Spring 2020

CHE 312-002: Chemical Process Safety

Richard T. Cimino

1. **ChE 312 - Chemical Process Safety**
2. **Credits and contact hours:** 3-0-3 (3 lecture hr/wk - 0 lab hr/wk - 3 course credits)
3. **Course Coordinator:** Dr. Richard T. Cimino
4. **Course Instructor:** Dr. Richard T. Cimino
5. **Textbook:** Daniel A. Crowl and J. F. Louvar, Chemical Process Safety, Fundamentals with Applications, 4th ed., Prentice Hall, 2019. 656 pages. ISBN-13: 978-0134857770
6. **Specific course information**
    a. **Description:** A study of the technical fundamentals of chemical process safety: includes impact of chemical plant accidents and concepts of societal and individual risk; hazards associated with chemicals and other agents used in chemical plants, including toxic, flammable and reactive hazards: concepts of inherently safer design; control and mitigation of hazards to prevent accidents, including plant procedures and designs; major regulations that impact safety of chemical plants; consequences of chemical plant incidents due to acute and chronic chemical release and exposures; hazard identification procedures; introduction to risk assessment.
    b. **Prerequisites:** none (Junior standing)
    c. **Corequisites:** none
    d. **Required, Elective, or Selective Elective** - Required
7. **Specific goals for the course**
    a. A student should be able to:
        1. Define major components of process safety and Process Safety Management (PSM)
        2. Use online e-learning tools and obtain SACHE certificates while recognizing the need for life-long learning in chemical process safety
        3. Explain and apply OSHA PSM and its 14 elements
        4. Identify the components of PSI and explain how it is obtained and utilized
        5. Describe safety and differentiate 'inherently safe' and 'safe'
        6. Describe risk in terms of frequency and consequences and use risk to define safety levels
        7. Identify and explain most common process hazard analysis (PHA) and risk assessment techniques (LOPA)
        8. Identify most of the basic toxicology terms and concepts that can impact workers in the chemical industry
        9. Differentiate compressible and incompressible fluids and calculate critical pressure and flows for compressible fluids
        10. Describe the fire triangle and differentiate various types of fires
        11. Describe the explosion pentagon and differentiate various types of explosions
        12. Describe overpressure and calculate safe distance from overpressure development
    b. This course explicitly addresses the following ABET student outcomes: 1, 2, 4, 7
8. **Topics**
    1. Course overview/Process Safety Overview; PSM/RBPS/OSHA PSM Acronyms
    2. Toxicology/Industrial Hygiene/Regulatory Concerns
    3. Source Models/Dispersion Modeling/ Facility Siting PSI/PS Laboratory
    4. Hazard and Risk Analysis
    5. HIRA/Chemical Reactivity Hazards
    6. Fires and Explosions

7. Mitigation/Prevention of Fires and Explosions
8. Relief System Concepts
9. Combustible Dusts
10. Risk Assessment Concepts
11. Safe Work Practices

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Instructor: Dr. Richard T. Cimino, Senior Lecturer
Office: 387 Tiernan Hall, Phone: 973-596-5729, E-mail: cimino@njit.edu
Class: Tuesday, Thursday, 8:30-9:50 AM; Room: CKB 217
Office Hours: By arrangement only - please sign up online at https://drcimino.youcanbook.me

Course Description and Requirements

A study of the technical fundamentals of chemical process safety: includes impact of chemical plant accidents and concepts of societal and individual risk; hazards associated with chemicals and other agents used in chemical plants, including toxic, flammable and reactive hazards: concepts of inherently safer design; control and mitigation of hazards to prevent accidents, including plant procedures and designs; major regulations that impact safety of chemical plants; consequences of chemical plant incidents due to acute and chronic chemical release and exposures; hazard identification procedures; introduction to risk assessment.

Prerequisites: none (Junior standing)
Corequisites: none (Junior standing)

Course Objectives

Taking this course, a motivated student will learn to:

- Define major components of process safety and Process Safety Management (PSM)
- Use online e-learning tools and obtain SACHE certificates while recognizing the need for life-long learning in chemical process safety
- Explain and apply OSHA PSM and its 14 elements
- Identify the components of PSI and explain how it is obtained and utilized
- Describe safety and differentiate 'inherently safe' and 'safe'
- Describe risk in terms of frequency and consequences and use risk to define safety levels
- Identify and explain most common process hazard analysis (PHA) and risk assessment techniques (LOPA)
- Identify most of the basic toxicology terms and concepts that can impact workers in the chemical industry
- Differentiate compressible and incompressible fluids and calculate critical pressure and flows for compressible fluids
- Describe the fire triangle and differentiate various types of fires
- Describe the explosion pentagon and differentiate various types of explosions
- Describe overpressure and calculate safe distance from overpressure development

Learning Materials

Textbook Required: Daniel A. Crowl and J. F. Louvar, Chemical Process Safety, Fundamentals with Applications, 4th ed., Prentice Hall, 2019. 656 pages. ISBN-13: 978-0134857770
The textbook is the main source for preparing for classes and reading the textbook **before** each class is necessary. Additional materials will be posted on Canvas.

Online Learning Materials: Students will complete online learning courses developed for the Safety And Chemical Engineering Education (SAChE) program by the AICHE. The program is described and Level 1 courses accessed at https://www.aiche.org/ccps/community/technological-communities/safety-and-chemical-engineering-education-sache/certificate-program/Level-One-Basic-Curriculum

Chemical Safety Board Videos: Videos to view will be assigned during the course. These videos are accessed at www.csb.gov. Click on the 'video room' tab near the top of the page.

Calculator: A high-end calculator (TI-83, TI-84 or TI-84SE) is required for solving numerical problems.

Computer: Students will be expected to bring their personal laptops or other approved electronic devices to every class meeting.

Course Outline

	Date	**Topic** (preliminary, subject to minor changes)
1.	Jan. 21, 23	Ch. 1 : Intro to Process Safety
2.	Jan. 28, 30	Ch. 8 : Chemical Reactivity
3.	Feb. 4, 6	Ch. 2-3 : Toxicology & Industrial Hygiene
4.	Feb. 11, 13	Ch. 4 : Source Models
5.	Feb. 18, 20	Ch. 5 : Dispersion
6.	Feb. 25, 27	Ch. 6 : Fires and Explosions 1, Exam 1
7.	Mar. 3, 5	Ch. 6-7 : Fires and Explosions 2
8.	Mar. 15-22	Spring Break - No Classes
9.	Mar 24, 26	Ch. 11 : Hazard and Risk Analysis (HIRA) 1
10.	Mar. 31, Apr. 2	Ch. 12 : HIRA 2, Exam 2
11.	Apr. 7, 9	Ch. 9 : Relief Systems
12.	Apr. 14, 16	Ch. 10 : Relief Systems Design
13.	Apr. 21, 23	Ch. 13 : Safe Work Practices
14.	Apr. 28, 30	Case Study Week
15.	May 5	Case Study Presentations

Assessment and Grading

Homework: Homework assignments will be posted weekly on Canvas. Homework assignments are due one week after they are assigned, and must be submitted electronically on Canvas. No late homework will be accepted. Students must submit homework individually.

SAChE Certificates: These will be due at fixed points throughout the semester. Students will upload completed SAChE certificates to Canvas. Each completed certificate carries the same weight (100% for each completion). Failure to upload your certificates by the specified deadlines will result in zeros for those certificates.

Team Assignments: Other assignments will require you to work in teams of up to 4 students. The instructor will designate the teams.

Peer Evaluation: You will use the Comprehensive Assessment of Team Effectiveness (CATME, `www.catme.org`) to evaluate the teaming behaviors of yourself and your teammates. These evaluations will be incorporated into the assignment of final grades.

Upon evaluation, each student is assigned a multiplier related to how you and your teammates rated your performance. Your multiplier ranges from 0 to 1.05 and is related to the team's average evaluation score. If your multiplier $= 1 \Rightarrow$, your rating is the same as the team average; $< 1 \Rightarrow$ your rating is less than the team average; $> 1 \Rightarrow$ your rating is greater than the team average. Your final team score is then weighted by this multiplier:

e.g. 90% total Team score $\times$ (1.05) = 94.5%

Conflict Resolution: Consult with your instructor immediately if a conflict arises that cannot be worked through by the team.

Firing: If a team member refuses to cooperate on an assignment, their name should not be included on the final deliverable. If the non-cooperation continues, the team should meet with the instructor so that the problem can be resolved, if possible. If no resolution is achieved the cooperating team members may notify the uncooperative team member in writing (by email, cc the instructor) that they are in danger of being fired. If there is no subsequent improvement on the next assignment, the team should notify the uncooperative team member in writing (by email, cc the instructor) that they are no longer with the team.

Quitting: Students who are consistently doing all the work for their team may issue a warning (by email, cc the instructor) that they will quit unless they start getting cooperation and a second memo (by email, cc the instructor) quitting the team if things do not improve. Students who are fired or quit must meet with the instructor immediately, or they will get zeros for the remaining team assignments. Students who quit will be allowed to join another team (cannot exceed 5 members) or to work alone, by their own choice. If a student decides to work alone, they may not later ask to join a team. Students who are fired may work together (if there is more than one at any time). Otherwise, they must work alone.

Quizzes: Regular quizzes will be given based on the homework and reading material, including both concepts and problems. The quizzes will be announced in advance. No make-up quizzes will be allowed. All quizzes will be closed book with no material allowed. The quizzes will often take place at the beginning of the class, so being on time is strongly encouraged.

Exams: There will be two midterm exams (80 min long) and one final exam (2.5 hours long). All exams will be closed book, however a handwritten sheet (double-sided, letter size) with materials

used to prepare for exams will be allowed for the midterm exams. Two sheets will be allowed for the final exam. Shared or copied preparation sheets, as well as use of any electronic materials will be considered as a violation of academic integrity.

Grading: Your final course grade will be calculated by weighted average, using the following weights:

Homework (individual)	10%
Team Assignments	5%
SACHE Certificates	10%
Quizzes	10%
Midterm #1	20%
Midterm #2	20%
Final Exam	25%
	100%

Final course grades will be assigned according to the following rubric:

$90.0\% \leq \text{A} \leq 100.0\%$
$85.0\% \leq \text{B+} \leq 89.9\%$
$80.0\% \leq \text{B} \leq 84.9\%$
$75.0\% \leq \text{C+} \leq 79.9\%$
$70.0\% \leq \text{C} \leq 74.9\%$
$60.0\% \leq \text{D} \leq 69.9\%$
$0\% \leq \text{F} \leq 59.9\%$

Important Dates

- Midterm exam #1: February 27, 2020
- Midterm exam #2: April 2, 2020
- Final exam: between May 8 and 14, 2020
- Withdraw Deadline: April 6, 2020

Policies

NJIT Honor Code: The NJIT Honor Code will be upheld and any violations will be brought to the immediate attention of the Dean of Students.
Special Needs: If you need accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services, Fenster Hall Room 260 to discuss your specific needs. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.
Lectures

- Attendance is strongly recommended. Missing a class will have consequences for preparation for group work, quizzes and exams.
- Classes start at 8:30, and students must be in class by that time. Being late to class may have consequences for the grade, since many of the classes will start with quizzes.

- Electronic devices other than calculators (laptops, tablets, cell-phones etc.) are not permitted during the class except when specifically designated by the instructor. No audio or video recording is allowed.
- Cellphones should be silenced during both lectures and exams and are not allowed under any circumstances during any tests.
- No distracting eating any time during the classes.

Course materials, office hours and correspondence

- The course Canvas page is the main platform for delivering information about the course. All relevant course materials and assignments will be posted on Canvas, so each student should check it regularly.
- Students must upload a professional-looking head shot for their Canvas profile.
- Students are strongly encouraged to attend Office Hours. Long questions which require derivations will be discussed only during the Office Hours and will not be answered by email. Questions regarding grades can be discussed only during the Office Hours.
- E-mail and Canvas correspondence is intended only for quick questions. Questions which require a detailed discussion should be discussed in person during the Office Hours.
- All correspondence should be conducted in a professional style, using formal English.
- To help ensure a quick response to your emails, please add "ChE312" in the subject of your emails.
- The instructor reserves the right not to respond to emails if the email does not have a greeting or a signature.

Exams, Quizzes, Homeworks and Grades

- A letter grade is based on the final score, calculated using an Excel spreadsheet in accordance with the Tables given in this syllabus. The assigned letter grade is final and cannot be negotiated.
- A student can dispute the exam scores within a week after the announcement of the score. Exam scores can be disputed during the official Office Hours, not during class time or via email.
- The graded exams must be returned within a week to be saved for the department course assessment initiative. If a student does not return the exam, the grade for this exam is zeroed.
- Students will get zero for not coming to quizzes, exams, or any other course activity. If students miss an exam due to extreme circumstances (such as a medical problem), they need to bring proof of the circumstance to the Dean of Student's office. Only in the case of official approval from the Dean of Student's office, may a make-up be given at the discretion of the instructor.
- A student must show as many details when solving a problem during an exam or a quiz. Not showing the work will cause lost points even if the final answer is correct.
- Partial credit may be awarded for solving problems, and will be assigned according to a rubric provided by your instructor.
- No partial credit will be given if there is not enough details to follow.
- The final answer should be always evaluated with respect to its reasonability. No partial credit will be given if the final answer is wrong and unreasonable, and it is not stated.
- If a student misses a quiz due to a legitimate reason (absence approved by the Dean of Students), this quiz is excluded from the calculation, and the weights of the quizzes are scaled proportionally.

- Student handwriting must be legible in order to receive points.
- A student coming to dispute a grade has to bring completed homework/quiz/exam sheets. No discussion of grades will be held without these documents.

Homework Format

- Homework involving calculations must be done on Engineering paper.
- Homework involving written responses must be typed.
- All homework submissions must be submitted online as a single PDF document, and must be submitted through Canvas. I will not accept emailed homework.
- Headers - The top of each sheet of a homework assignment must contain the following printed information from left to right:

Name	Course & Section No.	Date Due	Page number/total pages

- Writing Mechanics - All homework should be carefully written using proper English.
- Calculations - All homework calculations should be consistent with the following.
  - Include complete calculations for every calculation presented to demonstrate how results were obtained.
  - Include all units for each term in each equation. The units must balance.
  - Use the appropriate number of significant figures (often two or three) for all results (but use at least two extra significant figures in calculations).
  - Clearly indicate the final solution by boxing it in with a rectangle.
- Problem Order - Problems should clearly labeled, and presented in the order assigned (one, two, three, etc.).
- Problem Essentials - Problem solutions should include the following items in order.
  - Homework problem number listed at the beginning of the problem.
  - Brief problem statement. Provide bullet points of key aspects of the problem if it is longer than a few sentences.
  - The required information - the information or solution that we are looking for.
  - A straight-edge or carefully drawn diagram(s) that clearly illustrates the problem. Optional, but often needed.
  - The boxed solution of the problem including all required steps and calculations.