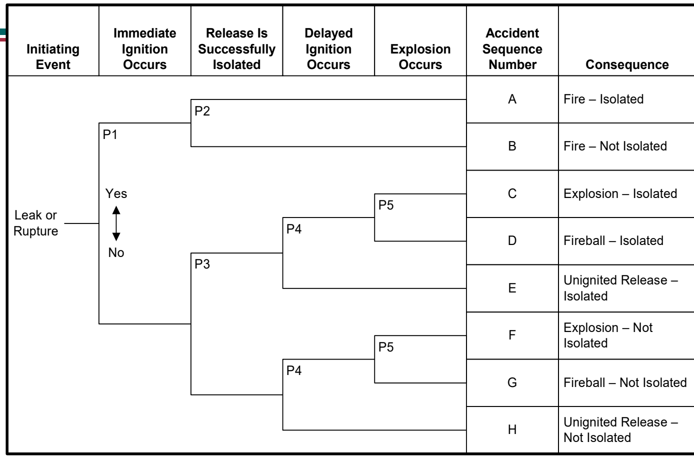
Example 1



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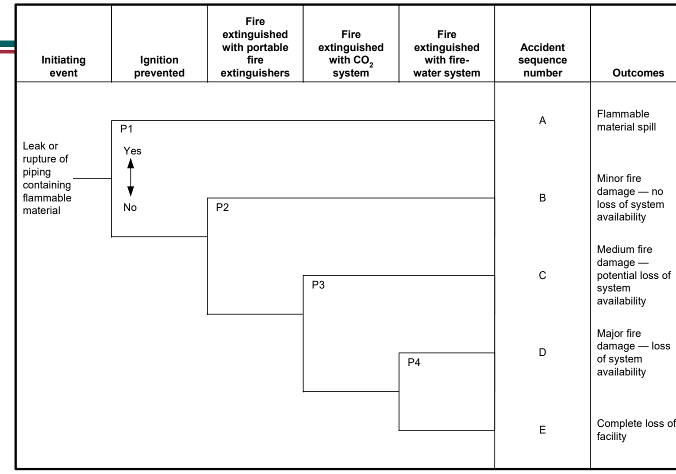
Example 2



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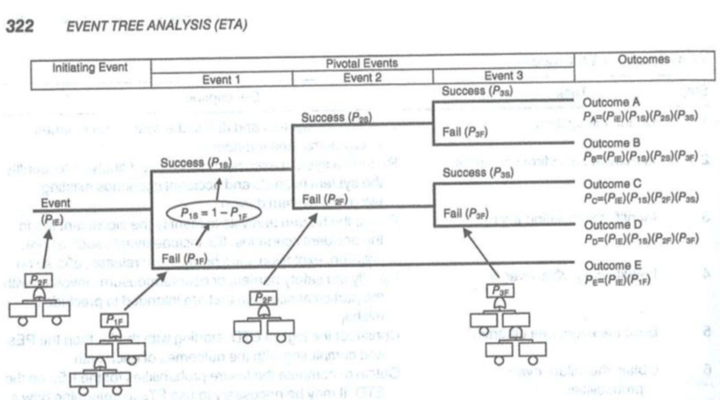

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Example 3
Reactor with Temperature Control

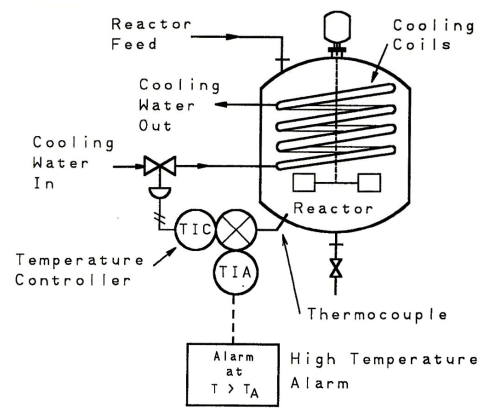

Figure 11-8 Reactor with high-temperature alarm and temperature controller.

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Loss of Coolant Event Tree

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Occurrence, Failure Rates

- **Loss of cooling: 1 event/year frequency**
- Hardware safety functions: Failure probability on demand = **0.01** failure/demand
- Operator notices high Temp 3/4 times; Operator adjusts coolant flow 3/4 times. Failure probability (for each)= **0.25** failure/demand
- Operator shuts down system 9/10 times. Failure probability = **0.10** failure/demand
- Add the occurrence probabilities

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ET Probability Computations

- **Failure probabilities**: Multiply the probability of failure of safety function times the probability of the incoming branch.
- Success probability of safety function = 1 - the probability of failure of the safety function.
- **Success probabilities**: Multiply the success probability of safety function times the probability of incoming branch.
- Event tree <u>net failure probability</u> is the sum of probabilities of unsafe states.

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ET Frequency Computations

- Obtain frequency of a downstream event by multiplying the probability of the event times the frequency of the initiating event.

Freq of an event =
Probability of the event x Frequency of initial event

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Event Frequency Determinations

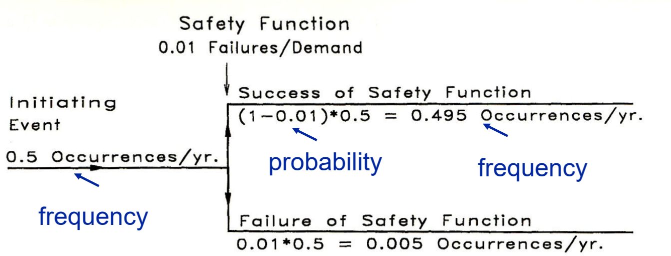

Figure 11-10 The computational sequence across a safety function in an event tree.

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Reactor Risk Assessment, 1

- From the event tree the net failure frequency is the sum of the unsafe state frequencies
- Frequency = ADE +ABDE + ABCDE = 0.025 failure/yr = 1 failure every 40 years
- The corresponding risk is considered too *high*, so the frequency must be reduced.
- Add a **high-temp reactor shutdown system**. Set the shutdown temp above the alarm value to allow operator to adjust coolant flow.

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Reactor Risk Assessment, 2

- From the event tree for the reactor with the added high-temp shutdown system, the net failure frequency leading to a runaway reaction is greatly reduced.
- Frequency = ADE**F** +ABDE**F** + ABCDE**F** = 0.00025 failure/yr = 1 failure every 4000 years
- The corresponding risk of a runaway reaction has been reduced by a factor of 100.
- Note that this significant reduction in risk was achieved by the addition of a second (redundant) shutdown system.

Crowl, D.A. and Louvar, J.F., Chemical Process Safety, 2nd ed, 2001, Prentice Hall

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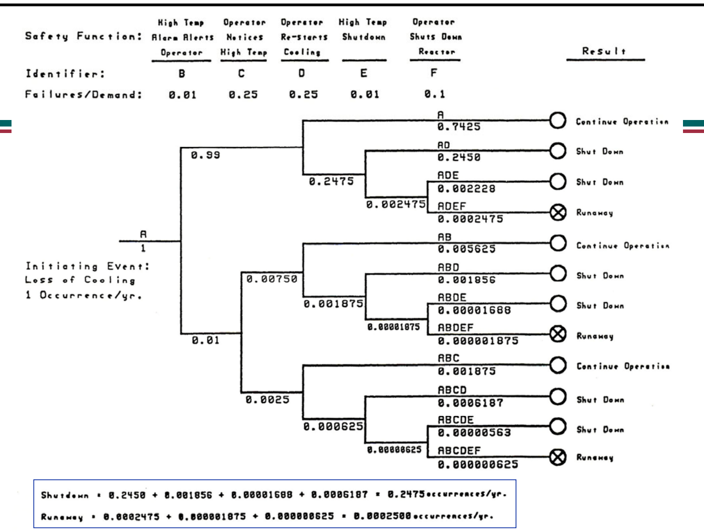

Figure 11-11 Event tree for the reactor of Figure 11-8. This includes a high-temperature shutdown system.

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Event Tree Analysis Advantages & Disadvantages

- Visual model
- Easy to do
- Structured and rigorous
- Models complex relationships
  - Vary levels of detail possible
- Computerized
  - Commercial software is available
- Follows fault paths across system boundaries
- Combines hardware, software and human interface
- Permits probability assessments

- Only one initiating event
- Overlooks subtle dependencies
- Bernoulli--Partial success or failure not detected
- Requires some training and experience
- Common Mistakes
  - Improper Initiating Event
  - Pivotal events may be missed

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Conclusions

- Event Tree yields scenarios of credible failure modes. The end events may not be anticipated.
- Can analyze multiple failures; identify single failures
- Identify system weaknesses leading to high risk; Use to modify design for lower risk levels
- Must anticipate pathways
- For a real system, the event tree can be huge, and data must be available for every safety function (probability & severity determinations) .

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