



Inherent Safety

CHEN 455 project
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Outline

- Introduction
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- Inherent Safety
 - INTENSIFICATION
 - SIMPLIFICATION
 - SUBSTITUTION
 - ATTENUATION
- Case Studies
 - FLIXBOROUGH DISASTER
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 - BHOPAL DISASTER
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Introduction

- Prevention is better than cure
- Extrinsic VS Intrinsic Safety
- Inherent Safety: How it Began
- Concepts:
 - INTENSIFICATION
 - SIMPLIFICATION
 - SUBSTITUTION
 - ATTENUATION

Transition Towards Inherent Safety

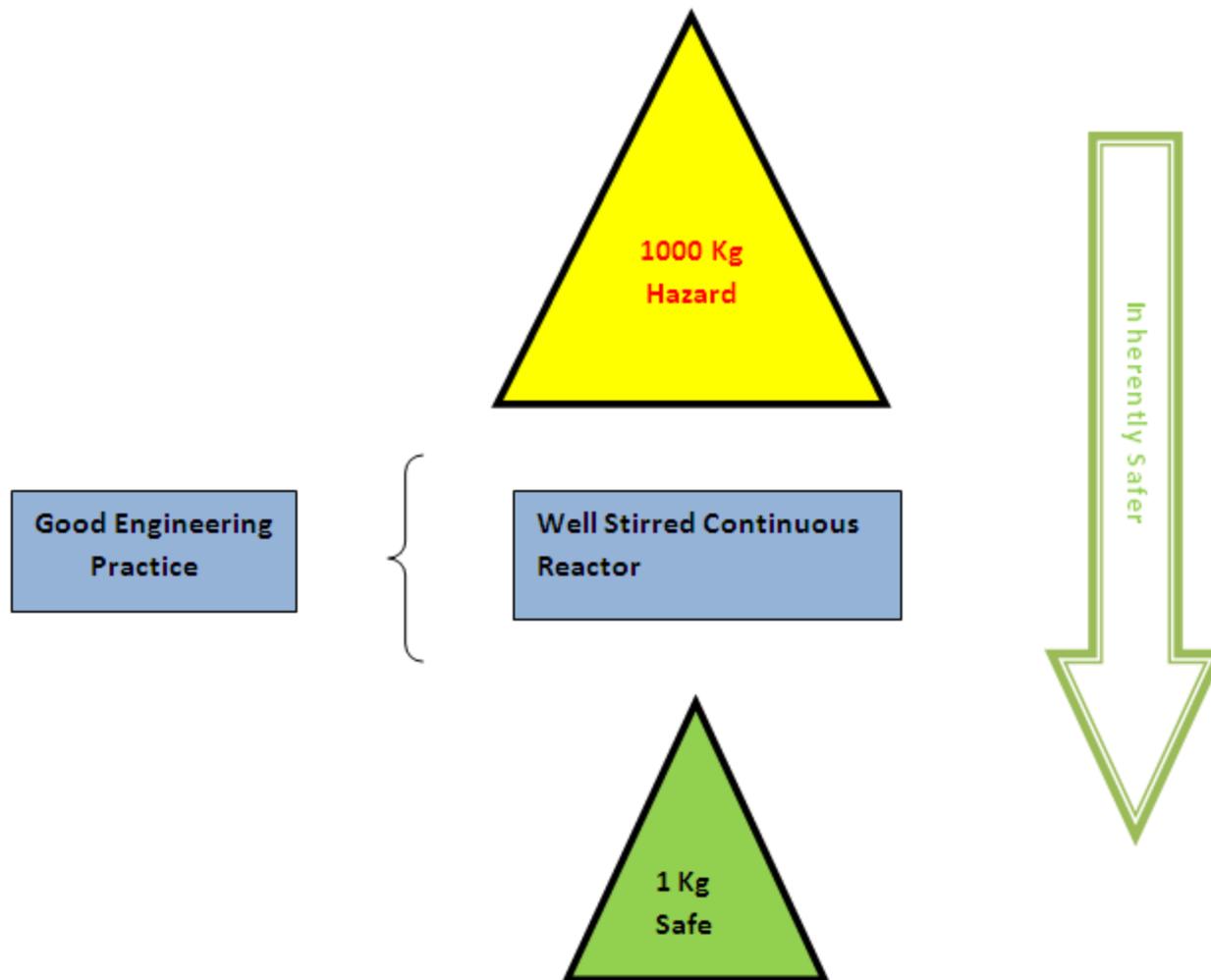
- Historical View of Safety in Processes
- Need for new approach towards safety after key disasters: *FLIXBOROUGH AND SEVESO.*
- Concept Of Inherent Safety Suggested By Dr. T. Kletz
- Final Step: Seveso II Directive

1. Intensification

- Eliminate or reduce the presence of hazardous material on site
- “What you don’t have can’t leak” T.A Kletz
- It can be done for different process units
- Economically profitable

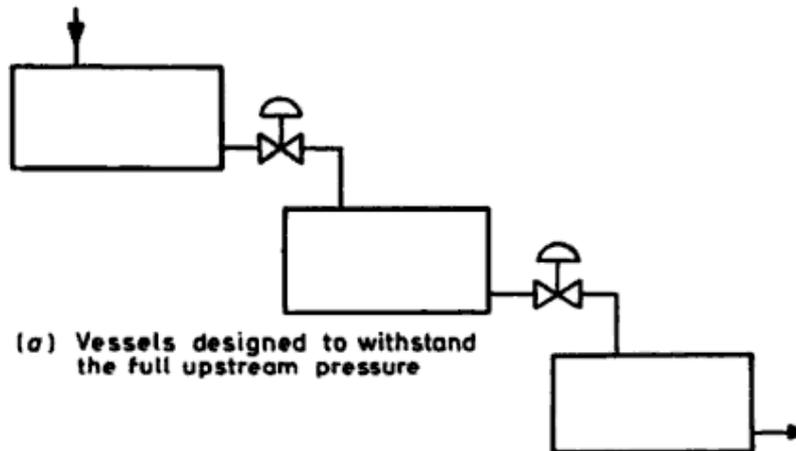
Nitroglycerin Production

- Produced from a mixture of glycerin and nitric and sulfuric acid
- Nitroglycerin is highly explosive
- Exothermic reaction
- Very slow reaction
- Larger Inventory is needed



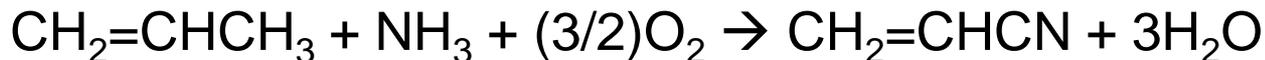
2. Simplification

- Eliminate or reduce unnecessary complexities
- “Equipment you don’t install cannot develop faults or be operated at the wrong time or in the wrong way” T.A Kletz
- Stronger equipments instead or relief systems

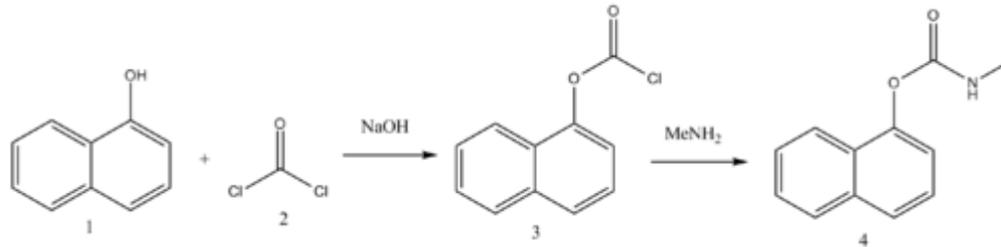
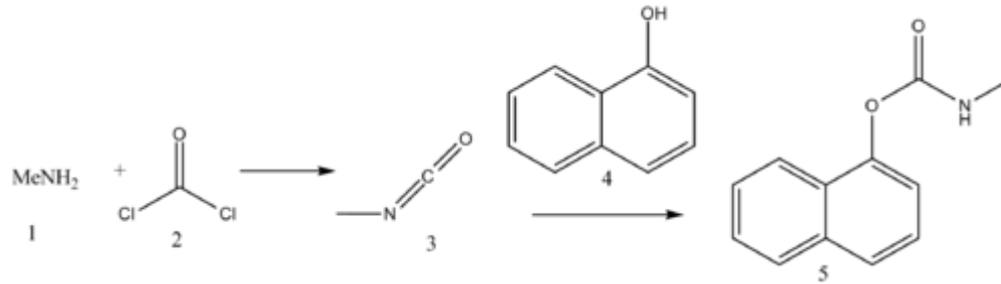


3. Substitution

- Replacement of a hazard to reduce risks associated with it
- Wide range of applicability:
 - Reaction chemistry
 - Acetonitrile manufacture



- Carbaryl manufacture



- Solvents
 - Paints
 - CFC's

4. Attenuation

- The use of hazardous materials in their least hazardous forms
- Or implementing processing options that involve less severe processing conditions
- Example:
 - chlorine and ammonia, they are stored as refrigerated liquids at atmospheric pressure

➤ Limitation of Effects

➤ BLEVE fireball

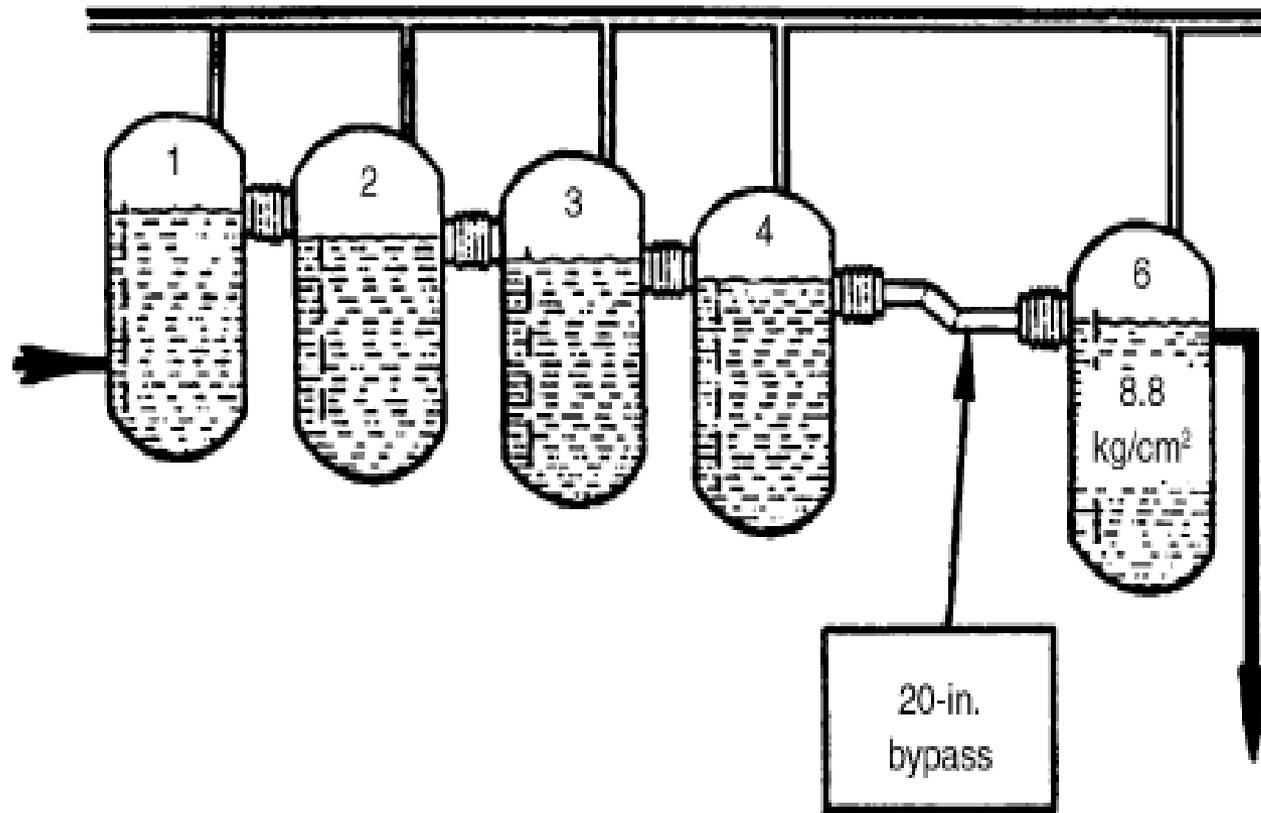
➤ Dilution of hazardous materials

➤ Dust Explosion

Case Studies

1. Flixborough Disaster

- ➔ UK's largest chemical industry explosion
- ➔ Occurred in a plant that produced nylon for nypro
- ➔ 28 fatalities
- ➔ Complete Destruction of the plant
- ➔ Occurred in the cyclohexane oxidation unit

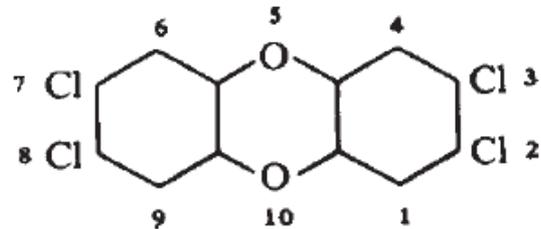


Applying Inherent Safety

- Official reports focused on operational issues
- Why did such amount of cyclohexane leak?
 - Large pipes
 - 400 ton inventory
 - Slow reaction due to the air oxidizing agent
- Possible solution:
 - Use O₂ as the oxidizing agent
 - Add water as an inert

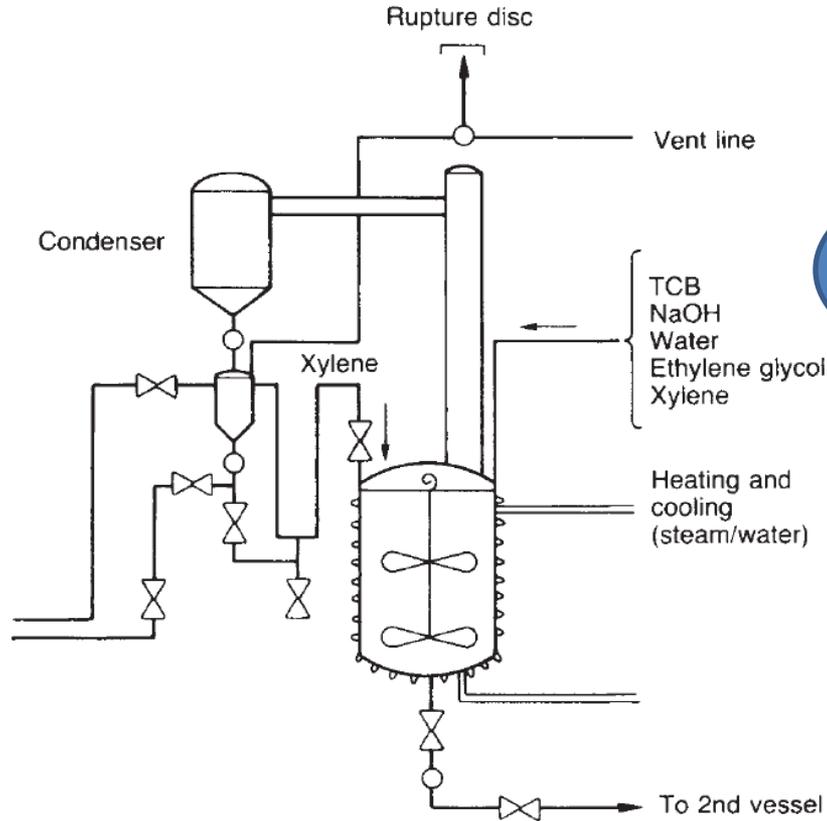
2. Seveso Disaster

➔ 9th of July 1976



- ➔ TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin) was released due to a Runaway Reaction
- ➔ Icmesa Chemical Company Seveso
- ➔ town of about 17,000

What had gone wrong?



Stage 1:
 170 -180°C

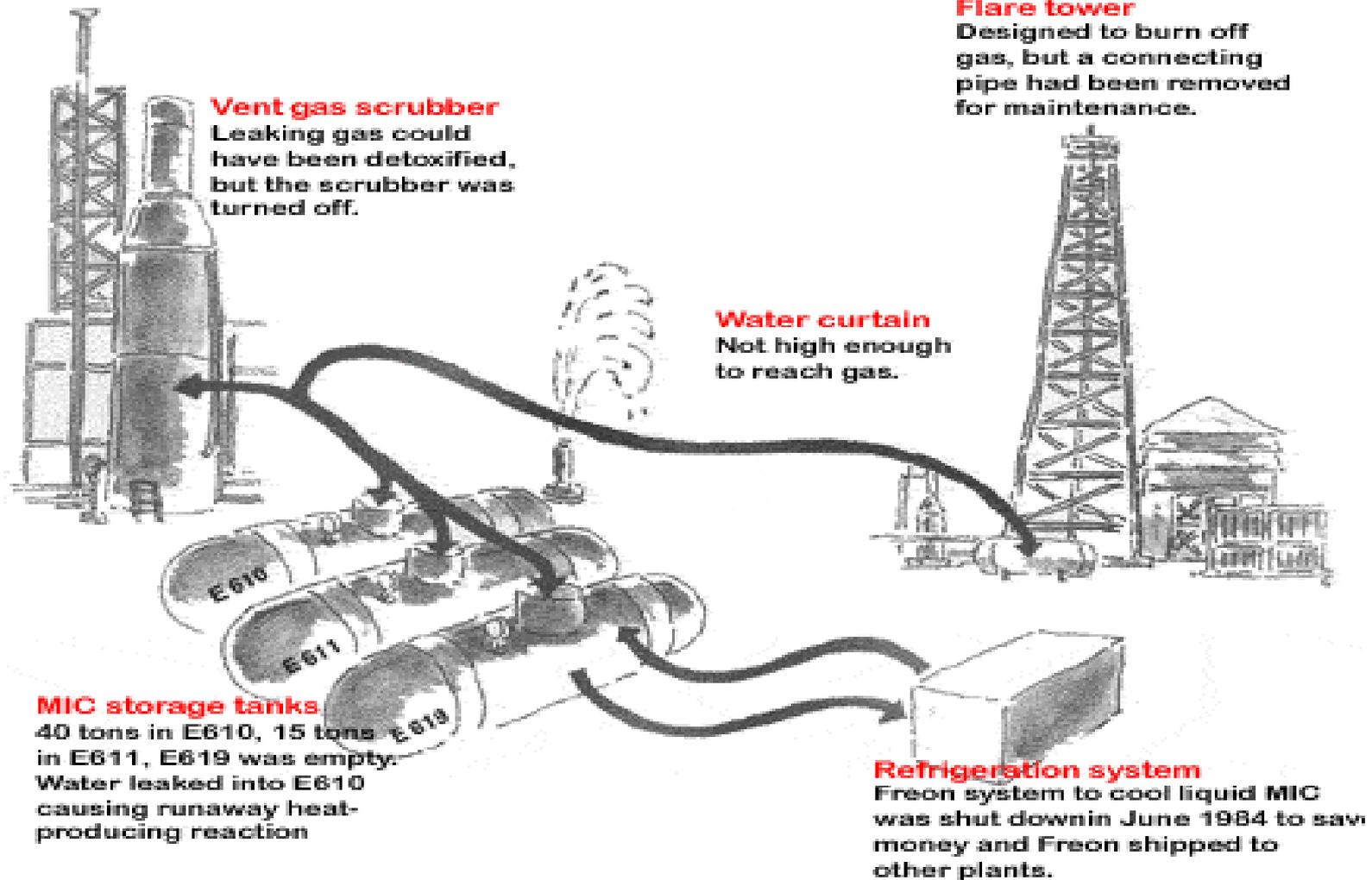
Stage 2:
 50 -60°C

Applying Inherent Safety

- Minimize
- Substitute
- Attenuate
- Simplify

3. Bhopal Disaster

- DEC 23, 1984: 250,000 people were exposed to toxic chemicals during a catastrophic gas leak
- More than 20,000 dead and over 100,000 left suffering from chronic illnesses
- Accident caused due to release of MIC, resulting from a large amount of water getting into the MIC storage tank.
- All six safety systems in place non-functional at the time of the incident



Applying Inherent Safety

- ➔ Replace MIC with less toxic chemical, or have a different reaction for carbaryl (substitution)
- ➔ Use of other cleaning agents other than water (substitution)
- ➔ Reduce amount of mic storage on-site (minimization)

- Have bunds/dikes to contain release/spill(attenuation)
- Location of plant away from city(attenuation)
- Improve safety systems (simplification)

Conclusion

- Modern era, complex and dangerous processes with great hazards and risks.
- Apply concepts of inherent safety where applicable, and use extrinsic measures to form a layer of protection
- Look back at disasters like Flixborough, Seveso and Bhopal, and learn from mistakes



Thank you for listening.

Questions?