CHEN 4838: Process Safety Engineering
Syllabus ~ Spring 2025

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Meeting: T/Th 2:30-3:45 in BIOT B115

Office Hours Tues/Thurs after class
Wed 11-12 in D1B20

Text *Chemical Process Safety: Fundamentals with Applications (4th Ed),* Crowl, D.A and Louvar, J.F., Pearson Education, 2019.

AIChE Membership

In order to watch AIChE videos for free you must register (for free) with AIChE as a student using your full name student email at https://www.aiche.org/students/membership.

Problems taking the classes for free? If you signed up as an AIChE student member but the website is still requiring you to pay for a class you may have to wait another day or more for AIChE to process your membership, even if AIChE sent you an emailing saying that the student membership was accepted. Please do the following:

- Wait a couple more days and keep trying/refreshing each day
- After a couple of days contact AIChE by one of the following methods:
  - Email CustomerService@aiche.org
  - Fill out a form with your issue at https://www.aiche.org/about/contact-us
  - Call 800.242.4363

Also note that if you made an AIChE account over a year ago you may need to renew your membership.

Other Materials: Chemical Reactivity Worksheet (please download)

A Chemical Reactivity Worksheet (CRW) giving reactivity of thousands of common hazardous chemicals, compatibility of absorbents, and suitability of materials of construction in chemical processes has been developed by collaboration of the Center for Chemical Process Safety, the Environmental Protection Agency, NOAA's Office of Response and Restoration, The Materials Technology Institute, Dow Chemical Company, Dupont, and Phillips. It is available for free download at https://www.aiche.org/ccps/resources/chemical-reactivity-worksheet.

Course Content

All class materials will be placed on Canvas for students to download.

Prerequisites

CHEN 3200 Fluids and CHEN 3010 Applied Data Analysis.

Course Catalog Description

Delves into the technical fundamentals of chemical process safety and loss prevention including toxicology, industrial hygiene, source and dispersion models, fires and explosions, chemical reactivity and relief systems. Presents techniques for process hazard identification, risk assessment and risk reduction through process design, hazard avoidance and incident investigation.

Course Objective

Teach engineers how to become process safety champions in their professional roles.

Course Learning Outcomes (CLOs)

By the end of this course, a student should be able to:

1. Promote a safety culture, evaluate risks, identify process safety regulatory requirements and standards, and apply inherently safer chemical process systems designs.
2. Understand effects of toxicants, TLV and PEL.
3. Evaluate and prevent potential hazardous exposures using tools such as an industrial hygiene study, SDSs, BSLs and the NFPA diamond.
4. Use source models to predict leakage rates.
5. Predict dispersion and expansion rate within simple geometries.
6. Characterize the flammability of gases, liquids and dusts and use the fire diagram to prevent flammable mixtures.
7. Mitigate fire and explosion dangers through practices such as inerting and static electricity prevention.
8. Identify reactive hazards using a chemical compatibility matrix and calorimeters.
9. Understand the various relief systems that are used such as spring relief valves and rupture disks.
10. Size a relief valve for a liquid, gas, or mix phase service.
11. Conduct a hazard analysis such as HAZOP and FMEA in the evaluation of a process operation.
12. Quantify which hazards deserve further mitigation via risk assessment methods such as Event Trees, Fault Trees, and LOPA.

Brief List of Topics to be Covered

- Accident process/loss statistics, safety culture and strategies
- Process safety in design (including inherently safer design)
- Regulatory requirements and standards
- Toxicology
- Industrial hygiene
- Source models
- Toxin release and dispersion
- Fires and explosions
- Chemical reactivity
- Relief and safety devices and sizing
- Hazard identification and risk analysis
- Case study critical analysis

ABET Student Outcomes Addressed

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

(3) an ability to communicate effectively with a range of audiences

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Methods of Assessing Student Achievement

Assessments in this course include (1) twelve portfolio sections applying each Course Learning Outcome to the student's chosen case study, (2) two oral presentations, and (3) a class engagement self-evaluation.

This course will utilize mastery-based assessment wherein students demonstrate mastery of the Course Learning Outcomes on three levels:

- **Well-Developed**: Demonstrates understanding of concepts with virtually no errors through strong argumentation and evidence.
- **Developing**: Conceptual or logical errors that could include unclear application of concepts to case study; underdeveloped applications; faulty assumptions; incorrect calculations; unprofessional or grammatically weak writing; unrefined presentation; or citation errors.
- **No Evidence**: No reasonable attempt made.

Every assignment will be assessed using these categories and will include feedback to help students better understand their learning. Once the grade is posted, **students have one week to resubmit their assignment** (including re-presenting to the instructor) if they wish to improve their grade up to Well-Developed.

	Portfolio Sections demonstrating Course Learning Outcomes	Oral Presentations	Class Engagement & Video Certificates & Safety Moments
A	11 Well-Developed & 1 at least Developing	2 Well-Developed	Strong
A-	11 Well-Developed & 1 at least Developing	2 Well-Developed	Weak
B+	10 Well-Developed	2 Well-Developed	Strong
B	10 Well-Developed	2 Well-Developed	Moderate
B-	10 Well-Developed	2 Well-Developed	Weak
C+	10 Well-Developed	1 Well-Developed	Strong
C	10 Well-Developed	1 Well-Developed	Moderate
C-	10 Well-Developed	1 Well-Developed	Weak
D+	8 Well-Developed	1 Well-Developed	Strong
D	8 Well-Developed	1 Well-Developed	Moderate
D-	8 Well-Developed	1 Well-Developed	Weak
F	< 8 Well-Developed	< 1 Well-Developed	---

Portfolios

Students will write 12 individual portfolio sections, each demonstrating one of the Course Learning Outcomes by applying pertinent class material to their chosen case study. Due dates of portfolio sections are given in the Schedule at the end of the syllabus.

In-Class Oral Presentations

These will be two 10-min individual oral presentations. Please submit slide decks to Canvas prior to 1:00pm on the day of your talk so they can be downloaded and ready to present on the instructor's computer.

Class Engagement Self-Evaluation

Based on class attendance, class engagement, AIChE video certificate uploads, and Safety Moment presentations, students will submit an argument for a plus grade, minus grade, or no change within their

grading bracket. This self-evaluation will include an opportunity to describe mitigating factors and other exceptional circumstances that may have impacted a student's grade bracket outcome. The instructor will review this argument and the body of work across the semester. If there are any disagreements, a Zoom meeting will be required to discuss the grade. Failure to submit the reflection will automatically result in the minus grade for the grading bracket being assigned.

Safety Moments

At the start of class spend 1-2 min discussing a safety topic; can optionally send one presentation slide to the instructor before noon the day of the discussion.

Class Participation Expectations

You will get the most out of this class if you are present and engaged. Active learning is a part of the course design and we will use iClicker questions and speaker/instructor "Portfolio" time to stay connected during class. Research repeatedly shows that being prepared for and engaged in class significantly improves your learning; therefore, you will find it helpful to complete any preparatory readings or video viewings ahead of time. Your contributions to class are valuable and there will be many opportunities to communicate with the instructor and your peers to build out the classroom culture and learn from each other. Content from class meetings may not be posted in full on Canvas, so your complete understanding of the material will require your presence in class. If I notice excessive or consecutive absences, I will reach out to you to figure out strategies for your success.

Videos

To augment learning, students are asked to view *prior to class* the videos presented in the course schedule. Videos are provided by both the U.S. Chemical Safety Board (CSB) and the American Institute of Chemical Engineers (AIChE) Safety and Chemical Engineering Education (SAChE) program.

1. **Chemical Safety Board (CSB) Videos:** Go to www.csb.gov and then click on the video room tab near the top right of the page.

2. **AIChE SAChE Videos:**
   https://www.aiche.org/sites/default/files/docs/pages/sache_recommendations_for_che_curriculum_r4_jan2023.pdf
   - Once you have watched the video and passed the exam, you will receive a certificate. **Please upload the certificate to Canvas.**
   - AIChE has many courses in its AIChE Academy but only some courses are free for students (all SAChE videos are free).
   - Students may wish to independently complete the CCPS Process Safety Fundamentals Certificate Program (CCPSf) which entails completing 24 SAChE courses and paying $100; this is NOT a requirement of this course.

AI

You may use generative AI tools in this course as you see fit. If you use gen AI tools on assignments in this class, document your usage with the Chicago Manual of Style or the citation style you decide to use (APA, MLA, etc.). Keep in mind that the goal of gen AI tools is to reproduce content that seems to have been produced by a human, not to produce accurate or reliable content; therefore, if you wish to use AI use it as a draft and then edit to apply to your system accurately. It is your responsibility—not the tool's—to ensure the quality, integrity, and accuracy of work you submit in any college course. In addition, you must be wary of unintentional plagiarism or data fabrication. Please act with integrity for the sake of both your personal character and your academic record.

University Policies

University Policies can be found here.

Honor Code
All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part in adhering to the Honor Code.
All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation
If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or DSinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.
If you have a temporary illness, injury or required medical isolation for which you require adjustment, please contact the course instructor.

Accommodation for Religious Obligations
Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, please contact the course instructor. See the campus policy regarding religious observances for full details.

Preferred Student Names and Pronouns
CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Classroom Behavior
Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email CUreport@colorado.edu. Information about university policies, reporting options, and OIEC support resources including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about their options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7. Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

CHEN 4838 Process Safety Eng Course Schedule – Spring 2025

SUBJECT TO CHANGE

Class	Date	**Topic** (please read before class)	**Assignments** (please watch before class)
#1	Tues 1/14	Ch 1: Introduction	
#2	Thurs 1/16	Dan Crowl (book author)	Watch AIChE's Intro to Process Safety (2.5 hrs)
#3	Tues 1/21		Watch CSB's Inherently Safer: Future of Risk Reduction (11:05)
#4	Thurs 1/23	Matt Lipscomb (biotech) Portfolio	
#5	Tues 1/28	Ch2: Toxicology	Watch AIChE's Toxicological Hazards (3 hrs) Portfolio CLO #1 due by Tues 11:59pm
#6	Thurs 1/30	Ch3: Industrial Hygiene	
#7	Tues 2/4	Kimberly Rosson (PTA Plastics) Ashley Merrill (NREL,pharma,biotech) Portfolio	
#8	Thurs 2/6	Ch4: Source Models	Portfolio CLOs #2 & #3 due by Thurs 11:59pm
#9	Tues 2/11	Portfolio	Watch AIChE's Source Models (3 hrs)
#10	Thurs 2/13	Ch5: Dispersion Models	Portfolio CLO #4 due by Thurs 11:59pm
#11	Tues 2/18	EH&S Tour or Portfolio	
#12	Thurs 2/20	Ch6: Fires and Explosions	Portfolio CLO #5 due by Thurs 11:59pm
#13	Tues 2/25		Watch CSB's Dangerously Close: Explosion in West, TX (12:32) Watch CSB's Combustible Dust: an Insidious Hazard (29:14)
#14	Thurs 2/27	Mark Flannery (Bayer) Portfolio	
#15	Tues 3/4	**Oral presentations**	Portfolio CLO #6 due by Tues 11:59pm
#16	Thurs 3/6	**Oral presentations**	
#17	Tues 3/11	Ch7: Design to Prevent Fires and Explosions	Watch CSB's Ethylene Oxide Explosion at Sterigenics (9:24)
#18	Thurs 3/13	Ch8: Chemical Reactivity	Watch CSB's Reactive Hazards (20:22) Watch CSB's Runaway: Explosion at T2 Laboratories (9:29)
#19	Tues 3/18	Jenny Brown (Corden Pharma) Portfolio	
#20	Thurs 3/20	Ch9: Intro to Reliefs	Portfolio CLOs #7 & #8 due by Thurs 11:59pm
	3/25 3/27	Spring Break	
#21	Tues 4/1	Portfolio	Watch AIChE's Hazards and Risk: Introduction to Pressure Protection (3.5 hrs)
#22	Thurs 4/3	Ch10: Relief Sizing	Watch CSB's Dangers of Propylene Cylinders (8:21) Portfolio CLO #9 due by Thurs 11:59pm
#23	Tues 4/8	Portfolio	
#24	Thurs 4/10	Ch11: Hazards Identification & Evaluation	Watch CSB's Explosion at Formosa Plastics (Illinois) (10:43) Portfolio CLO #10 due by Thurs 11:59pm
#25	Tues 4/15	Kelly Kepler (Medtronic) Portfolio	Watch AIChE's Hazards and Risk: Introduction to Hazard Identification and Risk Analysis (1 hr)
#26	Thurs 4/17	Ch12: Risk Assessment	Portfolio CLO #11 due by Thurs 11:59pm
#27	Tues 4/22		Watch AIChE's Risk Review Using LOPA (Layer of Protection Analysis) (2.5 hrs)
#28	Thurs 4/24	Joe Poshusta (Synthio Chemical) Portfolio	
#29	Tues 4/29	**Oral presentations**	Portfolio CLO #12 due by Tues 11:59pm
#30	Thurs 5/1	**Oral presentations**	Class Engagement Self-Evaluation