Risk Analysis in Chemical and Petroleum Industries

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Submitted to:

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Objective

- To know about the techniques used to analyze the risk in chemical and petroleum industry.
- Methods to eliminate those risks.
- Considering the risk factors like weighing factor, risk exposure, risk matrix etc to analyze risk.
- Determining the alternative approach using Fault tree analysis, decision trees and PORT.

Introduction

- Handling chemicals can pose risk to both humans and environment.
- Petroleum and chemical industries are implementing vast set of techniques to assess the risk in processing, storing and transporting chemicals and to improve safety.
- Risk analysis is a set of systematic methods used quantitatively and qualitatively
- Many companies choose to work with a risk value.
- The risk value depends for example on the constituent substances' hazard, exposure time, exposure potential, amounts and the technical protective measures.

Risk?

- Because of incorrect historic data.
- No proper knowledge of handling subtances

Significance of Risk analysis in Chemical industry

- Avoiding major future accidents and other events.
- Determining new approaches to mitigate the risk.
- Examining how the project outcomes and objectives might change due to the impact of the risk event.
- Helps to prioritize the risks and their respective control measures.
- Increases the success rate of the project.

Types and sources of risk in chemical industry

Types	Sources
• Chemical Explosion	Improper chemical handling
• Physical Explosion	Over pressure in steam boiler
• Toxic release	Unacknowledged leakages
• Fire	Ignition of Flammable gases
• Boiling Liquid Expanding Vapor Explosion (BLEVE)	Catastrophic failure of a vessel containing liquid flammable material in pressurized condition.

Techniques used in Risk Analysis

Qualitative

- Qualitative Weighing Factor
- Hazard and operability Analysis
- Risk Matrix

Quantitative

- Frequency of incidents
  (a)Poisson distribution
  (b) Negative Binomial distribution
- Incident Forecasting
  a) Incident probabilities
- Petrochemical Organization Risk Tringle (PORT)

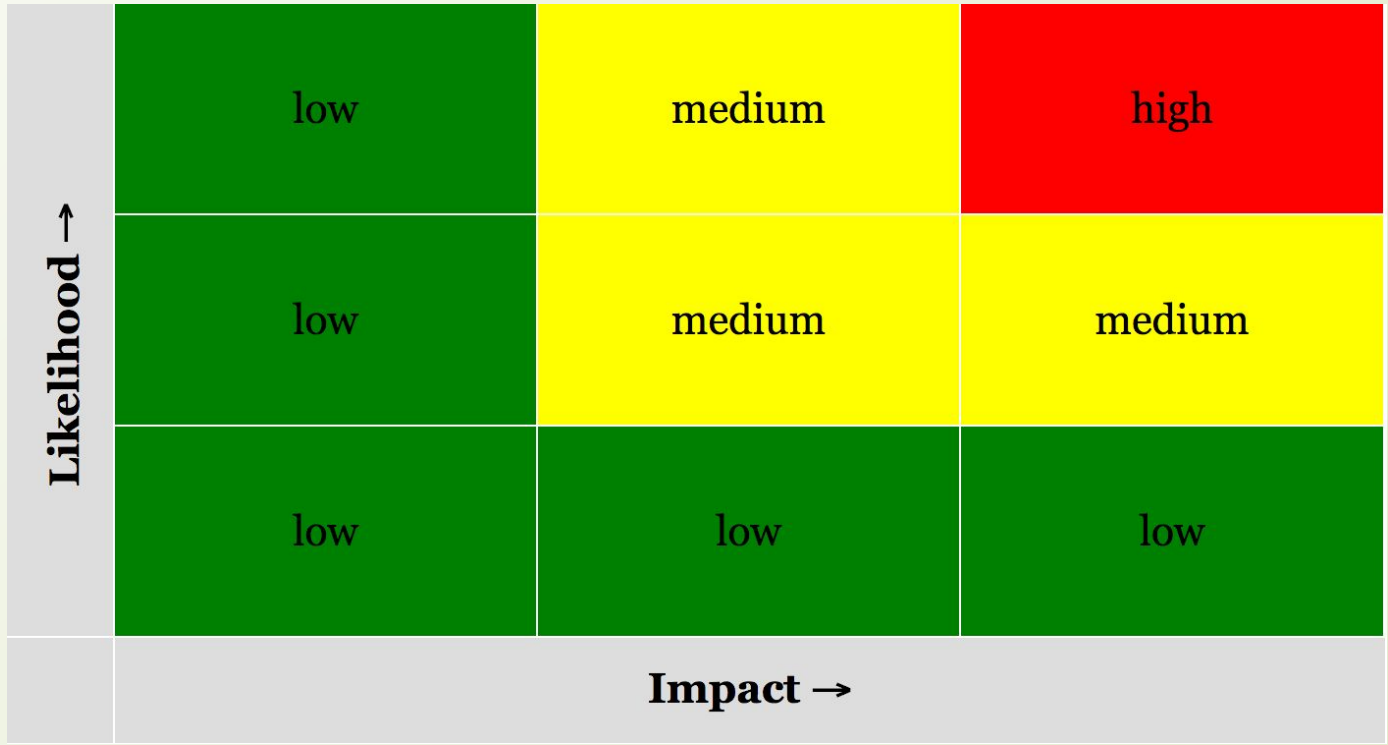
Qualitative Techniques

- **Qualitative Weighing Factors (QF):**
  - One of the most w**idely supported qualitative technique**
  - Usually estimated between 2 to 5 and between 8 to 11 for Petrochemical Industries.
  - Above values used to calculate indirect costs on workplace safety

- **Hazard and Operability Analysis (HAZOP):**
  - This technique is used for both risk **identification** and **analysis.**
  - Earlier, used to identify accidents due to equipment failure.
  - Modified HAZOP used to study human, management and organizational vulnerabilities.

Qualitative Techniques Cont.

- **Risk Matrix:**



Qualitative Techniques Cont.

- **Risk Matrix:**
  - This technique not an advanced type of analysis method.
  - Matrix represents the **risk frequency** and its **consequences** on its axis.

    Risk frequency X Consequences = Risk measure
  - It helps to identify, prioritize and manage all major risk.

Quantitative techniques

- **Frequency of Incidents:**

I. **Poisson Distribution:**

$$y \sim p(y = y_i) = \left\{ \frac{\lambda^{y_i} e^{-\lambda}}{y_i!} \right\}, \qquad y_i \in \{I^1\},\ y_i \geq 0,\ \lambda > 0$$

where: yi = no. of abnormal events in year i

λ- annual average number of abnormal events, with the expected value, E(y), and variance, V(y), equal to λ.

- The annual number of occurrences of an abnormal event is a non- negative and integrated valued.
- Thus, the above equation is used to estimate the annual occurrences of incidents.

Quantitative techniques Cont.

II. Negative Binomial Distribution:

- The annual number of occurrences of an abnormal event is a non- negative and integrated valued.
- Thus, the above equation is used to estimate the annual occurrences.

$$y \sim (q)^{\mu}(1-q)^{y_i} \quad y_i \in \{I^1\},\ y_i \geq 0,\ \mu > 0,\ q \geq 0$$

where; yi = no. of abnormal events in year I

V(y)= expected variance

AS per literature review, **probabilistic methods** are found to be more cost-effective, giving results that are easier to communicate to decision and policy makers.

Quantitative techniques Cont.

➢ **Incident Forecasting:**

I. **Incident Probabilities:**

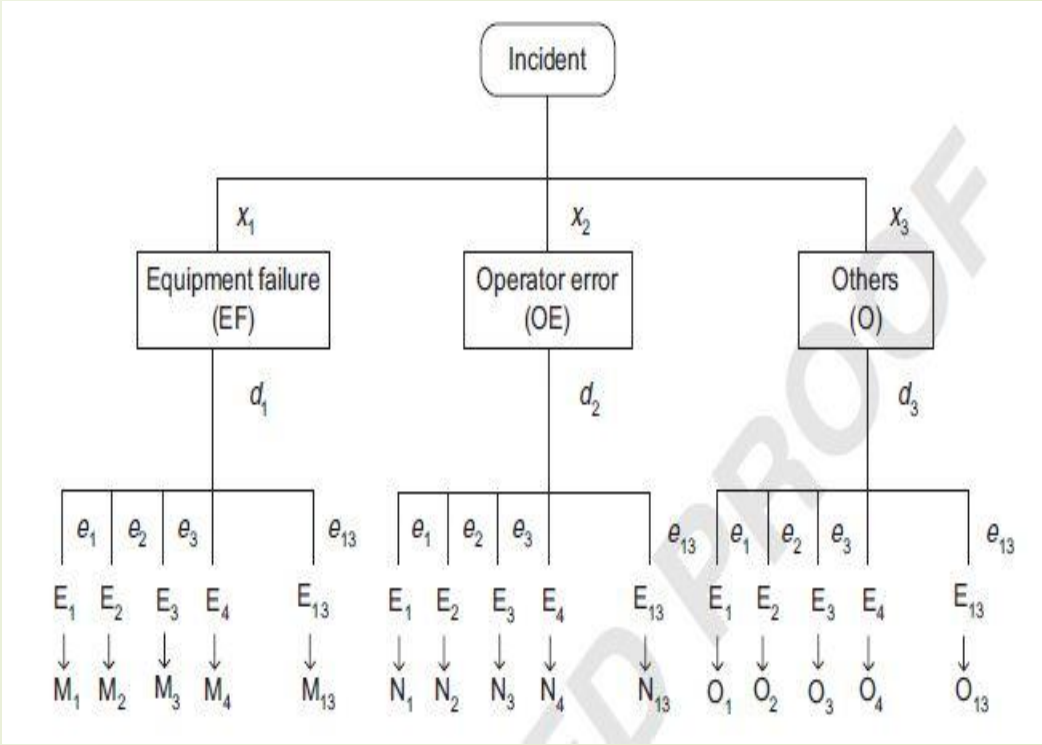
- Table shows the number of incidents (N Total) for the 7 companies extracted from the NRC database (from 1991-2002).
- The number of incidents are predicted using the Poisson Distribution

Company	Type	N_{Total}
A	Petrochemical	688
B	Petrochemical	568
C	Speciality chemical	401
D	Petrochemical	220
E	Speciality chemical	119
F	Speciality chemical	83
G	Speciality chemical	18

Quantitative techniques Cont.

II. **Causes and Equipment Types involved in an Accident:**

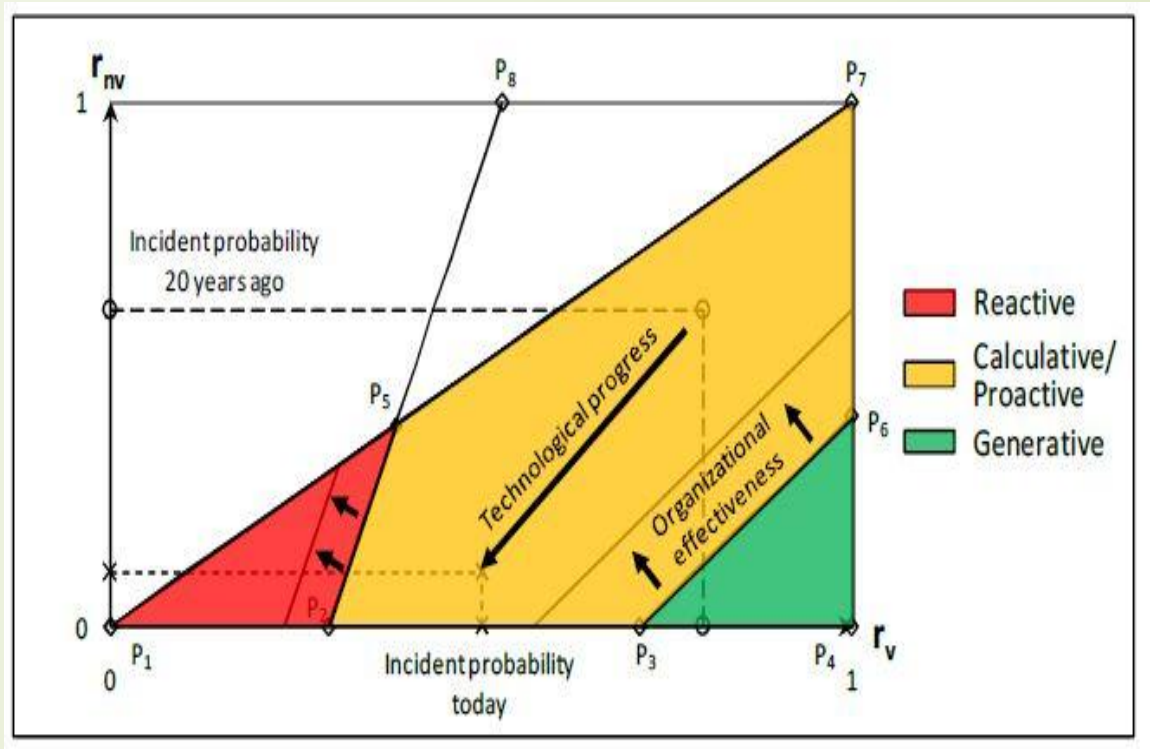
- Fault tree is mostly used to represent causes and effects.
- Tree could also be used to show the possible type of equipment followed by the possible causes for each incident.
- Represented tree displays the **possible causes for each incident and the possible types of equipment for each cause.**



Cause and Effect Tree

Quantitative techniques Cont.

- **Petrochemical Organizational Risk Triangle (PORT):**
  - A technique developed in risk management proposed in 2011.
  - PORT is a graphical risk management tool aim to achieve a movement that enables a generative security culture, i.e. the green area(shown in fig.) to be achieved.
  - The probability of an incident represented by r_v and r_{nv} determines X,Y coordinates of PORT and are calculates as:



$$r_v = p(I \mid v) = \frac{p(v \mid I) \cdot p(I)}{p(v \mid I) \cdot p(I) + p(v \mid NI) \cdot p(NI)},$$

$$r_{nv} = p(I \mid nv) = \frac{p(nv \mid I) \cdot p(I)}{p(nv \mid I) \cdot p(I) + p(nv \mid NI) \cdot p(NI)}$$

Quantitative techniques Cont.

These movements can be described in terms of several practical phenomena in the evolution of petrochemical risk management:

- Technological progress
- Organisational effectiveness
- Safety culture improvement

Conclusion

Risk management in the petrochemical industry has been strongly influenced by the findings of accident research and has continually evolved over the past fifty years.

Quantitative methods discussed have proved to be more beneficial and recommended for petrochemical industries than qualitative methods.

It is important to know an organization's accident numbers , its safety culture and application of appropriate technique to improve risk management practices to lead to safer and profitable future.

The major problems of residual safety do not belong solely to the technical or human domains, instead, the interactions between the technical and social aspects of the system are still little understood.

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Thank you

Questions?