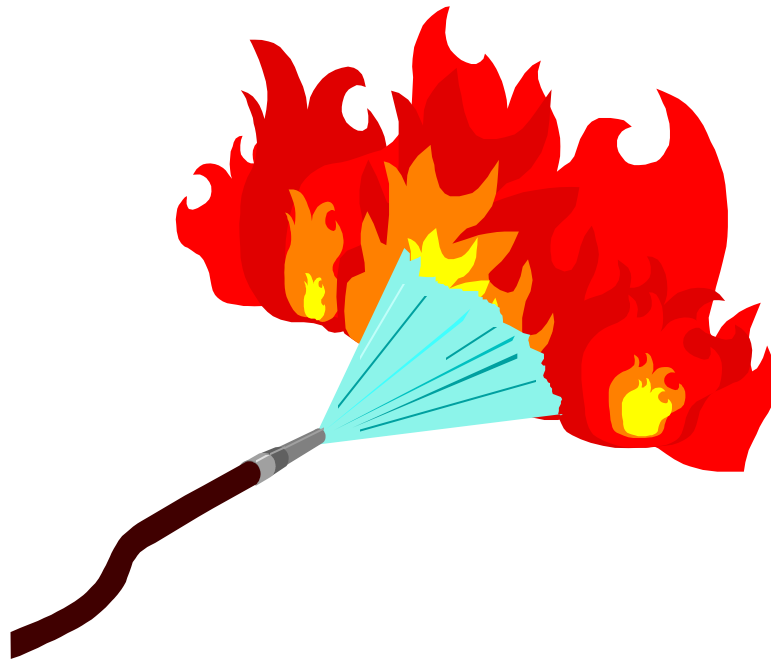# Chemical Process Safety

Outline of Lecture on Chemical Process Safety

- **Inherent Safety**

- **Hazard Identification**

- **Risk Assessment**

- **Fire Protection**

Inherently Safer Processes

Reduction or elimination of the hazards associated with a process, and this reduction or elimination is permanent and inseparable from the process.

Example: use a less toxic raw material to product a product.

Inherently Safer Process Methods

Minimize: Reduce quantity of energy in process.

Substitute: Use less hazardous raw materials.

Moderate: Use lower temperatures and pressures.

Simplify: Reduce unnecessary complexity in the design and operation.

KISS: Keep it simple and safe!

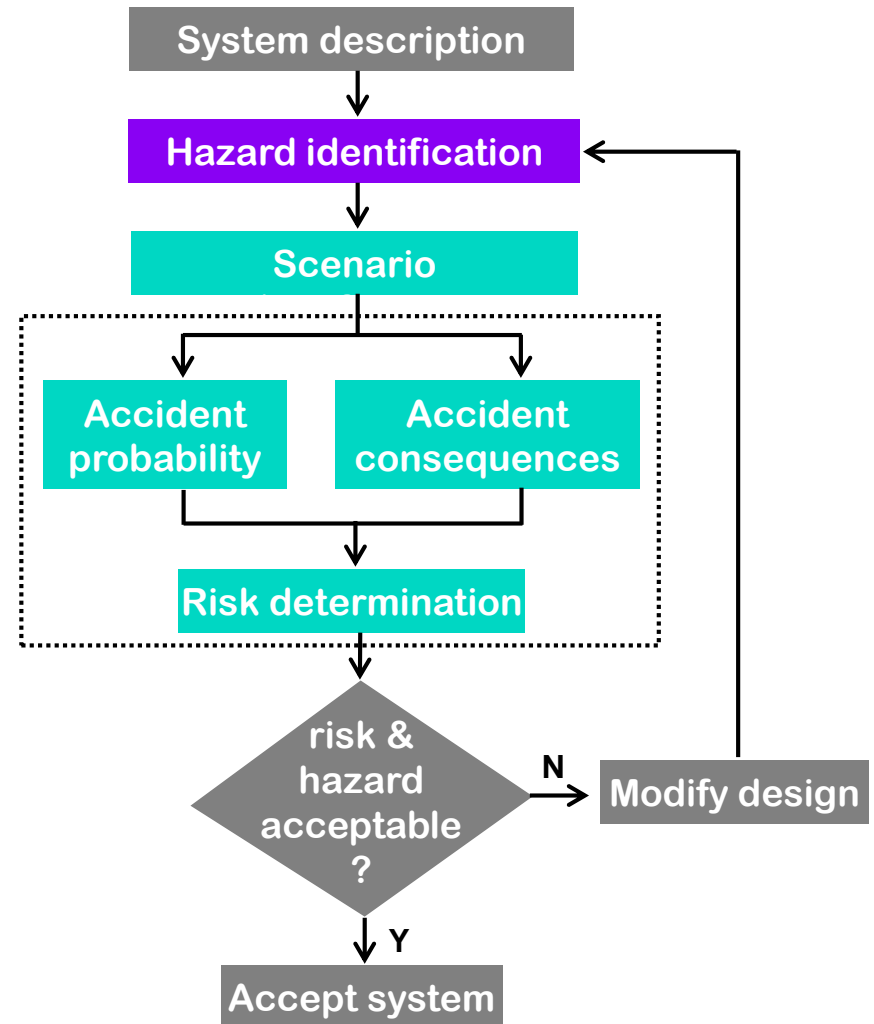# Hazard Ident. / Risk Assess. Procedure

HAZARD IDENTIFICATION METHODS:

- **Process hazard checklist**
- **Hazard survey: DOW index**
- **HAZOP hazard & operability study**
- **Safety review**

RISK ASSESSMENT:

- **What can go wrong & how ?**
- **What are the chances ?**
- **Consequences ?**

EXTREMES:

- **Low probability**
- **Minimal consequences**

System description

Hazard identification

Scenario

Accident probability

Accident consequences

Risk determination

risk & hazard acceptable ?

N → Modify design

Y → Accept system

Hazard Identification

Why? To identify hazards so that they can be eliminated or controlled.

How? Using a number of available procedures.

Relative Ranking Methods

Provide a unitless number representing the relative hazard.

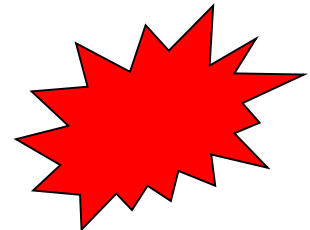Examples: Dow Fire and Explosion Index (F&EI)

Dow Chemical Exposure Index (CEI)

Case A > Case B

Dow Fire and Explosion Index

- Operates like an income tax form.
  - Penalties for unsafe situations
  - Credits for control and mitigation
- Produces a number - the bigger the number the greater the hazard.
- Only considers flammable materials
- Not effective for procedures.

Dow Chemical Exposure Index (CEI)

- Considers toxic materials only.

- Includes simple source and dispersion models.

- Not effective for procedures.

Dow Criteria: If sum of F&EI and CEI > 128, then more detailed hazard review procedure required.

Hazard and Operability Studies (HAZOP)

- Can identify hazards due to fixed equipment and procedures.

- Is a huge effort.

- Provides a controlled mechanism to consider the things that can go wrong.

- Customized for each company.

- Improves process performance, quality, etc.

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HAZOP Procedure - 1

1. Divide flow sheet into sections, i.e. reactor, storage.

2. Choose a study node, i.e. line, vessel, pump, operating instruction.

3. Describe its design intent.

4. Select a process parameter.

5. Apply a guide word.

6. Determine cause(s).
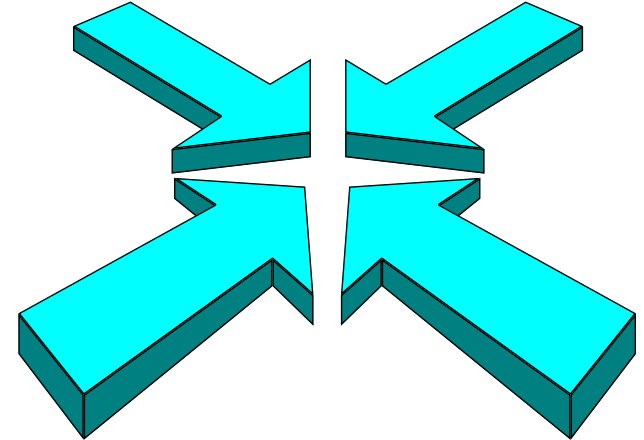
HAZOP Procedure - 2

7. Evaluate consequences/problems.

8. Recommend action:
    what? who? when?

9. Record info.

10. Repeat 5 to 9 for a new guide word.

11. Repeat 4 to 10 for a new process parameter.

12. Repeat 2 to 11 for a new study node.

13. Repeat 1 to 12 for a new flow sheet section.

HAZOP Summary

Advantages: Meets regulatory requirements

Plant operates better

Less down time

Product quality improved

Employees are happier

Disadvantages: Time, people and effort
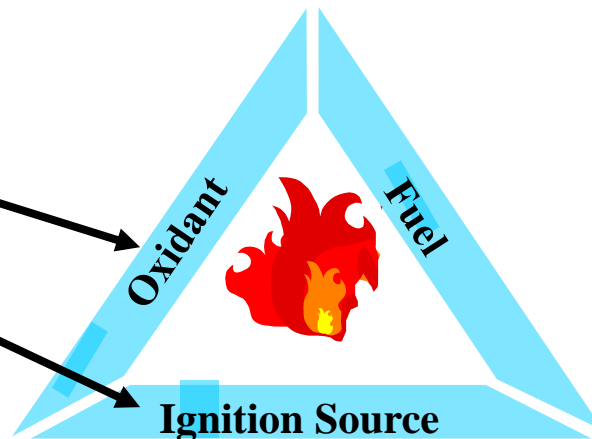
Information management problem

Fire Protection

Problem: How to safely store flammable liquids and gases to prevent fires and explosions?

Primary Design Objective: Prevent fires and explosions by preventing the existence of flammable mixtures.

Secondary Design Objective: Reduce or eliminate ignition sources.
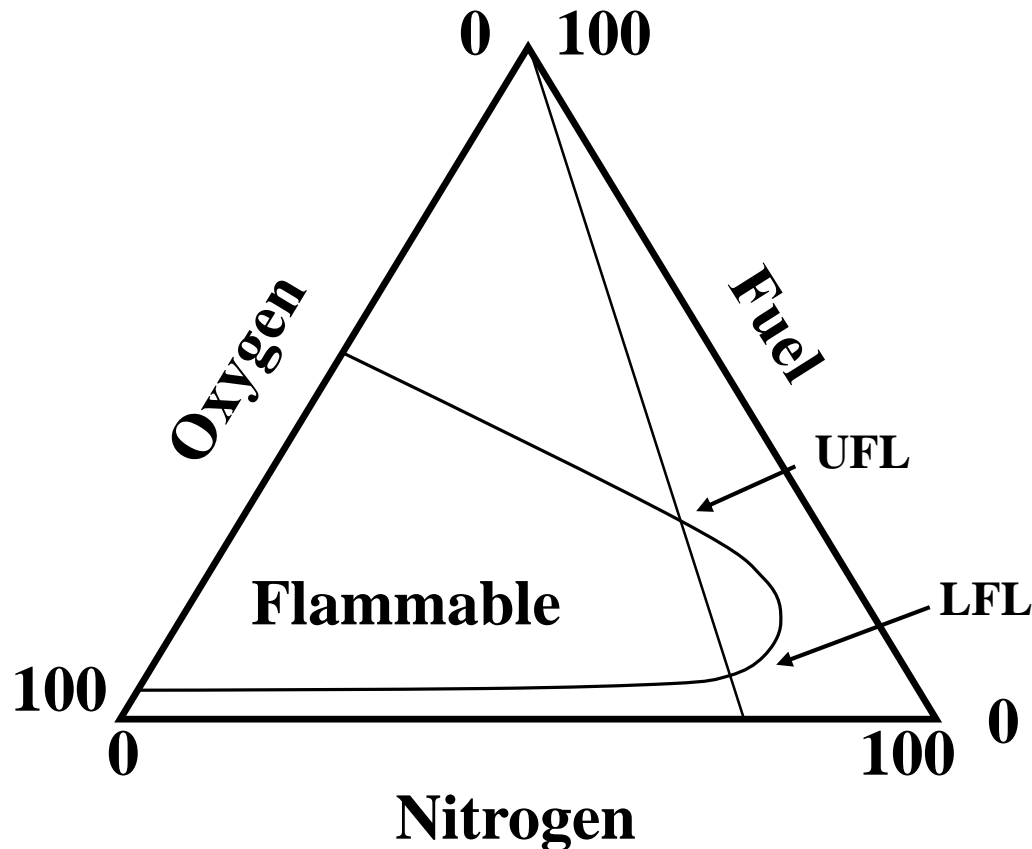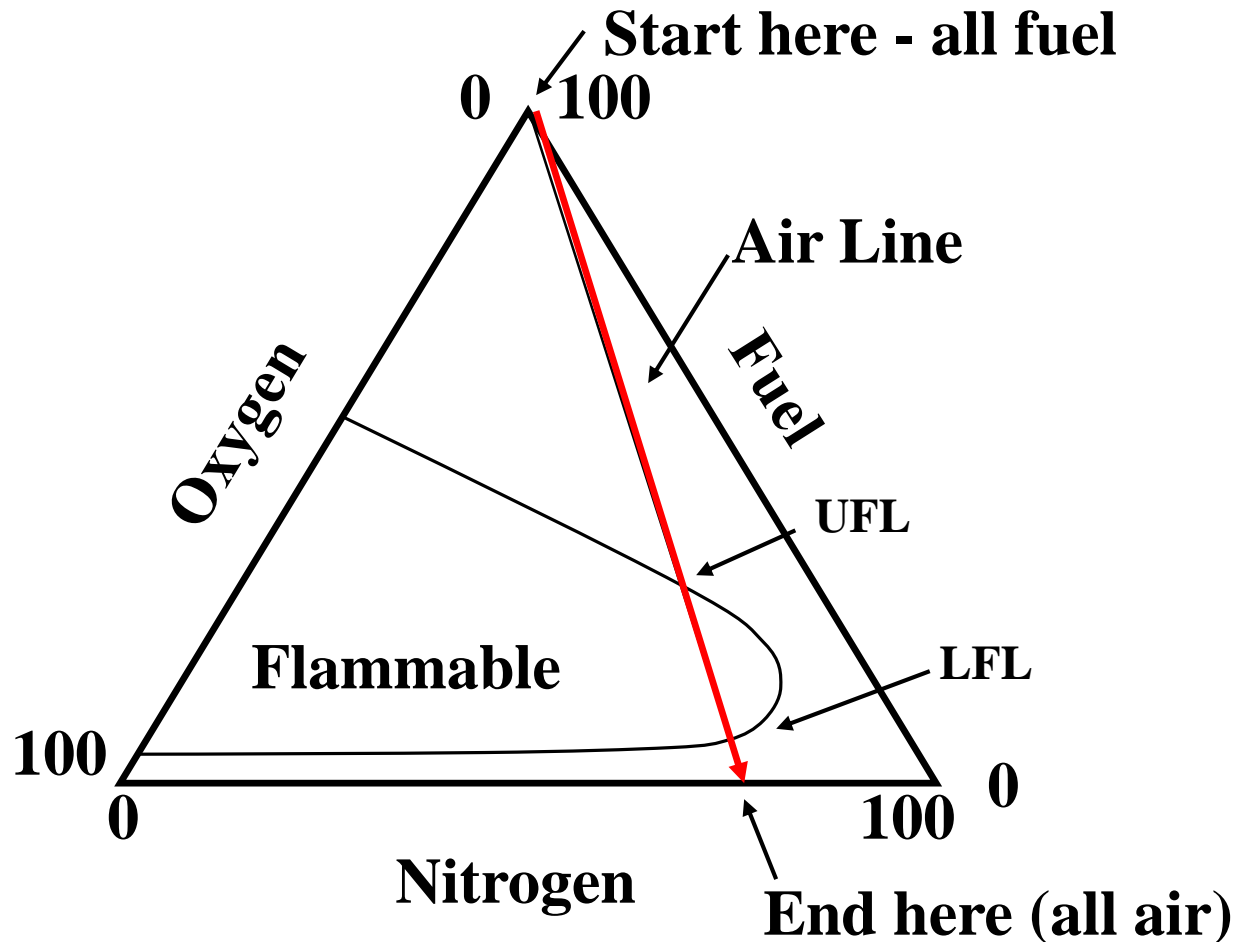
Remove this leg

Reduce this leg

Oxidant

Fuel

Ignition Source

(1) Fuel + (z) Oxygen ---> Products

Depressurize vessel to atmospheric, then blow air into vessel.

Start here - all fuel

0   100

Air Line

Oxygen

Fuel

UFL

LFL

Flammable

100

0

0

100

Nitrogen

End here (all air)

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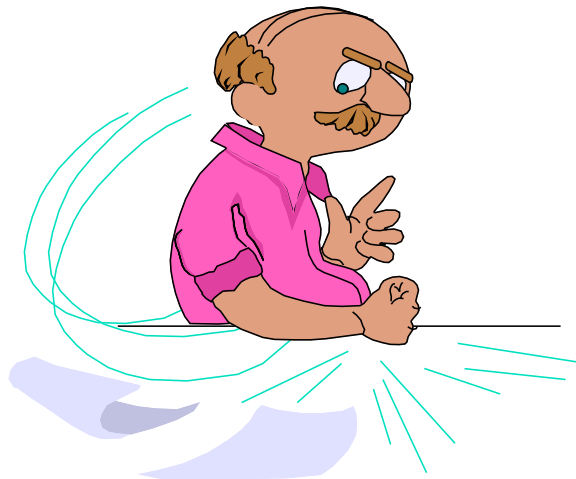**(1) Fuel + (z) Oxygen ---> Products**
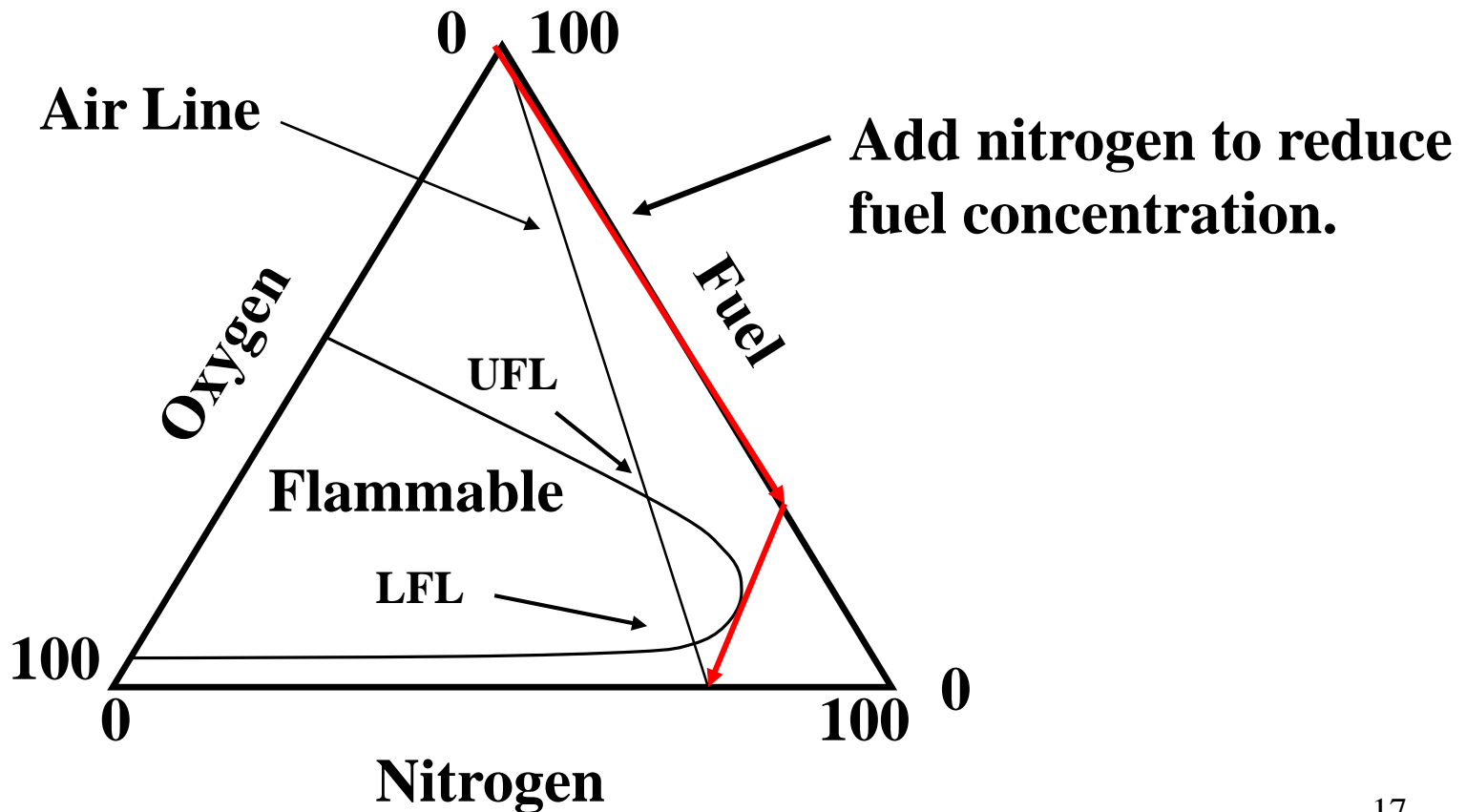
Most Important Point of Lecture

Chemicals used in chemical plants may be hazardous, but if you understand these hazardous properties and understand how they may cause accidents, then the chemicals can be handled safely.

S-A-F-E-T-Y

- **S** - **Management Systems**
- **A** - **Proper Attitude**
- **F** - **Understand Fundamentals**
- **E** - **Experience**
- **T** - **Time to do things safely**
- **Y** - **Your Participation**