COURSE INFORMATION

CHEMICAL PROCESS SAFETY CHEN 455/655

Instructor: Dr. M. Sam Mannan, JEB 246
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College Station, TX 77843-3122

This course is concerned with all aspects of Chemical Process Safety and Loss Prevention.

Process Safety differs from Personnel Safety (or Industrial Hygiene), in that it is concerned primarily with the identification of potential hazards and hazardous conditions associated with the processes and equipment involved in the Chemical Process Industries, and methods of predicting the possible severity of these hazards and presenting, controlling or mitigating them.

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, 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.

In addition to applications of engineering principles, concepts of management and individual responsibility are stressed, as well as teamwork and the appreciation for orders of magnitude estimation and relative significance.

The course topics follow those in the text by Crowl and Louvar, and homework assignments are taken mostly from the problems in the book (with occasional supplements). This material is supplemented and extended by student term projects, which culminate in a report and class presentation.

THE STUDENTS ARE GROUPED INTO TEAMS OF 3 OR 4, AND WORK ON THE HOMEWORK ASSIGNMENTS AND TERM PROJECT AS A TEAM EFFORT. STUDENTS SUBMIT THEIR HOMEWORKS IN A GROUP. TERM PAPERS SHOULD ALSO BE SUBMITTED AS A GROUP. IT IS STRESSED THAT THE PURPOSE OF WORKING IN TEAMS IS NOT TO “SPREAD THE WORK AROUND”, BUT TO ENABLE EACH TEAM MEMBER TO LEARN AND BENEFIT FROM THE KNOWLEDGE AND PERSPECTIVE OF THE OTHERS.
Course Prerequisite: Senior (455) or graduate student (655) in any engineering major.

Skill Prerequisites:
Knowledge of fundamental concepts of engineering
  ● Engineering application experiences at the senior level.
Knowledge of fundamental concepts of science and mathematics
  ● Basic skills in algebra, differential calculus, integral calculus, and first order differential equations.

Course Learning Outcomes. By the end of the course, students will be able to:
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 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.
10. Perform PHA analysis 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.

Computer Usage: Many of the homework assignments involve repetitive calculations (e.g. dispersion isopleths, emptying time for leaking vessels, explosion overpressure profiles, etc.), which are ideally suited for spreadsheet calculations. Over ½ of the
homework assignments and take-home exams involve computer solutions (mostly spreadsheet applications).

**Process Safety:** The course is 100% concerned with chemical process safety and loss prevention.

**Communication Skills:** Students are organized into teams of three or four, and team members work/study together. Each team also has a term project (selected from a list of topics provided), and the team makes a formal class presentation and submits a formal report on their project. Team members evaluate each other in terms of their contribution to the team effort.

Engineering sciences: 1 ½ credits or 50%
Engineering design: 1 ½ credits or 50%
# Process Safety Engineering

**Instructor:** Dr. M. Sam Mannan

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### I. Introduction - Process Safety Management
- **Failure**
- **Management Responsibility, Policy**
- **Hazard Identification**
- **Hazard Assessment**
- **Hazard Control**
- **Introduction to Process Safety Engineering, Loss Prevention**
- **Application of Fundamental Engineering Principles**

**Hours:** 2

### II. Toxic Materials - Introduction
- **Dose and Response Curves**
- **Threshold Limit Values and Permissible Exposure Levels**
- **Application of Engineering Principles - Problems**

**Hours:** 1

### III. Introduction to Hygiene
- **MSDS's**
- **Monitoring Volatile Toxicants, etc.**
- **Liquid Vaporization Rates - Exposure during vessel filling**
- **Ventilation**
- **Applications - Problems**

**Hours:** 2

### IV. Source Models
- **Applications of Fluid Mechanics to Leakage of Liquid and Gas Through Holes, Pipes, and Fittings**
- **Evaporation, Flashing, and Boiling**
- **Two Phase Flow**
- **Applications - Problems**

**Hours:** 5

### V. Toxic Release and Dispersion
- **Dispersion Models**
- **Pasquill-Gifford Plume and Puff Models**
- **Computer Applications**

**Hours:** 5

### VI. Fires and Explosions
- **Flammability of liquids and vapors**

**Hours:** 2
Minimum Oxygen Concentration, Ignition
Explosions - Detonations and Deflagrations
Blast Damage
Applications - Problems

VII. Fire and Explosion Protection and Prevention 3
    Inerting, Purging
    Static Electricity
    Explosion Proof Equipment
    Ventilation, Sprinklers
    Applications - Problems

VIII. Reliefs 1
    Location, Types, Systems
    Knockout Drums
    Flares
    Scrubbers, Condensers
    Applications - Problems

IX. Relief Sizing 5
    Spring Operated, Rupture Discs
    Design for Liquid, Vapor, Two-Phase Flow
    Venting for Dust and Vapor
    Thermal Expansion
    Applications - Problems

X. Hazard Identification 2
    Checklists, DOW Fire and Explosion Index
    HAZOP
    Safety Reviews
    Application - Problems

XI. Risk Assessment 3
    Probability Theory
    Interactions between units
    Event Trees
    Fault Trees

XII. Accident Investigations 1
    Procedures
    Diagnosis
    Recommendations

XIII. Term Project Presentations 8

Examinations 2
Total Hours: 42

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

Grading Criteria:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
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<tr>
<td>Project Report/Presentation</td>
<td>30%</td>
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<td>Quizzes</td>
<td>5%</td>
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<td>Hourly Exams</td>
<td>50%</td>
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TEAM GUIDELINES

Homework assignments and term projects will be done in groups or teams. There are two primary objectives of working in teams:

1. It gives you practice and experience in working with others, since this is the most common mode of operation in the "real world";
2. It gives you a chance to learn from each other, to expand your perspectives, and to pool your knowledge in order to maximize the quality of your work.

The greater the interaction among your team members, the better these objectives will be met.

NOTE: The objective is not just to divide up the work, so that each member has less to do (this would be self-defeating). STUDENTS SUBMIT THEIR HOMEWORKS AS WELL AS THE TERM PAPERS AS A GROUP.

Each team should have a team leader. The team leader position may be the same person throughout the semester, or may rotate, at the discretion of the team. You should decide at your first team meeting who will be the leader, and for how long.

THE TEAM LEADER - is responsible for insuring that everything gets done. This does not mean that he/she does it all, but the leader must coordinate the efforts of the team, and insure that everyone contributes. This usually includes:

Scheduling Team Meetings - The team should meet together at least twice each week to discuss the assignments and compare and check work. Additional communication can be by e-mail or phone.

Assigning Specific Tasks to Team Members - This may include doing calculations, explaining principles, checking someone else's calculations, checking format, etc.

Setting Deadlines - The leader must set deadlines, and insure that they are met. Your schedule should permit ample time for every member of the team to review and check all the work done by all members on every assignment, and provide time for appropriate feedback and/or corrections to be incorporated before the assignment is due. This means that meeting just before the class when the assignment is due is too late.

TEAM MEMBERS - may be required to do a variety of tasks relative to the assignments. This may vary from setting up and/or solving a problem, performing or checking the calculations, insuring that the Problem Solving Guidelines are followed, looking up references or data, etc. Every member of the team must contribute in some way to every assignment, even if it involves only checking the work that others have done, or checking for proper format and consistency. Every student is expected to understand every problem on every assignment, and you will have to demonstrate this individually on exams. Remember, the primary advantage of the teams is to enable you to learn from one another, not just to "divy up" the work!

Remember, COMMUNICATION is the key to effective teamwork!
Exam 1: Wednesday, September 24, 2008
Exam 2: Monday, October 27, 2008
Exam 3: Friday, November 21, 2008

Term Paper Presentations:

Monday, November 24, 2008, 5-9 pm
Tuesday, November 25, 2008, 5-9 pm
Wednesday, November 26, 2008, 5-9 pm

(Note: All students must attend all term paper presentations)
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