CHEMICAL PROCESS SAFETY; CHEN 455

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Class: MWF; 09:00 – 09:50 am; JEB 106

All aspects of Chemical Process Safety and Loss Prevention are addressed in this course. Process safety is concerned primarily with the identification of potential hazards and hazardous conditions associated with the processes and equipment involved in the chemical process industries. It includes methods of predicting the possible severity of the associated hazards and preventing, controlling or mitigating them. The material is thus different from personnel safety or industrial hygiene.

As such, it is necessary to understand the operation of these processes and the equipment, and to apply sound engineering fundamentals to the analysis and prediction of performance, under adverse circumstances. Thus, the course emphasizes quantitative engineering analysis. This is based on the application of mass and energy balances, fluid mechanics of liquid, gas, and two-phase flow, heat transfer and the conservation of energy, mass transfer, reaction kinetics, process control, statistics, and diffusion & dispersion under highly variable conditions,.

Techniques for performing process hazard analysis, risk assessment, and accident investigations are covered, including the review of several significant incidents in the chemical processing industry. The course topics follow those in the text: A. Crowl and Joseph F. Louvar, **'Chemical Process Safety: Fundamentals with Applications'**, Prentice Hall (3rd edition). Homework assignments are taken primarily from the problems in the book with occasional supplements. This material is supplemented and extended by student projects, which culminate in a report and class presentation.

Prerequisites: Fundamentals of mass and energy balances, thermodynamics, fluid mechanics, heat and mass transfer operations.

Course Learning Outcomes:
1. Recognize professional and ethical elements of an outstanding safety program.
2. Evaluate ethical issues that may occur in professional engineering practice.
3. Recognize ethical standards and professional codes of conduct for engineers, e.g., NSPE Code of Ethics for Engineers.
4. Identify government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact of plant design projects.
5. Be able to list examples of how unsound science or unethical behavior had a negative impact on society.
6. Identify and apply OSHA PSM and EPA RMP in the chemical process industries.

7. Describe and apply the principles and approach of inherently safer design to reduce and eliminate hazards and thereby lower the risk of new or currently operating chemical systems.
8. Describe the operation of chemical processes and equipment and apply engineering fundamentals to the analysis and prediction of performance under adverse circumstances.
9. Perform quantitative engineering analysis based upon the applications of mass and energy balances, fluid mechanics of liquid, gas, and two-phase flow, heat transfer and the conservation of energy, mass transfer, reaction kinetics, process control, statistics, and diffusion & dispersion under highly variable conditions,.
10. Perform PHA analyses of targeted chemical process industries and evaluate the safety performance.
11. Identify the potential hazards and hazardous conditions associated with the processes and equipment involved in the chemical process industries.
12. Work effectively in teams and develop problem solving skills. Prepare and present a professional project report.

Course Materials / Lectures: Weekly lectures will be posted on the VNET prior to class and available at: VNET.tamu.edu. Log on with your Net ID.

Teams: Students will be grouped into teams of ~3, and work on the homework assignments and term project as a team. **Each student will submit individual homework assignments.** The purpose of working in teams is not to 'spread the work around' but to capture the synergies of teamwork, benefiting from each member's perspective. Team members will periodically evaluate each other in terms of their contribution to homework and the team project, which will be reflected in grades.

Homework: Homework will generally be assigned Friday of each week. It is due the following Friday at the beginning of class (9:10.00) It is expected that **all team members** will participate in answering **all homework problems**. Homework will be submitted with a cover sheet which includes the date(s) that the team met to work the homework. Late homework will **not** be accepted, except when *prior approval has been obtained.* Homework solutions will be posted on the VNET.

Attendance: Class attendance is important. Class participation is encouraged, material will be covered in class beyond the text, including several videos, and there will be unannounced quizzes.

Project: Each team will prepare a term project (selected from a list of topics provided), and the team will make a formal class presentation and submit a formal report on their project. Topics will be distributed on February 23rd, teams will select their top three topics on February 27th, with the final topic confirmed by the Instructor on March 2nd. An abstract is due on March 13th and the report due on April 17th both electronically and as a hard copy. **Presentations will be on April 20th, 22nd & 24th from 5:30 – 10 pm (see Schedual for rooms).** Grading of the project is based on the abstract, written report, presentation, response to Q&As, teammate evaluations, and attendance and

participation at presentations. The former two are team grades, while all other areas are individual grades.

Exams: There will be three exams during the term. All exams will be open-book in class. Exam I is scheduled on Friday, February 20th; Exam II on Friday, March 27th; with Exam III at the time assigned by University, May 8th, 8:00 – 10:00 am.

Class Policy:

- All quizzes are closed-book, while exams are open book.
- Missing a quiz / exam results in a zero, unless arrangements were made with the instructor in advance.
- **No texting, Blackberry or cell phone use during lectures, exams or quizzes**.

Grading Criteria:		
	Homework	15%
	Project Report/Presentation	15%
	Quizzes	10%
	Exam I	20%
	Exam II	20%
	Exam III	20%

Grades:		
	90-100	A
	80-89	B
	70-79	C
	60-69	D
	<60	F

SUPPORT: Dr. Chad Mashuga (mashuga@tamu.edu)
Thursday: 9 – 11:00 & by appointment

TA – Melissa Santos (mcs723@tamu.edu)
Tuesday's: 1:00 – 3:00 in Rm 317 & by appointment

Distance Learn Support - Joan French (joanfrench@tees.tamus.edu)

NOTICES:

- The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in room B118 of Cain Hall, or call 979-845-1637.

- **"An Aggie does not lie, cheat, or steal or tolerate those who do."** Please see the Honor Council Rules and Procedures on the web at ***http://www.tamu.edu/aggiehonor***.

CHEN 455 Chemical Process Safety (Spring, 2015)

Course Schedule

Date		Topics	Note
Jan	21	Introductions, Syllabus, Why study process safety?	Piper Alpha video (29 min)
	23	Chapter 1. Introduction	HW1
	26	Chapter 1. Introduction	
	28	Teamwork	
	30	Chapter 2. Toxicology	HW2
Feb	2	Chapter 2. Toxicology	
	4	Chapter 3. Regulations & Management Systems	
	6	Chapter 3. Industrial Hygiene	HW3, **Quiz 1**
	9	Chapter 3. Industrial Hygiene	Acknowledge team member eval w/hwk
	11	Chapter 4. Source Models - I	BP TX City video (25 min)
	13	Chapter 4. Source Models - I	HW4
	16	Chapter 4. Source Models – II	
	18	Chapter 5. Toxic Release & Dispersion Models	
	20	**Exam I**	In class exam
	23	Chapter 5. Toxic Release & Dispersion Models	Project topics distributed
	25	Chapter 5. Toxic Release & Dispersion Models	
	27	Review exam	HW5, Teams select topics
Mar	2	Chapter 6. Fires & Explosions - I	Instructor confirms topics
	4	Chapter 6. Fires & Explosions - II	Submit team member evaluation w/ hwk
	6	Chapter 6. Fires & Explosions - II	HW6, Static Electricity video (10 min)
	9	Chapter 7. Designs to Prevent Fires & Explosions - I	**Quiz 2**
	11	Chapter 7. Designs to Prevent Fires & Explosions - I	Imperial Sugar video (10 min)
	13	Chapter 7. Designs to Prevent Fires & Explosions – II	HW7, Project abstract due
		Spring Break	
	23	Chapter 8. Chemical Reactivity	T-2 Incident video (10 min)
	25	Chapter 9. Intro to Reliefs	
	27	**Exam II**	In class exam
	30	Chapter 9. Intro to Reliefs	
Apr	1	Chapter 10. Relief Sizing	
	3	No Class	
	6	Review exam	
	8	Chapter 10. Relief Sizing	Formosa Fire & Explosion video (10 min)
	10	Chapter 11. Hazards Identification – I	HW8, **Quiz 3**
	13	Chapter 11. Hazards Identification - I	
	15	Chapter 11. Hazards Identification - II	
	17	Chapter 11. Hazards Identification – II	HW9, Project reports due
	20	**Project Reports 5:30 – 10:00**	Rm 106 JEB
	22	**Project Reports 5:30 – 10:00**	Rm 104 JEB
	24	**Project Reports 5:30 – 10:00**	Rm 106 JEB
	27	Chapter 12. Risk Assessment	
	29	Chapter 12. Risk Assessment	
May	1	Chapter 12. Risk Assessment; chlorine example	HW10, Emergency Preparedness video (20 min)
	4	Chapter 13. Incident Investigation	
	8	**Exam III**; 8 – 10 am	

Lecture Outline

		Hours
I.	Introduction - Process Safety Management Process vs. Personnel Safety & Metrics Safety Culture Hazard Identification, Assessment & Control Inherently Safer Design Ethics	3
II.	Teamwork	1
III.	Toxic Materials - Introduction Dose and Response Curves Threshold Limit Values and Permissible Exposure Levels	2
IV.	Introduction to Hygiene MSDS's PSM, RMP and Management Systems Monitoring Volatile Toxicants, etc. Liquid Vaporization Rates - Exposure during vessel filling Ventilation	3
V.	Source Models Applications of Fluid Mechanics to Leakage of Liquid and Gas Through Holes, Pipes, and Fittings Evaporation, Flashing, and Boiling Two Phase Flow	3
VI.	Toxic Release and Dispersion Dispersion Models Pasquill-Gifford Plume and Puff Models	3
VII.	Fires and Explosions Flammability of Liquids and Vapors Minimum Oxygen Concentration, Ignition Flammability Diagrams Explosions - Detonations and Deflagrations Blast Damage	3
VIII.	Fire and Explosion Protection and Prevention Inerting, Purging Static Electricity Explosion Proof Equipment Ventilation, Sprinklers	3
IX.	Chemical Reactivity	1

	Background Understanding	
	Commitment, Awareness & Identification of Reactive Chemical Hazards	
	Characterization of Reactive Hazards Using Calorimetry	
	Controlling Reactive Hazards	
X.	Reliefs	2
	Location, Types	
	Systems - Knockout Drums, Flares, Scrubbers & Condensers	
XI.	Relief Sizing	3
	Spring Operated, Rupture Discs	
	Design for Liquid, Vapor, Two-Phase Flow	
	Venting for Dust and Vapor	
	Thermal Expansion	
XII.	Hazard Identification	2
	Checklists, DOW Fire and Explosion Index	
	HAZOP	
	Safety Reviews	
XIII.	Risk Assessment	3
	Event Trees	
	Fault Trees	
	Risk Matrix	
	Quantitative Risk Assessments (QRA)	
XIV.	Emergency Response & Accident Investigations	2
	Procedures	
	Diagnosis	
	Recommendations	
XV.	Term Project Presentations	5
	Examinations	3
	Total Hours:	42

ABET Credit Classification: Engineering Science - 1 ½ hour, Engineering Design – 1 ½ hours

Relationship of course to program outcomes

Course Outcomes	ChE Program Outcomes
1. Recognize the professional and ethical elements of an outstanding safety program.	**6, 11**
2. Evaluate ethical issues that may occur in professional engineering practice.	**6**
3. Recognize ethical standards and professional codes of conduct for engineers, e.g., NSPE Code of Ethics for Engineers.	**6**
4. Identify government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact of plant design projects.	**8**
5. Be able to list examples of how unsound science or unethical behavior had a negative impact on society.	**10**
6. Understand and apply OSHA PSM and EPA RMP in the chemical process industries.	**11**
7. Understand and apply the principles and approach of inherently safer design to reduce and eliminate hazards and thereby lower the risk of new or currently operating chemical systems	**1, 5, 6, 8, 11**
8. Understand the operation of chemical processes and equipment and apply engineering fundamentals to the analysis and prediction of performance under adverse circumstances.	**1, 11**
9. Perform quantitative engineering analysis based upon the applications of mass and energy balance, fluid mechanics of liquid, gas, and two-phase flows, heat transfer and the conservation of energy, mass transfer, diffusion and dispersion under highly variable conditions, reaction kinetics, process control, and statistics	**1, 5**
10. Perform PHA analysis of targeted chemical process industries and evaluate the safety performance	**4, 5, 7**
11. Identify the potential hazards and hazardous conditions associated with the processes and equipment involved in the chemical process industries	**9, 10, 11**
12. Work effectively in teams and develop problem solving skills. Prepare and present a professional project report.	**4, 5, 7**

SYLLABUS PREPARED BY: Dr. Chad Mashuga (01/2015)