Fault Tree Analysis

Clint Guymon

Brigham Young University

1st Jan, 2025

Keywords Spiritual Safety, Process Safety, Chemical Engineering, Risk Assessment

Learning Outcomes

- Construct a Fault Tree Analysis (FTA) using deductive logic to map lower-level failures to a top-level hazardous event.
- Use Boolean logic gates (AND, OR) to combine contributing factors like equipment failure and human error.
- Identify steps to determine the combination of failures required to cause a system failure.

Reading

- Foundations of Spiritual and Physical Safety: with Chemical Processes; Chapter 5, Sections 2.2
- Fault Tree Analysis: Fault tree analysis

Fault tree analysis (FTA) is a top-down, deductive failure analysis in which an undesired state of a system is analyzed using boolean logic to combine a series of lower-level events. This analysis method is used to understand how systems can fail, to identify the best ways to reduce risk, and to estimate event rates of a safety accident or a particular system level (functional) failure.

1 1st Example of Fault Tree Analysis (FTA)

1.1 Procedure

Commute to work or school avoiding injury from a traffic accident or other hazards.

2 2nd Example of Fault Tree Analysis (FTA)

2.1 Procedure

A batch reactor is used to complete a reaction needed for the benefit of others. The reactor process has the following processing steps:

1. The reactor is filled with the raw material, a somewhat toxic material.
2. The reactor is heated to the desired temperature (100 F).
3. The reactor is pressurized to the desired pressure (20 psig).
4. Reactant B is slowly added to the reactor. An exothermic reaction occurs and the jacket must begin to cool the reactor to maintain the desired temperature.
5. The reaction proceeds at a given reaction rate at that temperature and pressure until all of the reactant B has been added.
6. The reactor is cooled to room temperature and the product is removed.

2.2 Some Hazards

- Product C has a low boiling point and is toxic. If the reactor is not cooled properly, the product will vaporize and escape from the reactor.
- If stirring is not maintained, the reaction will not proceed at the desired rate and the reactor will overheat.
- Reactor is used for multiple products

Figure 3: Image of the batch reactor credit to: https://www.essentialchemicalindustry.org/processes/chemical-reactors.html

3 Combination of FTA and FMEA:

An accident investigation prior to the accident

Example start on an FTA: (lower left is 'Blades fall off')

Example start of the FMEA/ Hazards Analysis

Action Items

1. Draw a Fault Tree Diagram for the production of polyethylene. Most safety concerns are around the plug flow reactor with a highly exothermic reaction occurring. A compressor is used to pressurize the ethylene feed to near 1500 bar. A cooling jacket surrounds the plug flow reactor where the temperature is controlled to near 70C. A separator is then used to collect the polyehtylene solids and the unreacted ethylene is recycled.
2. Identify a "Top Level Event" for a commute to school and deduce at least three sub-events that could lead to that outcome.
3. Comment on the both the success and failure portions of the Fault tree for spiritual scenarios FIgure V.10(Guymon, 2025) page (95). What covenants have you made or could you make with God to help you succeed and draw closer to God?

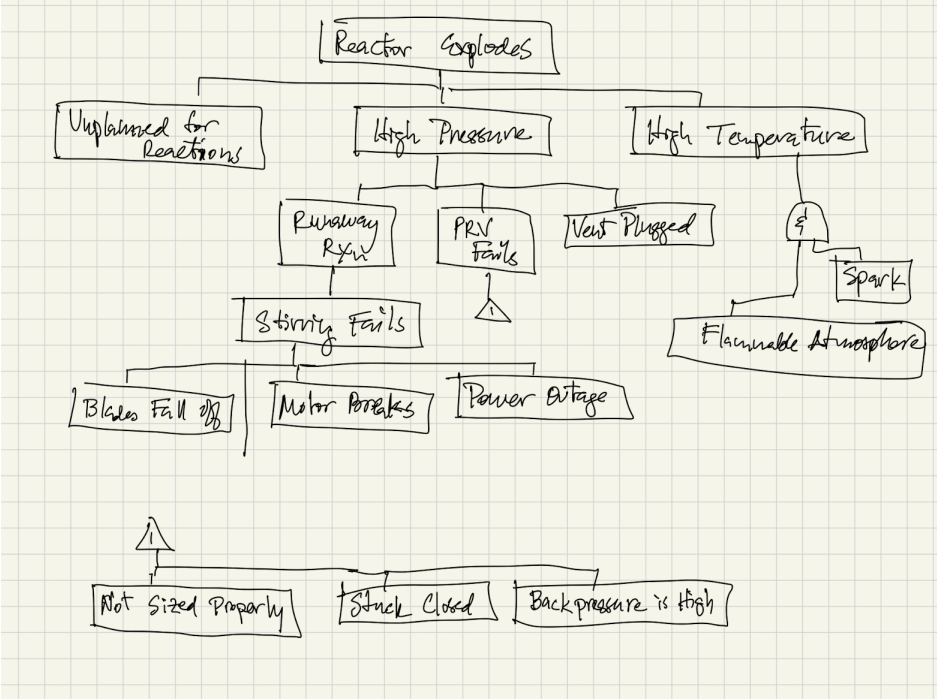

Figure 4: Example Fault Tree Analysis

BYU TIPICE

Job Hazards Analysis (JHA)

Title:	Document No.:	Page:
Operator/ Test Individual:	Rev:	Date:

BYU CH EN Job Hazards Analysis						
Task Description	**Hazard Type**	**Hazard Description**	**Consequence**	**Safeguards**	**Rank**	**Recommendations**
Reactor Operation - Stirring	Electrical Failure	Controller Fails from Power Outage	Stirring ceases resulting in a runaway reaction, high pressure, and potential violent reactor explosion	Battery Powered alarm present to indicate power failure Backup power generator present	2D	
Reactor Operation - Stirring	Component Failure	Motor Fails	Stirring ceases resulting in a runaway reaction, high pressure, and potential violent reactor explosion	Alarm present on motor indicating presence of stirring Emergency venting of reactor contents possible	2D	

Figure 5: FMEA Example

References

C. Guymon. *Foundations of Spiritual and Physical Safety: with Chemical Processes*. 2025.