CM4310: Chemical Process Safety/ Environment

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Office Hours:
Hours posted on door
By appointment

Structure of Course:

First 9+ weeks: **Process Safety**
D. A. Crowl
Last Lecture: Nov. 8

Last 4+ weeks: **Environment**
D. R. Shonnard
First Lecture: Nov. 10

Grading

Safety:
- **Exams (2):** **40% (20% each)**
- **Homework:** **20%**
- **Computer:** **5%**

TOTAL: **65%**

Environment:
- **Exams (1):** **15%**
- **Homework:** **10%**
- **Computer:** **5%**
- **Essay:** **5%**

TOTAL: **35%**

Homework for Safety Part

- **Bi-weekly**
- **4/5 total**
- **Solutions on web site.**
- **Put box no. on homework if you want handed back to your box.**

Help Sessions

- **Primarily to provide homework assistance.**
- **Will begin 2nd week of class.**
- **Held in evening.**
- **Typically 2 per week on week prior to homework deadline.**

Help Sessions

2nd Week Help Sessions

Tuesday, Sept. 12, 7 – 9 PM, Location TBA

Thursday, Sept. 14, 7 – 9 PM, Location TBA

Textbook for Safety

D. A. Crowl and J. F. Louvar

Chemical Process Safety, Fundamentals with Applications

Second Edition, 2002

Chapters 1-10, Appendix 1

Print out errata sheet from course website.

Videos: *Safety in Chemical Process Industries*

View on-line using links provided on course web site. Videos to view listed on outline.

Study Guide: Available for download / printing from course web site.

Please print-out study guide section prior to showing of video in class. Study guide contains detailed outline, figures, other resources.

Teaching Assistant

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General Course Page

CM4310 Course Page

Cell / Mobile Phones

If you have a cell / mobile phone, please either turn it off or place it in silent mode prior to class.

If you have any special problems or needs:

Please see me!

If you cannot hear me or see overheads or boards:

Please see me!

Expectations for Students

- Attend lectures, pay attention, listen and take notes.
- Work and submit homework.
- Homework problems are more open-ended than previous courses – need to make decisions. Homework is based on real plant problems.
- Homework problems are in both English and metric units – usually consistent.

Purpose of Safety Part:

To provide fundamental tools which are used to design / manage / operate a chemical plant safely

Definitions

Accident:	The occurrence of a sequence of events that produce unintended injury, death or property damage.
Safety:	Strategy of accident prevention.
Loss prevention:	Prevention of injury to people, damage to environment, loss of equipment, inventory or production.
Hazard:	A chemical or physical condition that has potential to cause an accident.
Significant Chemical plant hazards:	flammable, explosive, reactive & toxic hazards
Risk:	Probability and consequence of an accident.

S-A-F-E-T-Y

- S - Management Systems
- A - Attitude
- F - Fundamentals
- E - Experience
- T - Time
- Y - You

This course stresses fundamentals!

Most Important!

- Safety cannot be prioritized - it is a condition of employment!

Definitions

- Incident: Loss of control of material or energy.
- Scenario: A sequence of events which causes the hazard to result in an accident.
- Incident outcome: The physical manifestation of an accident.

Statistics-1

OSHA Occupational Safety & Health Administration

incidence rate per 100 worker years = 200,000 hours exposure
100 years x 2000 hours/year

FAR Fatal Accident Rate

fatalities per 1000 employees and entire life = 10^8 hours exposure
50 years x 2000 hours/year x 1000 employees

FR Fatality Rate

per person per year (exposure poorly defined)

For all of these indicators, smaller is better!

Statistics-2

	OSHA	FAR	Fatality Rate
Chemical Industry	0.35	1.2	
Steel Industry	1.28	8	
Coal Mining	0.26	7.3	
Agriculture	0.89	3.7	
Staying at Home		3	
Travelling by Car		57	17×10^{-5}
Rock Climbing		4000	4×10^{-5}
20 Cigarettes / day			500×10^{-5}
Struck by Meteorite			6×10^{-11}
Struck by Lightning			1×10^{-7}
Fire			150×10^{-7}
Run over by Car			600×10^{-7}

Statistics-3

1999 US Accident Fatalities:

Motor Vehicle:	41,200 – 113 per day
Work:	5,100 – 14 per day
Home:	28,400 - 78 per day
Public:	20,000 – 55 per day
Total Deaths:	92,200 – 253 per day

Statistics-4

1998 Work Related Fatalities:

Transportation:	**2,630**
Homicide/suicide:	**960**
Contact with objects:	**941**
Falls:	**702**
Exposure to harmful substance:	**572**
Fires / explosions:	**205**
TOTAL:	**6,010**

Statistics - 5

2004 Accident Statistics:

	Deaths	Rate/100,000 workers
Logging:	**85**	**92.4**
Aircraft pilots:	**109**	**92.4**
Fishing:	**38**	**86.4**
Structural steel:	**31**	**47.0**
Farmers:	**307**	**37.5**
Roofers:	**94**	**34.9**
Truck + Other Drivers:	**905**	**27.6**
TOTAL FATALITIES:	**5,703**	
	5,575 (2003)	

Significant disasters

Flixborough, England, 1974
rupture inadequately supported bypass pipe, 155 ° C, 7.9 atm
vapor cloud 30 ton cyclohexane
explosion & fire inventories (10 days)
28 killed, 36 + 53 injured, much damage

Seveso, Italy, 1976
reactor out of control (run away)
vapor cloud 2 kg dioxin
700 affected, 730 evacuated
25 ² km contaminated (40 factories)

Bhopal, India, 1984
not operating scrubber & flare system
vapor cloud 25 ton toxic MIC
2000 killed, 20.000 injured, no damage

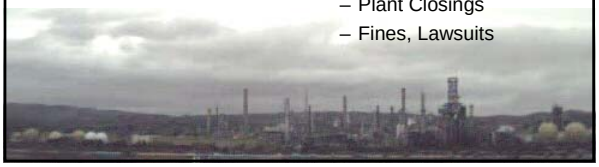
Major Process Industry Accidents

- Fires
- Explosions
- Toxic releases

Major Process Industry Incidents

Incident Outcomes
- Fires
- Explosions
- Toxic Releases

Consequences
- Fatalities
- Injuries
- Environ. Damage
- Property Damage
- Evacuations
- Business Losses
- Plant Closings
- Fines, Lawsuits



Key Questions

- Why **do Accidents occur?**
- How **do Accidents occur?**
- What **must** we do **to keep them from happening?**
- When**?**

Why do Accidents Occur?

- We choose to handle dangerous process materials and energies
  - **To make a living**
  - **To provide society with desirable products**

- As long as we choose to handle them, a potential for loss events exists

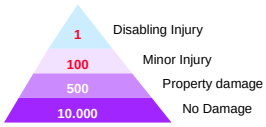
Things can be done to reduce their likelihood and severity to negligible or tolerable levels

Key Questions

- Why **do Accidents occur?**
- How **do Accidents occur?**
- What **must** we do **to keep them from happening?**
- When**?**

Chemical Plant Accidents

	Probability	------- Consequence --------- Hazard Fatalities	Hazard Economic Loss
Fire	High	Low	Intermediate
Explosion	Intermediate	Inter.	High
Toxic Release	Low	High	Low



Accident Pyramid

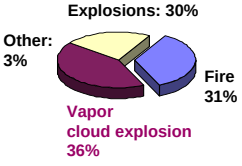


Figure 1-7 Nature of Accidents - 1

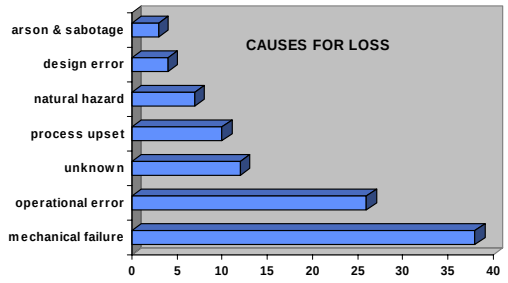
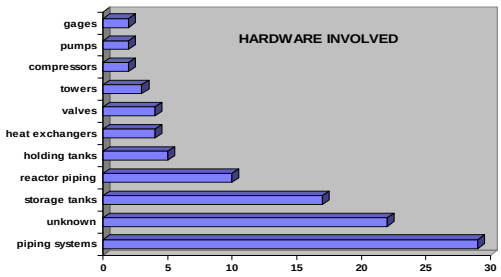


Figure 1-8 Nature of Accidents - 2



Key Questions

- Why **do Accidents occur?**
- How **do Accidents occur?**
- What **must** we do **to keep them from happening?**
- When**?**

What **must** we do **to keep them from happening?**

- **Design of process**
- **Management of process**
- **Operation of Process**
- **Regulations**

You will learn about these things in this course!

Procedure

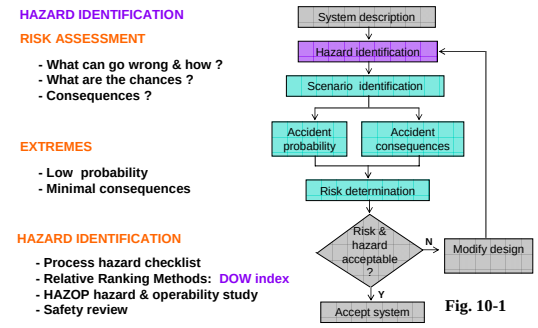


Fig. 10-1

Inherently Safer Design

Inherently safer designs

permanently and inseparably

reduce or eliminate process hazards

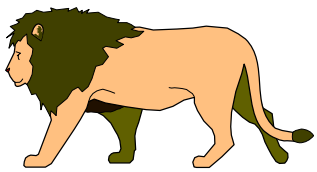
that must be contained and controlled to avoid accidents.

Inherently Safer Design

"The essence of the inherently safer approach to plant design is the avoidance of hazards rather than their control by added-on protective equipment."

T. A. Kletz, *Plant Design for Safety: A User-Friendly Approach* (NY: Hemisphere, 1991)

Crowl's Lion Farm



Crowl's Lion Farm

Hazard: **Lions**

Incident : **Driver loses control of pick-up truck.**

Scenario: **Truck drives thru Lion cage fence.**

Lions walk thru hole in fence.

Lions prowl around community.

Incident Outcome: Local community is alarmed, people are attacked, several dogs disappear.

Crowl's Lion Farm

Inherently Safer Design Approach: **If we are cultivating the lions for meat, why not use lambs instead? This way, the hazard is eliminated, control is simplified, fences are reduced in strength, and emergency response is eliminated.**

Inherently Safer Design Strategies

- MINIMIZE
- SUBSTITUTE
- MODERATE
- SIMPLIFY

Minimize

= Reduce hazardous material/energy quantity

- **Reduces energy**
- **Reduces potential accident severity**

Substitute

= Replace with a less hazardous material

- **Reduces/eliminates available chemical energy**
- **Reduces/eliminates potential accident severity**

Moderate

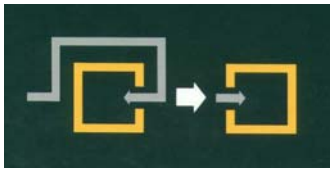
= Use under less hazardous conditions

- **Available energy may be the same, but**
- **Passively reduces potential loss event impacts**
- **For chemical processes, this usually means lower temperatures, pressures, concentrations, etc.**

Simplify

= Reduce unnecessary complexity

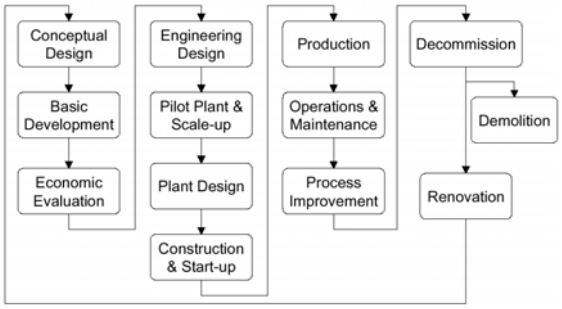
- **Reduces <u>likelihood</u> of an accident**



Key Questions

- Why **do loss events occur?**
- How **do loss events occur?**
- What **must** we do **to keep loss events from happening?**
- When**?**

Typical Process Life Cycle Stages



When?

Process safety must be integrated into the entire life-cycle of a plant, from conceptual design to decommissioning.