

Evidence for Process Safety Thread

ABET 2022

Background Information

In response to societal concerns about major disasters in the chemical process industries, The Chemical Engineering Department has incorporated chemical process safety into freshmen to senior level courses.

The below figure shows the Flow Chart of the Chemical Engineering Program degree requirements showing the safety thread, which is the strategy for ensuring that the hazard related portion of the program criteria is met.

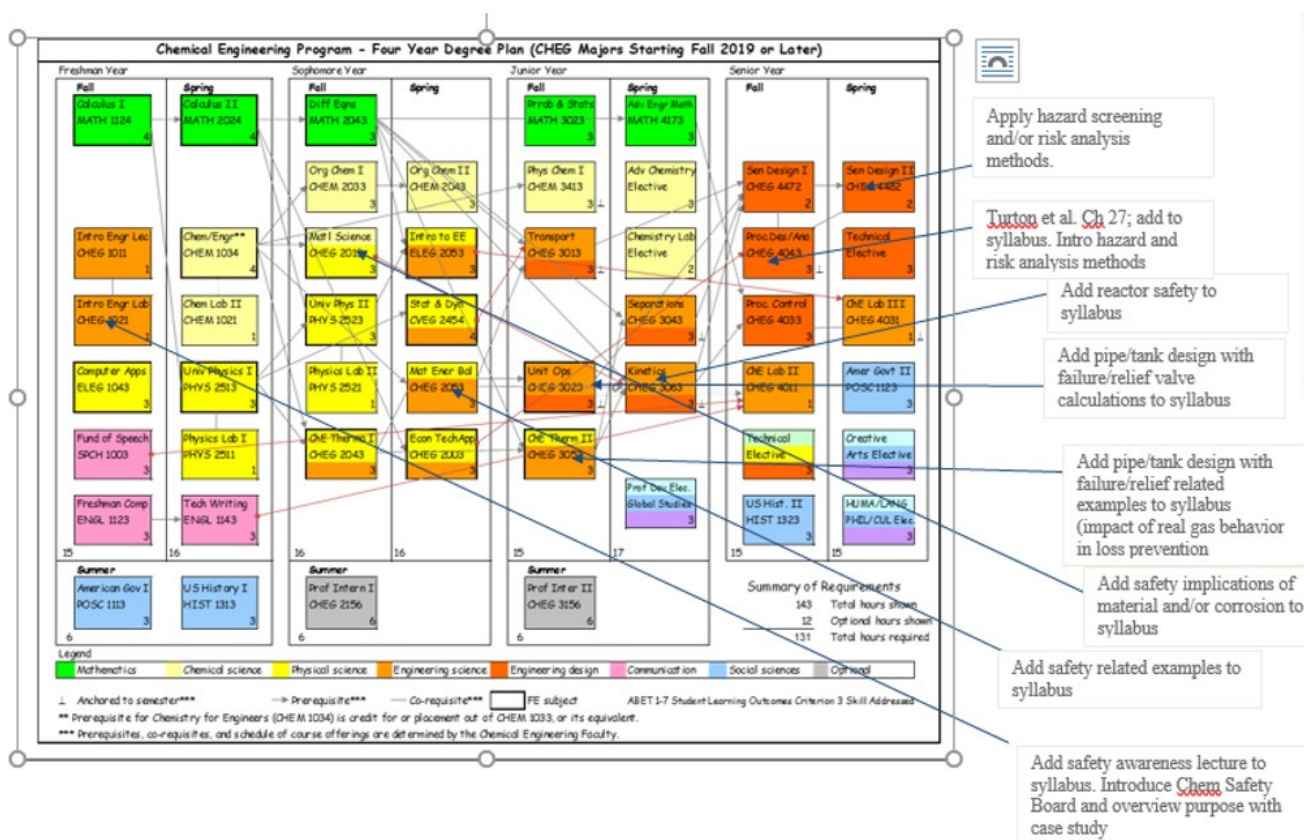


Figure 1 shows an overview of the Elements of Process Safety incorporated in chemical engineering courses.

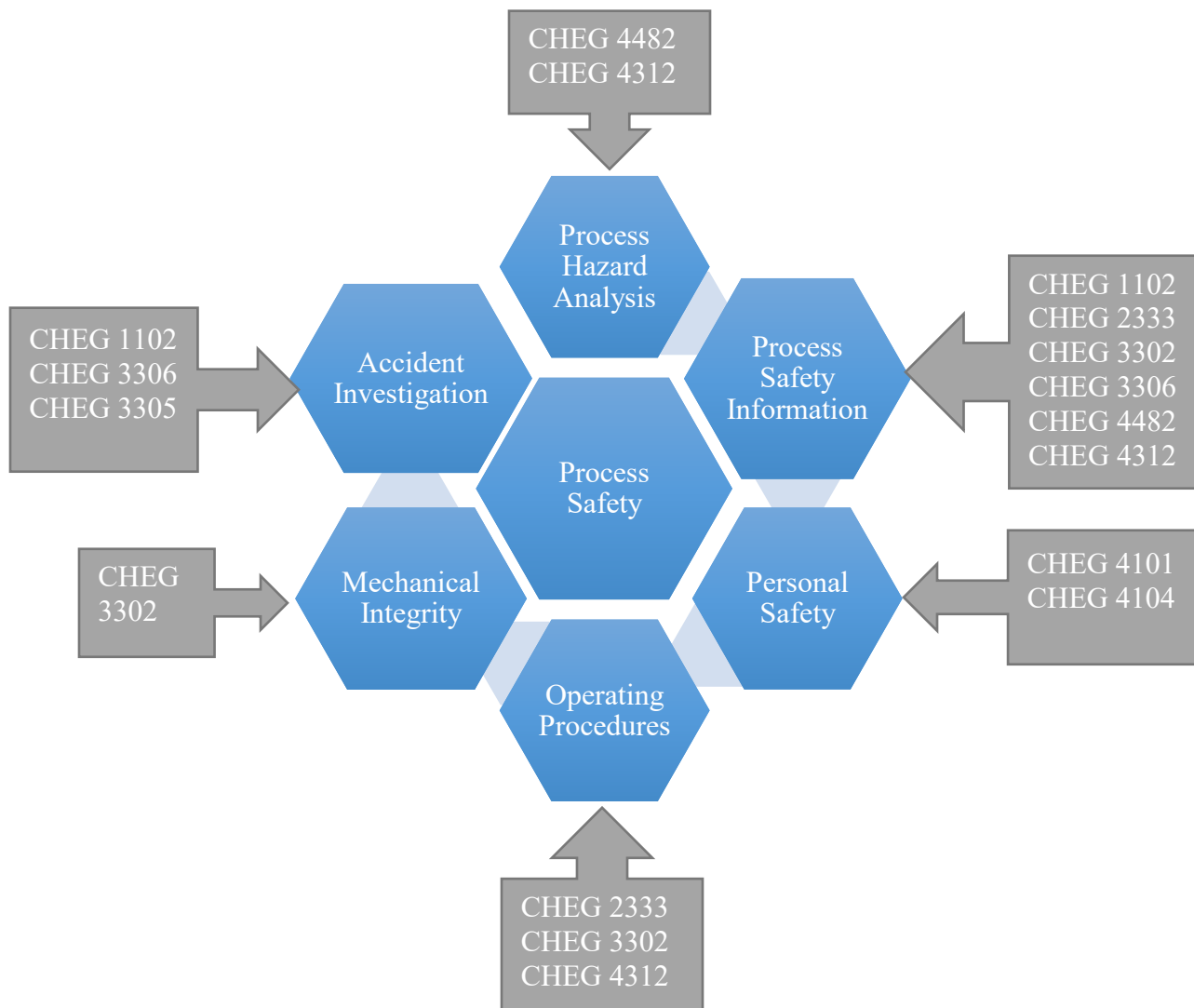


Figure 1. Elements of Process Safety incorporated in CHEG courses

Assessment results with evidence are summarized for the following courses

1. Intro to Chemical Engineering Laboratory 1 CHEG 1102
2. Materials and Energy Balance CHEG 2333
3. Unit Operations CHEG 3302
4. Kinetics and Reactor Design CHEG 3306
5. Equilibrium Separation Processes CHEG 3305
6. Senior Design and Professionalism II CHEG 4248
7. Process Safety Engineering Fundamentals CHEG 4312

Intro to Chemical Engineering Laboratory 1

CHEG 1102

- **Accident Investigation Presentation**
 - **Accident Investigation Quiz**



PRAIRIE VIEW
A&M UNIVERSITY

CHEG 1102: Disasters, Ethics, Plagiarism

Dr. Sheena M. Reeves, Instructor
Spring 2022



SEMESTER CALENDAR

- Week 8: Midterm
- Week 9: SPRING BREAK
- Week 10: Midterm Review; Disasters, Ethics, Cheating
- Week 11: How It's Made Videos (Process Engineering); Visio
 - Disaster Quiz Due
 - How It's Made Quiz Due
- Week 12: Plagiarism and Report Writing; Library Resources
 - Submit Process Videos
 - Visio Assignment Due
- Week 13: No In-Person Class
 - Watch Classmates videos and add to discussions
 - Writing Assignment Due
- Week 14: Water Purification Lab
- Week 15: Lab Report and Final Exam Review
- Week 16: FINAL EXAM

2



What are Disasters?

- Disasters are sudden events that cause significant change.¹
- Disasters can cause²
 - Significant damage and destruction
 - Loss of life
 - Physical damage
 - Environmental damage
- Disasters are the result of **poorly managed risk**.²
 - Based on vulnerability and the hazard

What is Risk?

- A possibility of loss or injury.
- Someone or something that creates or suggests a hazard.¹
- Two types of Engineering Risks⁵
 1. Intolerable risks – are not acceptable under any circumstances.
 - Hazardous exposure to process products affecting workers occupational safety and health.
 - Engineering design must include ways of removing such risks or drastically reducing their severity.
 2. Tolerable risks – are considered acceptable provided they offer some benefit, and the risk has been reduced as much as was reasonably practicable.

Engineering Disaster 1



Boston Molasses Disaster²

A 50 ft tall, 90 ft diameter tank contained approximately 2,300,000 US gal of molasses.



Boston Molasses Disaster²

A 50 ft tall, 90 ft diameter tank contained approximately 2,300,000 US gal of molasses.

Witness heard a loud noise sounding like a machine gun that shook the ground.



Boston Molasses Disaster³

A 50 ft tall, 90 ft diameter tank contained approximately 2,300,000 US gal of molasses.

Witness heard a loud noise sounding like a machine gun that shook the ground.

The tank had ruptured and sent a wave of molasses between 8 – 15 ft high down Commercial Street.



Boston Molasses Disaster³

A 50 ft tall, 90 ft diameter tank contained approximately 2,300,000 US gal of molasses.

Witness heard a loud noise sounding like a machine gun that shook the ground.

The tank had ruptured and sent a wave of molasses between 8 – 15 ft high down Commercial Street.

Trains were derailed, 21 were killed, 150 injured.



Engineering Disaster 2



St. Louis Dam Flooding³

William Mulholland successfully supervised the building of the Los Angeles Aqueduct.



St. Louis Dam Flooding³

William Mulholland successfully supervised the building of the Los Angeles Aqueduct.

His career ended in March 1928 after the St. Francis Dam failed 12 hrs after his safety inspection.



St. Louis Dam Flooding³

William Mulholland successfully supervised the building of the Los Angeles Aqueduct.

His career ended in March 1928 after the St. Francis Dam failed 12 hrs after his safety inspection.

12.4 billion gal of water escaped a crack in the dam sending a 10-story wall of water at 18 mph into the surrounding area.



St. Louis Dam Flooding³

William Mulholland successfully supervised the building of the Los Angeles Aqueduct.

His career ended in March 1928 after the St. Francis Dam failed 12 hrs after his safety inspection.

12.4 billion gal of water escaped a crack in the dam sending a 10-story wall of water at 18 mph into the surrounding area.

Santa Paula was buried in 20 ft mud and debris. Estimated 450 dead.



Engineering Disaster 3



St. Paul Daily Globe, May 3, 1928



Washburn 'A' Mill Explosion⁴

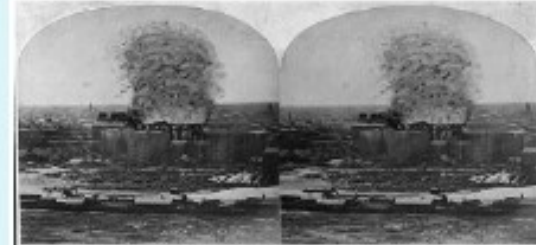
In 1878, it was the largest flour mill in the United States.



Washburn 'A' Mill Explosion⁴

In 1878, it was the largest flour mill in the United States.

The mill exploded when flour dust in the air ignited.



Washburn 'A' Mill Explosion⁴

In 1878, it was the largest flour mill in the United States.

The mill exploded when flour dust in the air ignited.

The explosion killed 18 and destroyed the surrounding area.



Washburn 'A' Mill Explosion⁴

In 1878, it was the largest flour mill in the United States.

The mill exploded when flour dust in the air ignited.

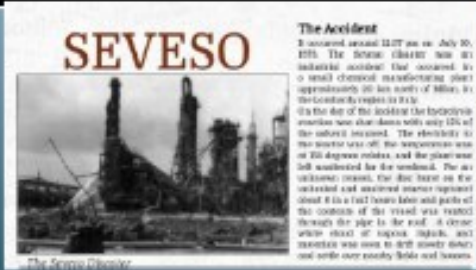
The explosion killed 18 and destroyed the surrounding area.

Led to the reformation of the milling industry and the creation of industry ventilation systems.



Engineering Disaster 4

The Seveso Disaster



The Seveso Disaster

Seveso

Occurred on July 10, 1976
at the company ICMESA
(Industrie Chimiche Meda
Società Azionaria)



Seveso

Occurred on July 10, 1976
at the company ICMESA
(Industrie Chimiche Meda
Società Azionaria)

The chemical-release
accident occurred when a
batch process was
interrupted prior to the
completion of the final step.



Seveso

Occurred on July 10, 1976
at the company ICMESA
(Industrie Chimiche Meda
Società Azionaria)

The chemical-release
accident occurred when a
batch process was
interrupted prior to the
completion of the final step.

Highest known exposure to
2,3,7,8-tetrachlorodibenzo-
p-dioxin (TCDD) in
residential populations.



Seveso

Occurred on July 10, 1976 at the company ICHESA (Industria Chimica Meda Società Anonima)

The chemical-release accident occurred when a batch process was interrupted prior to the completion of the final step.

Highest known exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in residential populations.

No human deaths reported; however, 73,000 farm animals and pets were killed.



Summary

- Negligence is defined as the failure to exercise the appropriate and ethical level of care for a specific circumstance.
- Engineers must consider the risk in every design, product, and process.
- The area of engineering dedicated to this study is called Process Safety.
- Several entities exist to aid in monitoring risk and safety.
 - OSHA, EPA, TCEQ

References

1. Merriam Webster Dictionary
2. Donationsfordisasters.org
3. Listverse.com
4. Mnhs.org
5. (2009) Safety and Risk in Engineering Design. In: Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design. Springer, London

What is Ethics?

- The philosophy of morals or the standard of character set by any nation or race.
- Morals - pertaining to action with reference to right and wrong
- Engineering ethics is the study of moral values, issues, and decisions as they relate to the engineering practice.

WHAT ARE ENGINEERING ETHICS?

Engineering ethics are the rules and standards governing the conduct of engineers in their role as professionals.

ABET REQUIREMENT:

By the time of graduation students will have an understanding of professional and ethical responsibility.

How Engineering affects Society:

- If the bridge has an inadequate support, it will fail.
- If the gas tank is positioned too close to the bumper, it might explode from a small accident.
- If a medical instrument isn't accurate, improper doses of medication can be given.
- If the process for refining gas produces too much toxins, it harms the local community.

Typical Ethical Issues that Engineers Encounter

- | | |
|------------------------|------------------------------------|
| ▪ Safety | ▪ Conflict of interest |
| ▪ Acceptable risk | ▪ Honesty/Dishonesty |
| ▪ Compliance | ▪ Societal impact |
| ▪ Confidentiality | ▪ Fairness |
| ▪ Environmental health | ▪ Accounting for uncertainty, etc. |
| ▪ Data integrity | |

Hot off the Press!

Drexel Professor Unethical Behavior

<https://www.cnn.com/2019/10/08/us/pennsylvania-drexel-professor-strip-club-money/index.html>

COVID-19 Funds

<https://www.news-press.com/story/news/crime/2020/09/02/fort-myers-businessman-casey-crowther-alleged-misused-2-million-covid-funds/5694243002/>

PLAGIARISM & CHEATING

- Many components go into being a **good engineering student**.
- One of the most important, as reflected by the codes of ethics for engineers, is to be **competent** in your field of engineering.
- To be competent, it is **necessary** that one actually knows **what they claim to know**.
- **Proving to others that you know what you are supposed to know** requires certification through a degree.

WHAT STUDENTS SAY

- 70% of American high school seniors admit to cheating on at least one test
- 95% of the students who said they cheated were never caught.
- An average of 75% of college students report cheating sometime during their college career

Cheating in Online Student Assessment: Beyond Plagiarism, Neil C. Rowe: 2004

CHEATING IS WRONG?

- Cheating also undermines the work of fellow students who are honest.
- When you cheat, all the other students who didn't cheat are penalized. They end up getting lower grades. As a consequence of lower grades they lose out on scholarships and recommendations.

CHEATING vs. TEAMWORK

- Working on a team for an assigned project is **not** cheating.
- However, failing to do your assigned task on a team project is a form of cheating. It is called **free-riding**, which is benefiting from the work of others without doing any work of your own.
- **Teamwork** is important in engineering, but free-riding is wrong, since if everyone did it nothing would get done.

COPYING

- One obvious type of cheating that we all recognize is copying someone's work on a homework assignment, exam, or paper.
- Submitting someone's work as your own is a kind of cheating.

SURROGATE

- Surrogate cheating occurs when someone else either does your homework, takes an exam for you, or writes your paper.
- Doing someone's work for them is a kind of cheating.

WHY IS CHEATING WRONG?

- Cheating undermines the credibility of the university and the degrees it awards.
- If too many people cheat at PVAMU, then the degrees awarded by PVAMU won't certify that its students are **competent**. So, by cheating you not only hurt yourself, you also hurt others.

ETHICS – COURAGE & INTEGRITY

- As we will be seeing more and more being ethical requires:
 1. *Courage to do the right thing the situation calls for.*
 2. *The integrity to withstand the pressures that push you in the wrong direction.*

Student Work Above Average

Score for this quiz: 40 out of 40
Submitted Apr 2 at 2:31am
This attempt took 130 minutes.

Question 1

5 / 5 pts

Which of the following scenarios is considered a tolerable risk?

- ☐ Placing a new petroleum plant in a highly populated area.
- ☐ Feeding young children Tide Pods
- ☐ Flying on a full airplane without a mask.
- ☒ Operating a nuclear energy facility on an isolated island.

Correct!

Additional Comments:

Question 2

5 / 5 pts

Consider the molasses tank explosion. What caused the tank to rupture?
Use a complete sentence.

Your Answer:

A few factors led to the molasses tank exploding in Boston during the year 1919. One reason is that the steel tank wasn't assessed correctly by the engineers, and other workers in charge of building, manufacturing, and designing the tank. Also, the steel walls were too thin, therefore, making them not strong enough to withhold the weight of a full tank of molasses. Another issue was that the rivet holes of the tank were too stressed which later led to cracks in the tank. Additionally, the tank was quickly built and rushed to meet the demand for alcohol which could be made from distilling molasses, therefore the tank wasn't built efficiently. Lastly, the tank was never inspected or tested, plus it was not made with enough manganese, which resulted in it obtaining a high transition temperature. This made the tank liable to be extremely brittle when the surrounding temperature reached below 59 degrees Fahrenheit.

Additional Comments:

Question 3

7 / 7 pts

Consider the example of the dam leaking. What do you think is an appropriate punishment for Mr. Mulholland? Explain your answer.

Your Answer:

In my opinion, a proper punishment for Mr. Mulholland would be at least fifteen years in prison, plus I think he should have had to donate money to the families affected by the flood. I also feel like Mr. Mulholland should have given a heartfelt public apology to the community and families affected by the flood.

Additional Comments:

Question 4

7 / 7 pts

Consider the Mill Explosion. How does this case impact your stance on dusting and cleaning?

Your Answer:

The Mill Explosion impacted my stance on dusting and cleaning by allowing me to understand that fine particles, especially dust mixed with flour or flour by themselves are way more dangerous than I thought. This means that I should be careful about what substances I ignite or mix together when dusting or cleaning. The reason is, that dust or small particles, especially those containing flour are very flammable. Flour and dust particles are extremely small which mean that they burn instantly, the small particles have a large surface area plus there is a lot of oxygen between each particle making it easy for dust or flour particle to ignite on fire. When one flour or dust particle is ignited the other particles near it are lit instantaneously. This results in the fire expanding.

Additional Comments:

Question 5

7 / 7 pts

Consider the Seveso Disaster. In your own words and using examples from this case, how does the chemical engineering profession impact society.

Your Answer:

The Seveso disaster impacts society by showing why it's important for chemical plants to not be close to residential areas and communities. The release of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) during the Seveso disaster resulted in 73,000 farm animals dead. This is alarming seeing that these animals were family pets and livestock that probably could have fed thousands of families. Additionally, a large amount of money was put into maintaining and raising the animals, and the animals dying means that thousands of dollars were wasted. Also, babies born in this area were more likely to develop thyroid issues because of this disaster. This disaster affected engineering by causing engineering companies to have a preference to build their chemical plants away from residential areas, and it made them do in-depth inspections of the tolerable and intolerable risks in the case that an outbreak occurred.

Additional Comments:

Question 6

9 / 9 pts

Consider Negligence and your Coursework. How important is attention to detail for undergraduate students? Give an example or two.

Your Answer:

Negligence is when there is a failure to exercise the appropriate amount of ethical care to a specific circumstance. For my coursework, I will have to ensure that I carefully design, produce and think of all the tolerable and intolerable risks when completing it. For an undergraduate student, this is important because even now my mistakes in class, during labs, during projects, or during coursework can affect those around me and potentially teach me what mistakes to avoid now and in my future career. For example, If an engineering student is doing an internship at a company that makes medical instruments and the instrument is inaccurate, an improper dosage of medication will be given to patients; this can lead to further medical issues for the patient, death, and lawsuits against the hospital or company the engineering student works for. Another example of negligence is if an engineering student did a bridge 3D building project, but the bridge is built inadequate it could fall and in real life, it could potentially cause the death of whoever is near or on the bridge at that time.

Additional Comments:

Fudge Points: -

You can manually adjust the score by adding positive or negative points to this box.

Final Score: 40 out of 40

Update Scores

Student Work

Average

Score for this quiz: 33 out of 40
Submitted Mar 29 at 6:13pm
This attempt took 22 minutes.

Question 1

5 / 5 pts

Correct!

Which of the following scenarios is considered a tolerable risk?

- ☒ Operating a nuclear energy facility on an isolated island.
- ☐ Placing a new petroleum plant in a highly populated area.
- ☐ Flying on a full airplane without a mask.
- ☐ Feeding young children Tide Pods

Additional Comments:

Question 2

2 / 5 pts

Consider the molasses tank explosion. What caused the tank to rupture?
Use a complete sentence.

Your Answer:

The tank was not properly built to hold the amount of molasses in it.

Additional Comments:

Question 3

5 / 7 pts

Consider the example of the dam leaking. What do you think is an appropriate punishment for Mr. Mulholland? Explain your answer.

Your Answer:

The appropriate punishment is him going to prison for homicide. His negligence at work caused for hundreds of people to lose their lives even if he didn't intend to.

Additional Comments:

Question 4

5 / 7 pts

Consider the Mill Explosion. How does this case impact your stance on dusting and cleaning?

Your Answer:

This case makes me want to dust and clean more so if I light a candle I don't have to worry about my house exploding.

Additional Comments:

Question 5

7 / 7 pts

Consider the Seveso Disaster. In your own words and using examples from this case, how does the chemical engineering profession impact society.

Your Answer:

The chemical engineering profession can have huge effects not the surrounding society if done wrong. Many people lost food and income sources from the large amount of farm animals that died after the disaster.

Additional Comments:

Question 6

9 / 9 pts

Consider Negligence and your Coursework. How important is attention to detail for undergraduate students? Give an example or two.

Your Answer:

Attention to detail is important since it could mean the difference between getting an A in the class or an F. In math it doesn't matter if you know how to solve the problem if you are making a bunch of careless mistakes.

Additional Comments:

Fudge Points:

You can manually adjust the score by adding positive or negative points to this box.

Final Score: 33 out of 40

Update Scores

Student Work

Below Average

Score for this quiz: 10 out of 40
Submitted Apr 3 at 1:53pm
This attempt took 13 minutes.

Question 1

0 / 5 pts

Which of the following scenarios is considered a tolerable risk?

- ☐ Flying on a full airplane without a mask.
- ☐ Operating a nuclear energy facility on an isolated island.
- ☒ Placing a new petroleum plant in a highly populated area.
- ☐ Feeding young children Tide Pods

Correct Answer

You Answered

Additional Comments:

Question 2

0 / 5 pts

Consider the molasses tank explosion. What caused the tank to rupture?
Use a complete sentence.

Your Answer:

The tank overfilled to the point where it became too much molasses for the tank and it exploded.

Additional Comments:

Question 3

4 / 7 pts

Consider the example of the dam leaking. What do you think is an appropriate punishment for Mr. Mulholland? Explain your answer.

Your Answer:

I think that a good punishment is that he should go back into training and learn what he did wrong and give him another chance and if he messes up again then he should lose his job.

Additional Comments:

Question 4

4 / 7 pts

Consider the Mill Explosion. How does this case impact your stance on dusting and cleaning?

Your Answer:

I think it is very important that things are done according to protocol. If protocol says clean up and take care of things then that's the way it should be.

Additional Comments:

Question 5

0 / 7 pts

Consider the Seveso Disaster. In your own words and using examples from this case, how does the chemical engineering profession impact society.

Your Answer:

The profession is impacted because now employers are going to look at the job differently, they are going to have more detailed background checks and make sure things are done correctly and the right way.

Additional Comments:

Question 6

2 / 9 pts

Consider Negligence and your Coursework. How important is attention to detail for undergraduate students? Give an example or two.

Your Answer:

It is important because we as students need to make sure that we are getting our work done on time. We also need to make sure that we are doing our best on the assignments to finish them and get the best grade possible.

Additional Comments:

Fudge Points:

You can manually adjust the score by adding positive or negative points to this box.

Final Score: 10 out of 40

Update Scores

**Safety Thread in
Materials and Energy Balance
CHEG 2333**

- **Assignment on Process Safety Information**
 - **Operating Procedures**

**CHEMICAL ENGINEERING DEPARTMENT
MATERIAL AND ENERGY BALANCES CHEG 2333
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR SPRING 2022 SEMESTER**

CHEG STUDENT OUTCOME D1: an ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve integral and differential equations analytically or numerically, and (2) apply appropriate conservation laws, chemical and physical principles to solve problems in material and energy balances.

Name: COVER PAGE

Title of Assignment: HOMEWORK 2 Due Date: APRIL 29, 2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply the knowledge of material balances to problems involving safe handling of flammable mixtures <i>This assignment tests students' knowledge and application of material balances to safe handling and use of flammable fuel-air mixtures in processes.</i>		
TOTAL	100	

Material and Energy Balances (Spring 2022): Home Work 2

April 20, 2022

Due: April 29, 2022

Answer all questions. You will be graded based on (1) your ability to apply knowledge of safety in handling flammable compounds, and (2) your ability to apply your knowledge of material balances. Clarity of presentation would ensure that you do not lose all the points for a calculation if you should make a mistake.

1. A mixture of methane and air is capable of being ignited only if the mole percent of methane is between 5 % and 15 %. A mixture containing 9.0 mole % methane in air flowing at a rate of 7.00×10^2 kg/h is to be diluted with pure air to reduce the methane concentration to the lower flammability limit. Calculate the required flow rate of air in mol/h the percent by mass of oxygen in the product gas. Air may be taken to consist of 21 mole % O_2 and 79 mol % N_2 and to have an average molar mass of 29.0 g/mol.
2. The percentage of fuel in a fuel-air mixture below which the mixture cannot be ignited is called the lower flammability limit (LFL), sometimes referred to as lower explosion limit (LEL). There is an upper flammability limit (UFL) also known as the upper explosion limit (UEL). For example, the LFL of propane in air is 2.3 mole % C_3H_8 and the UFL is 9.5 mole %. Thus, if the percentage of propane in a propane-air mixture is greater than 2.3 mole % and less than 9.5 mole %, the gas mixture can ignite if exposed to a flame or spark.

A mixture of propane in air containing 4.03 mole % C_3H_8 (fuel gas) is fed to a combustion furnace. If there is a problem in the furnace, a stream of pure air (dilution air) is added to the flue mixture prior to the furnace inlet to make sure that ignition is not possible.

- (i) Draw and label a flowsheet (block flow diagram) of the fuel gas-dilution air mixing unit, assuming that the gas entering the furnace contains propane at the LFL, and do the degree-of-freedom analysis
- (ii) If propane flows at a rate of 150 mol C_3H_8 /s in the original fuel-air mixture, what is the minimum molar flow rate of the dilution air?
- (iii) How would the actual dilution air feed rate probably compare with the value calculated in (b)? (<, >, =) Explain.

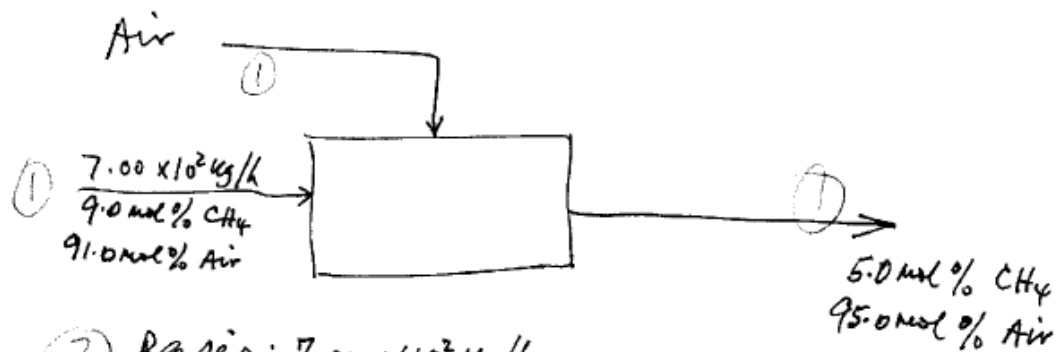
Solution to the assignment Problem

Material and Energy Balances

Homework 2

1 of 5

1.



(2) Basis: $7.00 \times 10^2 \text{ kg/h}$ 9.0 mol % CH_4 in Air

Given: (i) Average molar mass of Air = 29.0 g/mol

(ii) Composition of Air = 21 mol % O_2 and 79 mol % N_2

Calculation of Molar mass of 9.0 mol % CH_4 in Air

Basis: 100 mol of 9.0 mol % CH_4 in Air (1)

$$\text{mol CH}_4 = 9.0$$

$$\text{mol Air} = 91.0$$

$$\text{mass of CH}_4 = 9.0 \text{ mol} \times \frac{16.0 \text{ g}}{\text{mol}} = 144.0 \text{ g} \quad (1)$$

$$\text{mass of Air} = 91.0 \text{ mol} \times \frac{29.0 \text{ g}}{\text{mol}} = 2639.0 \text{ g} \quad (1)$$

$$\text{Total mass of 9.0 mol \% CH}_4 \text{ in Air} = 2783 \text{ g}$$

$$\text{mol of 9.0 mol \% CH}_4 \text{ in Air} = 100 \text{ mol} \quad (2)$$

$$\text{Molar mass of mixture} = \frac{2783 \text{ g}}{100 \text{ mol}} = 27.83 \text{ g/mol}$$

$$\text{Mass Flow rate of 9.0 mol \% CH}_4 \text{ in Air} = 7.00 \times 10^2 \text{ kg/h} = 7.00 \times 10^5 \text{ g/h}$$

$$\text{molar flow rate of 9.0 mol \% CH}_4 \text{ in Air} = 7.00 \times 10^5 \text{ g/h} \times \frac{1}{27.83 \text{ g/mol}} \quad (2)$$

$$= 7.00 \times 10^5 \text{ g/h} \times \frac{\text{mol}}{27.83 \text{ g}}$$

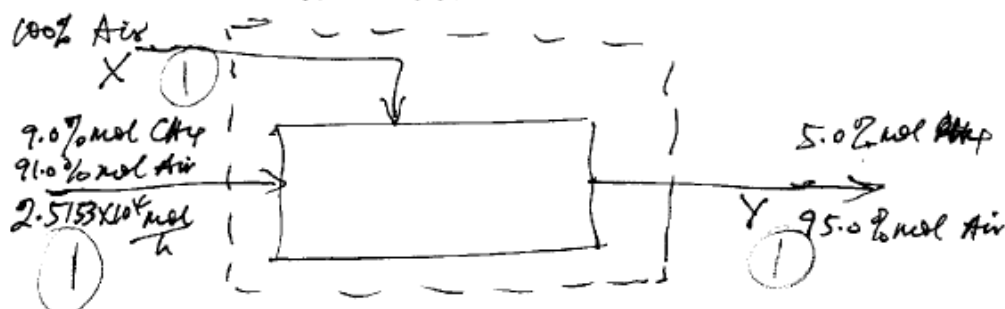
$$= 2.5153 \times 10^4 \text{ mol/h} \quad (2)$$

Material & Energy Balances

Homework 2

2 of 5

1. contd



Overall mass balance

Input + generation - Consumption - output = Accumulation
 Since no reaction takes place during the mixing, there is no net change of moles in the process

$$\therefore \text{Moles } 100\% \text{ Air } (X) + 2.5153 \times 10^4 \frac{\text{mol}}{\text{h}} - Y(5.0\% \text{ mol } \text{CH}_4 \text{ in Air}) = 0$$

$$\therefore X + 2.5153 \times 10^4 - Y = 0 \quad (1)$$

$$X + 2.5153 \times 10^4 = Y \quad (1)$$

CH₄ balance

$$\frac{9}{100} \times 2.5153 \times 10^4 \frac{\text{mol}}{\text{h}} = \frac{5}{100} \times Y \quad (2)$$

$$Y = \frac{9}{5} \times 2.5153 \times 10^4 \frac{\text{mol}}{\text{h}}$$

$$= 4.5275 \times 10^4 \frac{\text{mol}}{\text{h}} \Rightarrow \text{Molar flow rate of product gas} = Y = 4.53 \times 10^4 \frac{\text{mol}}{\text{h}} = 45.3 \frac{\text{kmol}}{\text{h}}$$

$$Y = X + 2.5153 \times 10^4 \quad (2)$$

$$X = Y - 2.5153 \times 10^4$$

$$X = 2.0122 \times 10^4 \frac{\text{mol}}{\text{h}}$$

$$\therefore \text{The molar flow rate of pure air } X = 2.01 \times 10^4 \frac{\text{mol}}{\text{h}} = 20.1 \frac{\text{kmol}}{\text{h}}$$

Material & Energy Balances

Homework 2

2 of 5

d. cont'd

$$\text{Molar flow rate of product gas} = 4.5275 \times 10^4 \text{ mol/h}$$

$$\text{molar flow rate of CH}_4 \text{ in product gas} = 2.264 \times 10^3 \text{ mol/h}$$

$$\text{molar flow rate of Air in product gas} = 4.301 \times 10^4 \text{ mol/h} \quad (1)$$

$$\text{molar flow of O}_2 \text{ in mixture (product gas)} = 0.21 \times 4.301 \times 10^4 \text{ mol/h} \\ = 9.032 \times 10^3 \text{ mol/h} \quad (1)$$

$$\text{molar flow rate of N}_2 \text{ in product gas} = 3.398 \times 10^4 \text{ mol/h} \quad (1)$$

$$\text{Mass flow rate of CH}_4 \text{ in product gas} = 2.264 \times 10^3 \text{ mol/h} \times 16 \text{ g/mol} \\ = 3.6224 \times 10^4 \text{ g/h} \quad (2)$$

$$\text{mass flow rate of O}_2 \text{ in product gas} = 9.032 \times 10^3 \text{ mol/h} \times 32 \text{ g/mol} \\ = 28.9024 \times 10^4 \text{ g/h} \quad (2)$$

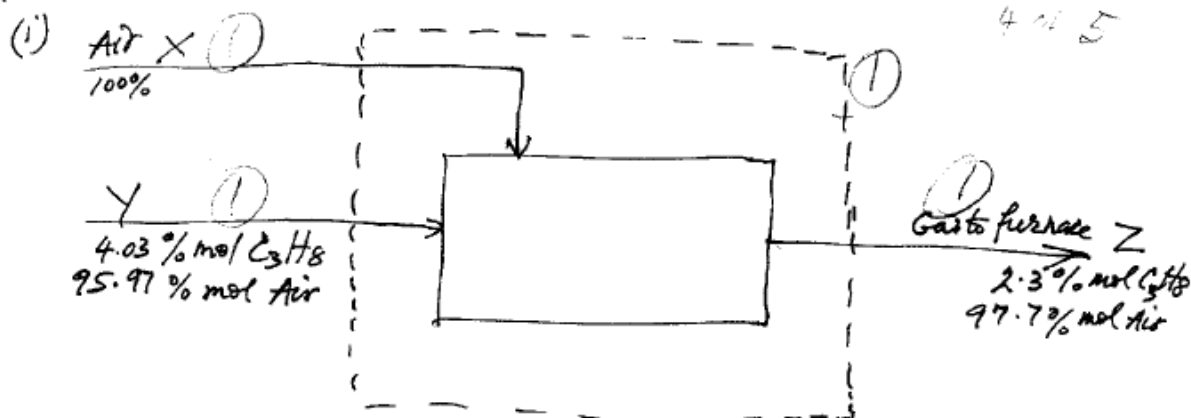
$$\text{mass flow rate of N}_2 \text{ in product gas} = 3.398 \times 10^4 \text{ mol/h} \times 28 \text{ g/mol} \\ = 95.141 \times 10^4 \text{ g/h} \quad (2)$$

$$\text{mass flow rate of product gas} = 127.6658 \times 10^4 \text{ g/h} \\ = 1.277 \times 10^4 \text{ g/h} = 12.77 \text{ kg/h}$$

$$\text{mass \% of O}_2 \text{ in product gas} = \frac{28.9024 \times 10^4}{127.6658 \times 10^4} \times 100 \% \\ = 22.64 \% \quad (5)$$

Material & Energy Balances Homework 2

2.



Unknowns: X, Y and $Z = 3$ (2)

Species: Air and $C_3H_8 = 2$ (Air containing O_2 and N_2 is considered a single species) (2)

Degree-of-freedom $= 3 - 2 = 1$ (4)

(ii) Basis: 150 mol C_3H_8/s fuel mixture 4.03 % mol C_3H_8 and 95.97 % mol Air (2)

overall mass balance

No reaction takes place during the mixing so a mole balance gives moles in = moles out

$$X + Y = Z \quad \text{--- (1) (5)}$$

C_3H_8 balance

$$0.0403 Y = 0.023 Z \quad (5)$$

$$0.0403 Y = 150 \text{ mol } C_3H_8/s$$

$$Y = \frac{150 \text{ mol } C_3H_8/s}{0.0403 \text{ mol } C_3H_8/\text{mol fuel mix}} = 150 \frac{\text{mol } C_3H_8}{s} \times \frac{\text{mol fuel mix}}{0.0403 \text{ mol } C_3H_8}$$

2. Contd

Material & Energy Balances Homework 2

5 of 5

$$Y = 150 \frac{\text{mol C}_3\text{H}_8}{\text{s}} \times \frac{\text{mol fuel mixture}}{0.0403 \text{ mol C}_3\text{H}_8}$$

$$Y = 150 \frac{\text{mol fuel gas}}{\text{s}} \times \frac{1}{0.0403} = \frac{150}{0.0403} \frac{\text{mol fuel gas}}{\text{s}} \\ = 3722.1 \frac{\text{mol}}{\text{s}} \text{ fuel gas} \quad (5)$$

$$0.0403Y = 150 \text{ mol C}_3\text{H}_8/\text{s} = 0.023 Z \quad (5)$$

$$Z = \text{Gas to furnace} = \frac{150 \text{ mol}}{0.023 \text{ s}}$$

$$Z = \text{Gas to furnace} = 6521.74 \frac{\text{mol}}{\text{s}} \quad (5)$$

$$\text{But } X + Y = Z$$

$$\therefore X + 3722.1 = 6521.74 \quad (2)$$

Where X = molar flow rate of the dilution air

$$X = 2799.64 \text{ mol/s} \quad (2)$$

$$X = 2.8 \text{ kmol/s}$$

- (iii) The dilution rate should be greater than the value of 2.8 kmol/s calculated in (i) to ensure that propane in the propane-air mixture is less than 2.3 mole %.

(5)

Student Work Above Average

**CHEMICAL ENGINEERING DEPARTMENT
MATERIAL AND ENERGY BALANCES CHEG 2333
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR SPRING 2022 SEMESTER**

CHEG STUDENT OUTCOME D1: an ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve integral and differential equations analytically or numerically, and (2) apply appropriate conservation laws, chemical and physical principles to solve problems in material and energy balances.

Name: Juan Pedro Bihang Nguema Ojano

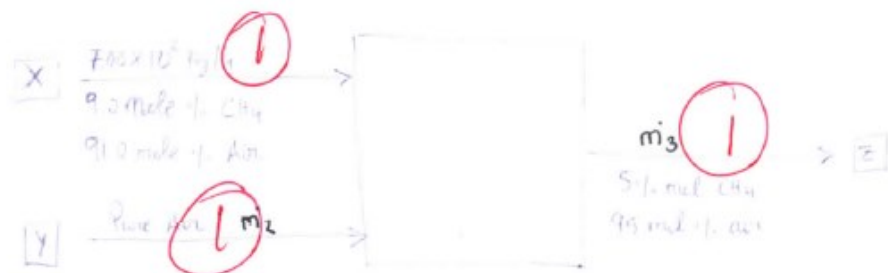
Title of Assignment: Homework 2 Due Date: April 27, 2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply the knowledge of material balances to problems involving safe handling of flammable mixtures <i>This assignment tests students' knowledge and application of material balances to safe handling and use of flammable fuel-air mixtures in processes.</i>	100	84
TOTAL	100	84

Problem #1

$$M_w(CH_4) = 12.14 = 16 \text{ g/mol}$$

$$M_w(Air) = 29.0 \text{ g/mol}$$



$$\begin{array}{r} 1 - 40 \\ 2 - 44 \\ \hline 84 \end{array}$$

* Basis of calculation (2) $700 \times 10^3 \text{ kg/h}$ in X mixture

* Average Molar Mass at X mixture = $0.09 \times 16 \text{ g/mol} + 0.91 \times 29 \text{ g/mol}$
 $= 27.83 \text{ g/mol}$

Molar flow rate at X mixture = $\frac{\text{mass flow rate} \times 1000}{\text{Average Molar Mass}} = \frac{700 \times 10^3 \text{ kg/h} \times 1000}{27.83 \text{ g/mol} \times 1000}$

$$X = 25152.71 \text{ mol/h}$$

* Component molar balance: molar CH_4 In = molar CH_4 Out

$$0.09 \times X = 0.05 \times Z \Rightarrow Z = \frac{0.09 \times 25152.71 \text{ mol/h}}{0.05} = 45274.83 \text{ mol/h}$$

* Overall Balance: $X + Y = Z$

$$Y = Z - X = 45274.83 - 25152.71 \Rightarrow Y = 20122.17 \text{ mol/h}$$

The molar flow rate of Air required to reduce CH_4 concentration is 20122.17 mol/h

* Molar flow rate of CH_4 at Z = $0.05 \times Z = 0.05 \times 45274.83 = 2263.74 \text{ mol/h}$

* Molar flow rate of Air at Z = $0.95 \times Z = 0.95 \times 45274.83 = 43011.14 \text{ mol/h}$

* Since Air had 21 mole % O_2 and 79 mole % N_2

molar flow rate of O_2 = $0.21 \times 43011.14 = 9032.34 \text{ mol/h}$

$$\text{mass flow rate of } O_2 = 9032.55 \frac{\text{mol}}{\text{h}} \times \frac{32 \text{ g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 289.03 \frac{\text{kg}}{\text{h}}$$

$$\bullet \text{ molar flow rate of } N_2 = 0.79 \times 43011.14 = 33978.8 \frac{\text{mol}}{\text{h}}$$

$$\text{mass flow rate of } N_2 = 33978.8 \frac{\text{mol}}{\text{h}} \times \frac{28 \text{ g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 951.40 \frac{\text{kg}}{\text{h}}$$

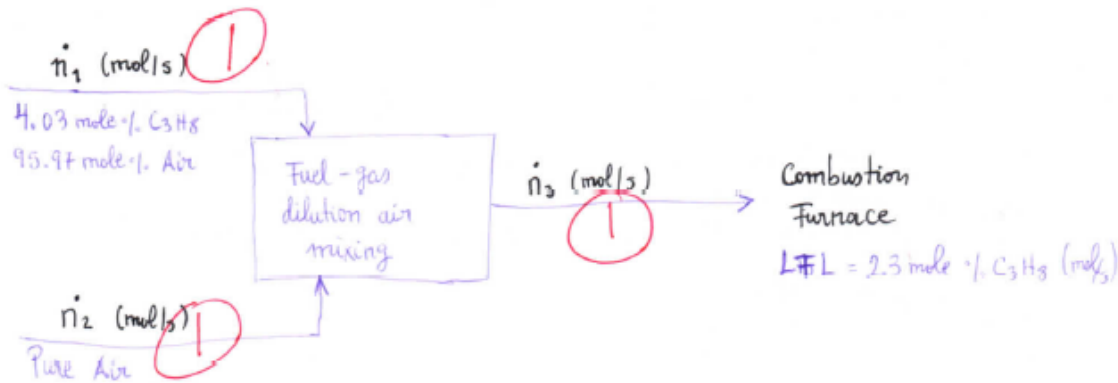
$$\bullet \text{ mass flow rate of } CH_4 \text{ in } Z = 2263.74 \frac{\text{mol}}{\text{h}} \times \frac{16 \text{ g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 36.22 \frac{\text{kg}}{\text{h}}$$

Therefore, Mass percent of O_2 in the gas product (CH_4, O_2, N_2)_Z

$$= \frac{289.03 \text{ kg/h} \times 100\%}{289.03 \text{ kg/h} + 951.40 \text{ kg/h} + 36.22 \text{ kg/h}} = 22.64\% O_2$$

Problem #2

(i)



Degree of freedom analysis:

Unknowns: n_1, n_2, n_3

2 Component species: C_3H_8, Air

$$\text{Dof} = 3 - 2 = 1$$

(ii)

• Basis of calculation: flow rate of C_3H_8 in original fuel air mixture is 150 mol/s. Assuming that n_2 is mole percent of C_3H_8 output.

Input = Output

Overall balance

$$\dot{n}_1 + \dot{n}_2 = \dot{n}_3$$

5

Propane balance

$$150 \text{ mol C}_3\text{H}_8/\text{s} = \frac{2.3}{100} (\dot{n}_3) \text{ mol C}_3\text{H}_8/\text{mol} \Rightarrow$$

$$\dot{n}_3 = \frac{150 \text{ mol C}_3\text{H}_8/\text{s}}{0.023 \text{ mol C}_3\text{H}_8/\text{mol}} \Rightarrow \dot{n}_3 = 6521.74 \text{ mol/s}$$

10

$$\dot{n}_1 = \frac{150 \text{ mol C}_3\text{H}_8/\text{s}}{0.0403 \text{ mol C}_3\text{H}_8/\text{mol}} \Rightarrow \dot{n}_1 = 3722.08 \text{ mol/s}$$

5

From $\dot{n}_1 + \dot{n}_2 = \dot{n}_3 \Rightarrow \dot{n}_2 = \dot{n}_3 - \dot{n}_1 = 6521.74 - 3722.08 \Rightarrow$

5

$$\dot{n}_2 = 2799.66 \text{ mol/s}$$

(iii)

In order ~~not~~ to present ~~difficulties~~ ^{ignition}, C_3H_8 need to be less than 2.3 mole% and greater than 9.5 mole%. _{molar flow rate}

Since I did my calculations using the LFL 2.3 mole% as reference, the result

$\dot{n}_2 = 2799.66 \text{ mol/s}$ obtained means that this is the minimum molar flow

rate ^{necessary} to keep the combustion furnace working (producing ignition).

any value $< 2799.66 \text{ mol/s}$ will not produce ignition.

5

44

Student Work

Average

**CHEMICAL ENGINEERING DEPARTMENT
MATERIAL AND ENERGY BALANCES CHEG 2333
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR SPRING 2022 SEMESTER**

CHEG STUDENT OUTCOME D1: an ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve integral and differential equations analytically or numerically, and (2) apply appropriate conservation laws, chemical and physical principles to solve problems in material and energy balances.

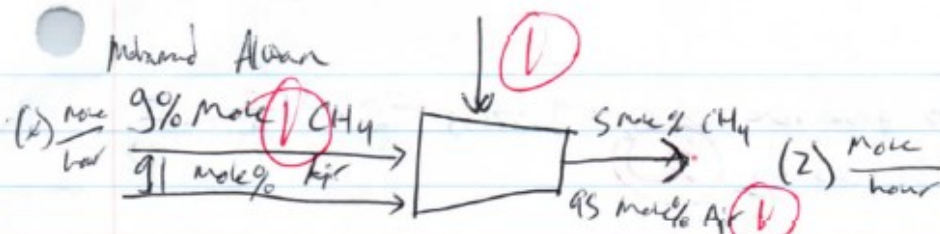
Name: Mohammad Alwan

Title of Assignment: Homework #2 Due Date: 4/29/2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply the knowledge of material balances in a mixing processes <i>This assignment tests students' knowledge and application of material balances to mixing processes.</i>	100	73
TOTAL	100	73

Pure Air $\frac{\text{mole}}{\text{hour}} (y)$

Mixed Air



basic $7 \times 10^3 \text{ kg/h}$ in x Mixture (2)

$$\text{Average Molar mass of } x \text{ mixture} = .09 \times 16 \text{ g/mol} + .91 \times 29 \text{ g/mol} = 21.83 \text{ g/mol} (5)$$

$$\text{Molar flow rate of } x \text{ mixture} = \frac{\text{mass flow rate } x}{\text{average molar mass } x} = \frac{7 \times 10^3 \text{ kg/h}}{21.83 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}}} = 25152.71 \frac{\text{mol}}{\text{h}} (5)$$

CH_4 balance: mole CH_4 in = mole CH_4 out

$$.09 \times X = .05 \times Z (2)$$

$$Z = \frac{.09 \times 25152.71 \text{ mol/h}}{.05} = 45274.88 \frac{\text{mol}}{\text{h}} (5)$$

overall balance $x + y = z$

$$y = z - x = 45274.88 - 25152.71 = 20122.17 \frac{\text{mol}}{\text{h}} (4)$$

The molar flow rate of air that is needed to reduce CH_4 concentration is $20122.17 \frac{\text{mol}}{\text{h}}$

$$\text{Molar flow rate of } \text{CH}_4 (z) = .05 \times Z = .05 \times 45274.88 = 2263.74 \frac{\text{mol}}{\text{h}}$$

$$\text{Molar flow rate of air in } z = \frac{.95}{.10} \times z = .95 \times 45274.88 = 43011.14 \frac{\text{mol}}{\text{h}} (1)$$

Air has 21 mole% O_2 and 79 mole% N_2

$$\text{Molar flow rate of } \text{O}_2 = .21 \times 43011.14 = 9032.33 \frac{\text{mol}}{\text{h}} (1)$$

Mass flow rate of $O_2 = 1032.33 \frac{\text{mol}}{\text{h}} \times 32 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}}$
 $= 289.03 \frac{\text{kg}}{\text{h}}$ (2)

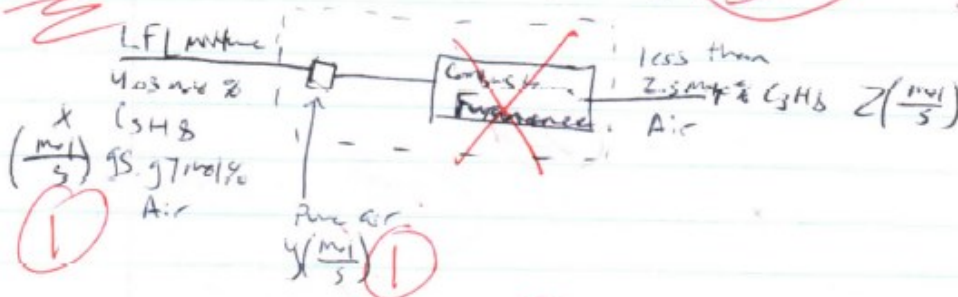
Molar flow rate of $N_2 = .79 \times 43011.14 = 33975.8 \frac{\text{mol}}{\text{h}}$

Mass flow rate of $N_2 = 33975.8 \frac{\text{mol}}{\text{h}} \times 28 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}}$
 $= 36.22 \frac{\text{kg}}{\text{h}}$ (2)

Mass percent of O_2 in the gas product (C_3H_8, O_2, N_2)

$= 289.03 \frac{\text{kg}}{\text{h}} \times 100\%$

$\frac{289.03 \frac{\text{kg}}{\text{h}} + 451.40 \frac{\text{kg}}{\text{h}} + 36.22 \frac{\text{kg}}{\text{h}}}{289.03 \frac{\text{kg}}{\text{h}} + 451.40 \frac{\text{kg}}{\text{h}} + 36.22 \frac{\text{kg}}{\text{h}}} = 22.64\%$ (5)



i) unknown = x, y, z (3)

2 Components Species = C_3H_8, Air (2)

Degree of freedom = $3 - 2 = 1$ (4)

ii) Basic: flow rate of C_3H_8 in original fuel air

Mixture x is $150 \frac{\text{mol}}{\text{s}}$ (2)

Assume x is mole percent of C_3H_8 output

Component C_3H_8 balance: $\frac{4.03}{100} x = x \cdot 2 = 150 \text{ mol/s}$

$x = \frac{150 \frac{\text{mol}}{\text{s}} \times 100}{4.03} = 3722.08 \frac{\text{mol}}{\text{s}}$ (10) $z = \frac{150 \frac{\text{mol}}{\text{s}}}{x}$

Mohamed Alwan

ii) Overall balance $x + y = 2$

$$3722.08 + y = \frac{150}{x}$$

$$x = \frac{150}{3722.08 + y}$$

$$x < \frac{2.3}{100} = 0.023$$

$$\frac{150}{3722.08 + y} < 0.023 \Rightarrow \frac{150}{0.023} < 3722.08 + y$$

$$6521.74 < 3722.08 + y \Rightarrow 6521.74 - 3722.08 < y$$

$$2799.65 < y$$

Minimum Molar flow rate of the dilution of air is

$$2799.65 \frac{\text{mol}}{\text{s}}$$

How did you get this?

iii) The real dilution air feed rate is most likely greater than $2799.65 \frac{\text{mol}}{\text{s}}$ because the product need to have less than 2.3 mole% C_3H_8 So it does not combust.

Student Work

Below Average

**CHEMICAL ENGINEERING DEPARTMENT
MATERIAL AND ENERGY BALANCES CHEG 2333
COURSE ASSIGNMENT GRADING AND OUTCOME ASSESSMENT SHEET
FOR SPRING 2022 SEMESTER**

CHEG STUDENT OUTCOME D1: an ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics

Assignments that test competency in this area will include problems that test a student's ability to apply knowledge of and (1) solve integral and differential equations analytically or numerically, and (2) apply appropriate conservation laws, chemical and physical principles to solve problems in material and energy balances.

Name: Alexander Ortiz _____

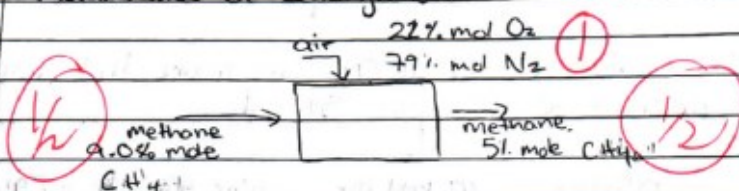
Title of Assignment: hw 2 _____ Due Date: 4/29/2022

Description of Performance Criteria Being Assessed	Max for this Assignment	Your Score
Ability to apply the knowledge of material balances to problems involving safe handling of flammable mixtures <i>This assignment tests students' knowledge and application of material balances to safe handling and use of flammable fuel-air mixtures in processes.</i>	100	58
TOTAL	100	58

HW#2 Material Balance and Energy

A mixture of methane and air is capable of being ignited only if the mole percent of methane is between 5% and 15%.

A mixture containing 9.0 mole % methane flowing at a rate of 7×10^2 kg/h is to be diluted with pure air to reduce the methane concentration to the lower flammability limit. Calculate the required rate of air in mol/hr the percentage by mass of oxygen in the product gas. Air may be taken to consist of 21 mol % O_2 and 79 mol % N_2 and to have an average molar mass of 29.0 g/mol.



700 kg/hr flow rate mixture with 9% of CH_4

Molecular Weight Average

$\bar{M}_w = y_a M_a + y_b M_b + \dots$

$$\bar{M}_w = (0.09 \frac{g}{mol}) (16 \frac{g}{mol}) + (0.91 \frac{g}{mol}) (29 \frac{g}{mol})$$

$$\bar{M}_w = 27.83 \frac{g}{mol}$$

$$27.83 \frac{g}{mol} \times \frac{11 \text{ kg}}{1000 \text{ g}} \times \frac{1000 \text{ mol}}{1 \text{ kmol}} = 27.83 \frac{kg}{kmol}$$

mass flow rate $= \dot{m} = \frac{dm}{dt}$; flow is 700 kg/hr for CH_4 and assuming 0 for Air

$$\dot{m} = \frac{700 \text{ kg/hr}}{27.83 \text{ kg/kmol}} = 25.15 \frac{\text{kmol}}{h}$$

what is the mixture rate and its molecular average of mixture.

9% of methane

91% of air; Average MW 29.0 g/mol

$$0.91 \frac{g}{mol} \times 1 \text{ mol} = 3.137 \text{ mol air}$$

$$0.09 \frac{g}{mol} \times 1 \text{ mol } CH_4 = 0.005625 \text{ mol } CH_4$$

1-26
2-32
CS

$$\dot{n}_{\text{mixture}} = 25.15 \frac{\text{kmol}}{\text{hr}}$$

but we want the air alone and CH_4

if we have the % of air (91%)

$$(0.91)(25.15 \frac{\text{kmol}}{\text{hr}})$$

$$= 22.88 \frac{\text{kmol}}{\text{hr}} \text{ of air}$$

verify that equals to mixture flow rate

if we have the % of CH_4 (9%)

$$(0.09)(25.15 \frac{\text{kmol}}{\text{hr}}) = 2.2635 \frac{\text{kmol}}{\text{hr}}$$

$$22.88$$

$$+ 2.26$$

$$= 25.14$$

However we want to know how much air is needed for 5% CH_4

Since we know flow rate of CH_4 at 9%, we assume that from it, it will be composed of 95% air 5% CH_4

$$2.2635 \frac{\text{kmol}}{\text{hr}} \times \frac{0.95 \text{ kmol air}}{0.05 \text{ kmol CH}_4} = 43 \frac{\text{kmol air}}{\text{hr}}$$

$$43 \frac{\text{kmol air}}{\text{hr}}$$

molar flow rate for 95% air

Now

$$43 \frac{\text{kmol air}}{\text{hr}} - 22.88 \frac{\text{kmol air}}{\text{hr}} = 20.12 \frac{\text{kmol air}}{\text{hr}}$$

$$20.12 \frac{\text{kmol air}}{\text{hr}}$$

for dilution

$$\text{Now molar mass average} = 700 \frac{\text{kg}}{\text{hr}} (0.91) + 20.12 \frac{\text{kmol}}{\text{hr}} \left(\frac{29 \text{ kg air}}{\text{mol}} \right)$$

from 95% Air and 91%

$$\dot{m}_{\text{air}} = 1220.4 \frac{\text{kg air}}{\text{hr}}$$

But we want oxygen now, we know

21% is O_2 in Air

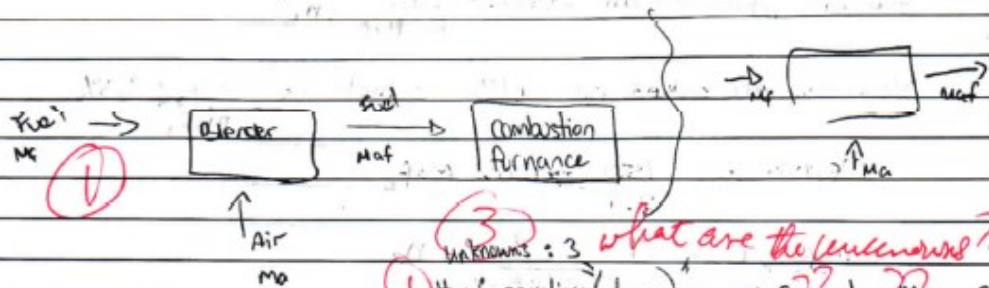
$$\dot{m}_{\text{O}_2} = 0.21 (1220.4 \frac{\text{kg}}{\text{hr}}) = 256.28 \frac{\text{kg O}_2}{\text{hr}}$$

$$\dot{m}_{\text{O}_2} = \frac{256.28 \frac{\text{kg O}_2}{\text{hr}}}{700 \frac{\text{kg}}{\text{hr}} + (20.12 \frac{\text{kmol}}{\text{hr}} \cdot \frac{29 \text{ kg air}}{\text{kmol}})} \times 100\% = 19.96\% \approx 20\% \dot{m}_{\text{O}_2}$$

Question #2

A mixture of propane and air containing 4.03 mol-% C_3H_8 is fed to a combustion furnace. If there is a problem in the furnace a stream of pure air (dilution air) is added to the ~~fuel~~ mixture prior to the furnace inlet to make sure that ignition is not possible.

- a) Draw and label flow chart of the fuel gas dilution air mixing unit, assuming that the gas entering the furnace contains propane at the LFL (lower explosion limit) and do the degree freedom



Therefore $DOF = 3 - 2 - 1 = 0$

Unknowns: 3 what are the unknowns?
 (1) # of equations (two) = m_{af} and $\frac{m_a}{m_f} = 2.30\%$

32

if propane flows at a rate of 150 mol C_3H_8/s in the original fuel-air mixture, what is the minimum molar flow rate of the dilution air?

flow rate 150 mol C_3H_8/s mixture of propane with air = 4.3% C_3H_8 in feed to combustion furnace

$$150 \text{ mol } C_3H_8 \times \frac{100}{4.3} = 3722.08 \text{ mol/s mixture}$$

$$\text{flow rate of dilution air} = 3722.08 \text{ mol/s mixture} = n_1$$

Now we are asked on LEL which is $\frac{m_f}{m_{af_2}} < 2.3\%$

$$m_f = 150 \therefore \frac{150}{2.3} \times 100 < m_{af_2}$$

$$m_{af_2} > 6521.73 \frac{\text{mol}}{\text{s}} = n_2$$

$$n_2 - n_1 = 6521.73 - 3722.08 = 2799.66 \text{ minimum mol-flow rate}$$

How would the actual dilution air feed rate probably compare with value calculated in (b)

- Because the accuracy of the combustion is not 100% efficient, we must keep the amount of air bigger than what shows on point b) and also it is good to supply more air in the event of not 100% distribution of propane and oxygen inside the furnace

Unit Operations CHEG 3302

Assignments to understand different types of pumps and Valves and their applications

Assignment on

- **Mechanical Integrity**

Student Work

Above Average

Prairie View A&M University



Unit Operations of Chemical Engineers –CHEG 3023 P01

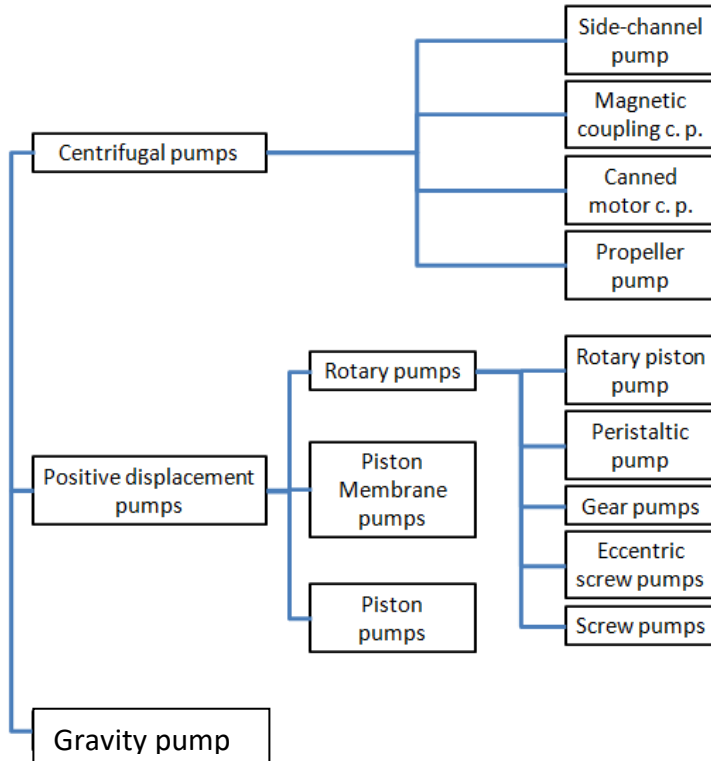
Pumps and Valves Chart

Lilia Yang

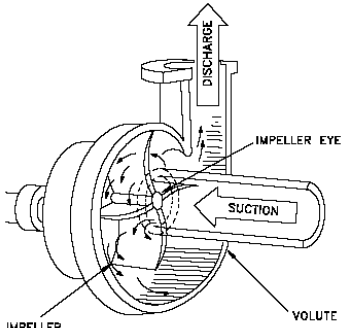
Tuesday, November 5, 2019

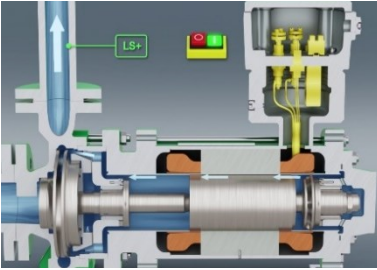
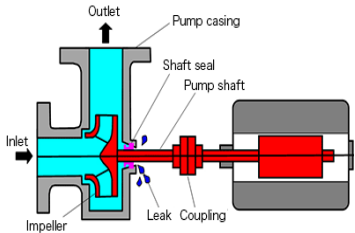
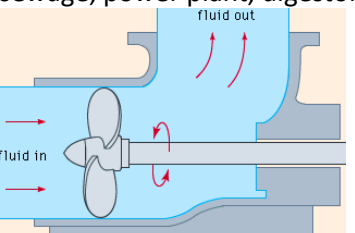
Dr. Nabila Shamim

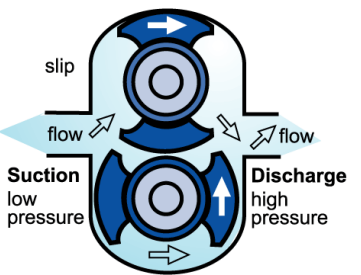
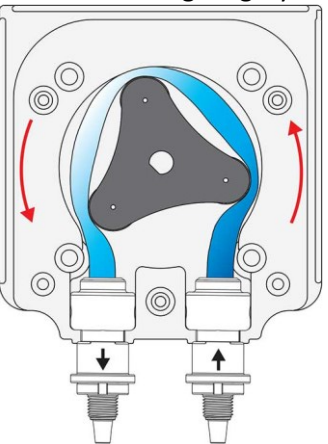
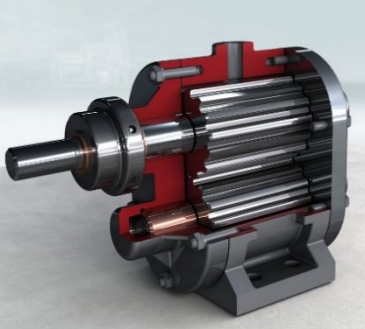
Pumps



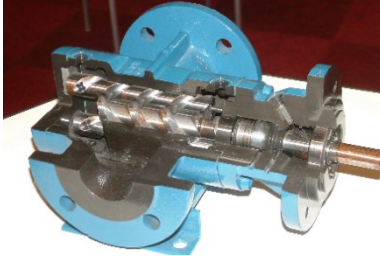
There are many different types of pumps with different types of applications. Each pump has its advantages and disadvantages. A portion of the variety of pumps will be discussed in the table below. Pumps is a device that moves liquids from low pressure to high pressure.

Type of Pumps	Applications	Advantages	Disadvantages
Centrifugal pump  Most popular and commonly used for fluid transfer Involves a rotating impeller to move fluids using centrifugal force	Oil and Energy- pumping crude oil, slurry, mud Industrial and Fire Protection- Heating and ventilation, boiler, air conditioning, fire protection sprinkler system Waste Management, Agriculture and Manufacturing- drainage, wastewater Pharmaceutical, Chemical and Food Industries - paints, sugar refining, food and beverage production 	Handles large quantity of fluids Provide very high flow rates Can adjust flow rate over wide ranges	Generally designed and suitable for liquids with low viscosity, thus cannot handle fluids with high viscosity (will require more energy)

Side-channel pump  Consists of one or more impeller assemblies Each stage consists of a suction disk, impeller, and discharge disk	Commonly used in the chemical industry Suitable in handling high temperature fluids Volatile liquid transfer Boiler feed LPG pumping Tank emptying Heating/ air conditioning Condensation extraction Reverse osmosis Hot water circulation Refrigerants	Ability to self-prime Handle liquid/vapor mixtures (able to pump liquids with up to 50% gas content without interruption or damages) Require low throughputs at high differential heads Generate higher pressures than other types of pumps of same size	Can only be used with only liquids (no solids) Stable fluid film is required between impeller and suction and discharge disk to avoid contact between rotating and stationary parts Handling volatile liquids with low viscosity
Canned Motor centrifugal pump  Composes a centrifugal hydraulic connected to a special motor through a one piece assembly	Applicable in oil and gas Refineries Petrochemicals Plastic Processing Cleaners and Detergents Energy Utilities 	Does not have a dynamic seal on the structure, only static seal Suitable for transporting flammable, explosive, valuable liquid and toxic, corrosive and radioactive liquids Compact stable running, low noise low maintenance cost	Pump efficiency is lower than the centrifugal pump Reverse circulation
Propeller Pump  Requires very high flow rate and low pressure	Axial Flow Propeller Pumps & Mixed Flow Propeller Pumps- Great as water cooling pumps Raw water intake, dewatering, storm water removal, flood control Used to circulate fluids in sewage, power plant, digestors 	Single stage, high specific speed impeller for high flow low head. Can pump liquids with or without solids if proper impeller type is chosen Achieve very high flow rate with very low head	Must use relatively thin liquids High speed will increase wear Heavy solids and floating debris cannot be pumped Dry-running is fatal

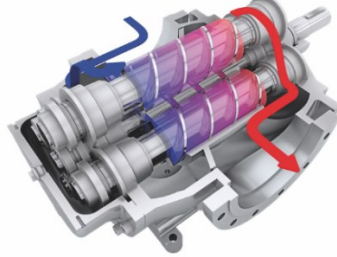
Positive Displacement pump  Does not have impellers, but relies on rotating or reciprocating parts to directly push the fluids to enclosed space, until pressure builds up to move into the discharge system	Positive Displacement Pump  Oil production, high force washing, treatment of water, food industries, petrochemical, fuel transferring and loading, irrigation	Works well with high viscosity fluids, presence of fragile solids Produces consistent flow rate even with changes in pressure	Need low flow and high pressure Does not work well with shear sensitive mediums
Peristaltic pump  Mimics the biological process called peristalsis Classified as a positive displacement pump Consist of a tube surrounded by a casing	Used for percise applications Often used to move fluids that are sterile or aggressive chemicals Pump IV fluids or slurries Used for heart and lung machines during surgery 	Can run on a continuous basis Used for precise applications Fluid only touches the hose portion of the pump Easy to clean and maintain	Tube wear out on slow, consistent basis due to constant squeezing Diminish feed rate if tubes deteriorate Uses more power under constant load to squeeze pressure on tube
Gear pump  A type of positive displacement pump that moves fluid using interlocking cogs or gears	Used in petrochemical industries, food industries, paint, oils 	Used for pumping high viscosity fluids Accurate control of volumetric output	Not recommended for abrasive media or solids. Expensive Noisy Limited by their size Unsuitable for operation with large bulk flow rates

Screw pump (water screw)



A type of positive displacement pump that uses one or more screws to move fluids

Used for fuel transferring, production of oil, irrigation, fuel injection, oil burners, lubrication, hydraulics



Handle wide range of flows, pressures, liquid types, and viscosity
Constant flow
High tolerance for entrained air
Self-priming operation and good suction characteristics

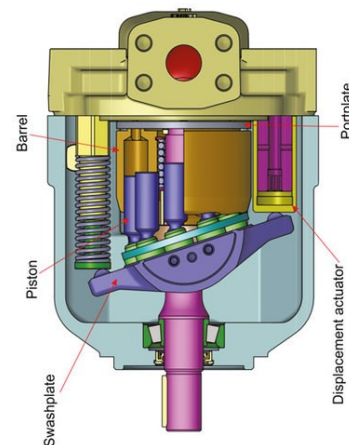
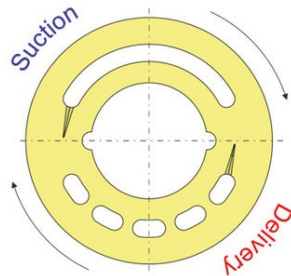
Performance characteristics sensitive to viscosity change
High pressure capability requires long pumping elements

Piston pump (reciprocating pump)



Uses the reciprocating motion of a piston rod to move fluids to cylindrical chamber where pressure builds up and forces fluid through pump

Used for paint spraying, oil production, heavy machinerys, and high force washing.



Has a wide pressure range
Pressure can be controlled without changing rate of flow
Has continuous rate of discharge
Pressure change and discharge rate does not really affect performance
Works with viscous fluid, high gas volumes and solids

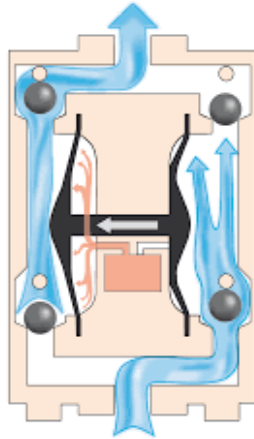
Cost more per unit to run compared to centrifugal pumps
Mechanical parts prone to wear (high maintenance costs)
Heavy due to large size and weight

Diaphragm pump (Membrane pump)



Positive displacement pump that uses a combination of the reciprocating action of rubber diaphragm and suitable valves

used for metering, spraying, treatment of water, oils, and paints
used to push corrosive chemical, volatile solvents, viscous, shear-sensitive foods, pharma product, abrasive slurry, and gel



Handles wide variety of fluids with high solid content
Self-priming
Explosion proof
Pump efficiency remains constant
Cannot overheat
Submersible, portable
Handles shear sensitive fluids

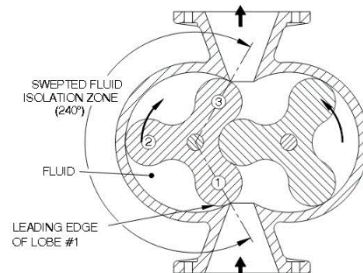
Works best when liquid is clean and free of particles or gases
If valves become clogged, accuracy decreases
Works best without back-pressure

Lobe pump



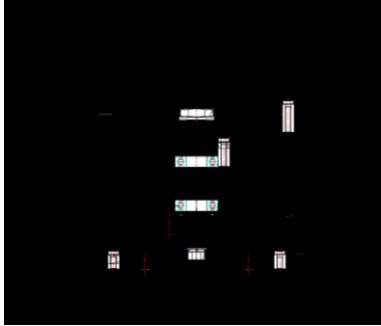
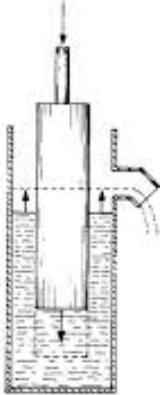
A type of positive displacement pump where the lobes are designed to almost meet

Used in food and chemical industries pharmaceutical, biotechnology, sanitary



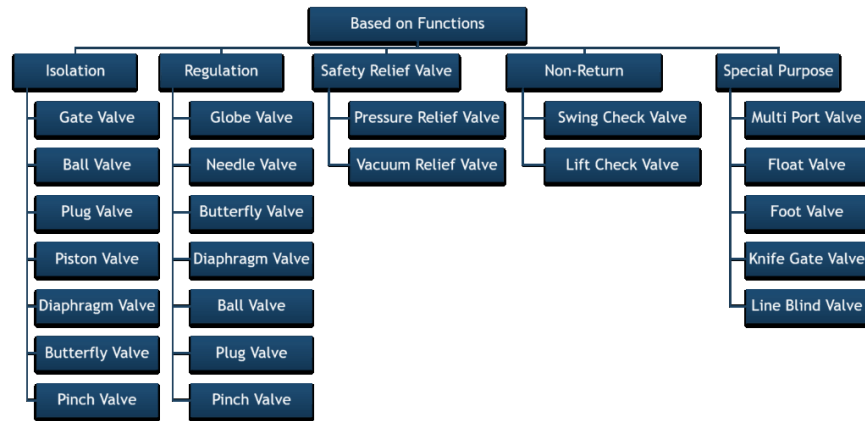
Suitable for low and high viscosity media
Low pulsation and vibration
Dry running
Independent of the direction of rotation

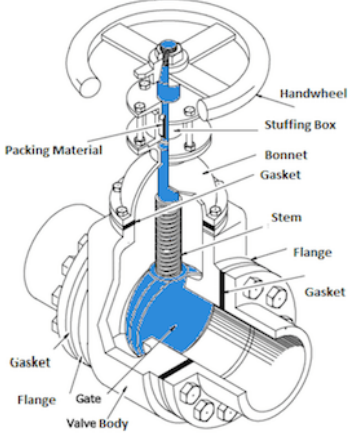
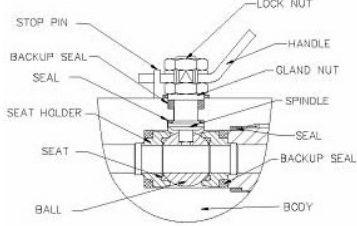
Does not work well with high pressures (over 16 bars)
Investment costs are high

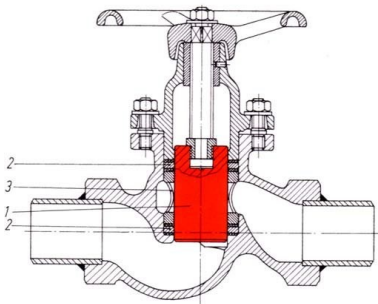
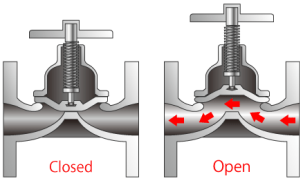
Submersible pump (electric submersible pump)  An air-tight sealed motor close-coupled to the pump body that can be fully submerged in water	Sewage treatment plants, handling seawater, water well and deep water drilling, offshore drilling rigs, irrigation systems 	Prevents pump cavitation Pump does not need to be primed Effective- low energy usage (uses water pressure) Some can handle solids Quiet	Some can only handle liquids Seals can become corroded over time Made to work with thin liquids If used outside of water, will overheat Has specific usages
Plunger Pump  A positive displacement pump where high-pressure seal is stationary and a cylindrical plunger slides through	 used to pump low viscosity fluids, paint spraying, oil production, and high force washing.	Can be used in higher pressure range Pressure can be controlled without changing rate of flow Has continuous rate of discharge Pressure change and discharge rate does not really affect performance Works with viscous fluid, high gas volumes and solids	Cost more per unit to run compared to centrifugal pumps Mechanical parts prone to wear (high maintenance costs) Heavy due to large size and weight

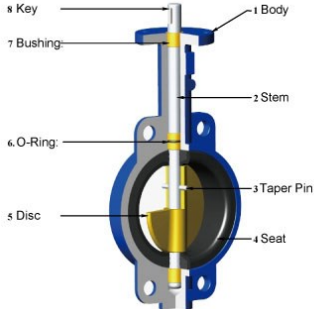
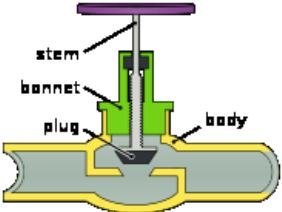
Valves

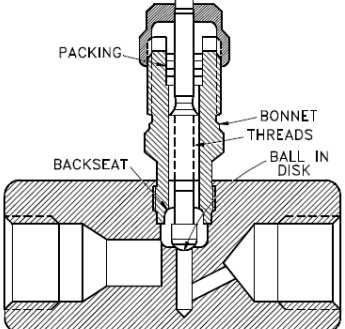
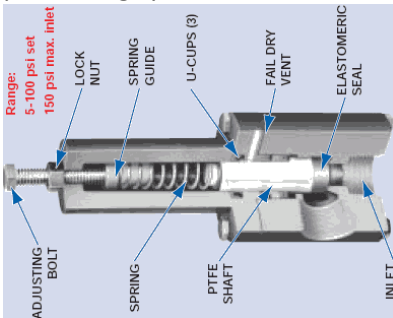
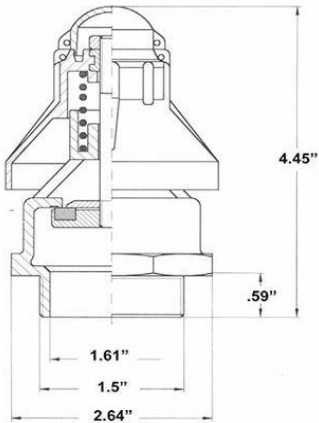
There are many different types of valves that are used for different applications. All valves have advantages and disadvantages which will be discussed in the table below.

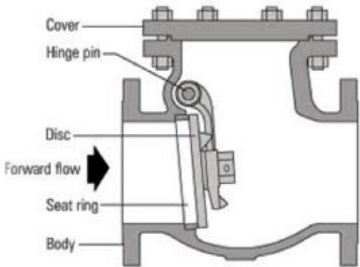
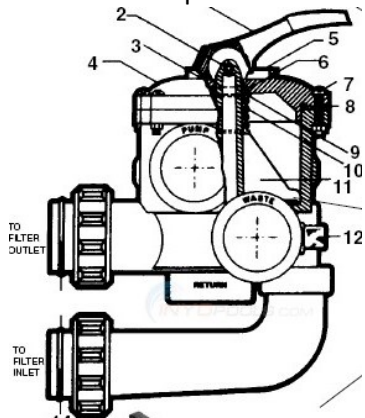
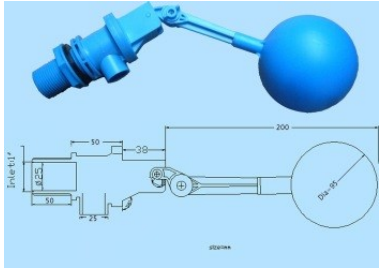


Type of Valves	Applications	Advantages	Disadvantages
Gate Valve 	Linear motion valve Most common type of valve used in process plants. Used where vertical space is limited (don't really take up extra space) 	Used in almost all fluid services (ex: air, fuel, steam) Provides good shutoff Offer small fluid resistance Energy-efficient alternative Overall structure is shorter than globe valve Erosion of sealing surface is lighter.	Sealing surface is more prone to damage Opening and closing is time-consuming Has many components which makes maintenance and manufacturing more costly
Ball Valve 	A quarter-turn rotary motion that uses a ball-shaped disk to stop or start flow. Requires a 90° turn of valve handle to operate. 	Smaller and lighter than gate valve Don't need any lubrication Gives bubble-tight seal with low torque Can maintain and regulate high pressure, volume and temperature	Poor throttling characteristics thus more prone to erosion at high velocity flow Wear and tear with fluids such as slurries and solid particles

Plug Valve 	Quarter-turn rotary motion valve Has a cylinder or cone shape that can be rotated inside the valve body to control flow of fluids essential in acidizing, cementing, coiled tubing, fracturing, and sand control Extensive applicability in the field of chemical industry	one-piece valve thus no leakage strong corrosion resistance Body and plug have no wear Long service life, high reliability	Requires large force to actuate due to high friction
Piston Valve 	Linear motion valve to control fluid Fine chemicals, Plastic and polymers, General chemicals, Petrochemicals 	reverse the engine if the flow of air is reversed Low maintenance easy to lubricate critical in preventing blow-by	extremely difficult to seal leakage and wear are typically still inevitable
Diaphragm Valve 	Linear motion valve to start/stop and control fluid flow Consists of a valve body with two or more ports Use pneumatic, hydraulic or electric actuators 	Usage of opening, closing, and throttling Good chemical resistance Fluid is isolated from bonnet group No accumulations	Prevent pipeline from completely discharging Must be used under 14 bar and 204°C Hydrostatic pressure applied is limited Dimensions are limited

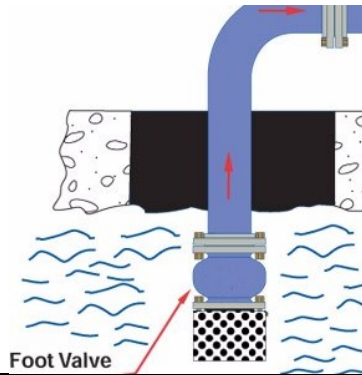
Butterfly Valve 	A quarter-turn rotary motion valve used to stop, regulate, and start flow Have short circular body Used in pharmaceutical, chemical, and food industries 	Suitable for large valve application Has a compact and lightweight design Requires less space in-built simple and affordable design (low maintenance) Can transfer mud Good sealing at low pressure Open and shut easily	poor sealing function at high pressures Throttling is restricted to low-pressure drop systems Possible cavitation and choked flow
Pinch/Clamp Valve 	A linear motion valve used to stop, regulate, and start flow Uses rubber/pinch tube and pinch mechanism to control fluid Bulk and solids handling, Cement industry, wastewater, food and beverages	Ideal in handling slurries (liquid with suspended solids) and system that convey solid materials pneumatically	Temperature range is limited Medium operating pressure is limited
Globe Valve 	Uses linear motion Used to stop, start and regulate flow Used in oil and gas industry 	Used where flow control is required and leak tightness is necessary Provides better shut off than gate valve	Cost more than gate valves Higher pressure drop compared to gate valve Requires greater force Require larger actuator to set valve

Needle Valve 	Used to stop, start and regulate flow Has sharp-pointed conical disc Used for flow-metering applications (calibrate) 	Gives very accurate control of flow in small diameter piping systems.	Incompatible with high-flow situations
Pressure Relief Valve (Pressure Safety Valve) 	Releases pressure at pre-defined set pressure Used in oil and gas, petrochemical, and power generation industries Used in refining and chemical processing systems 	used to protect equipment or piping system during an overpressure event Operate bubble tight at higher operating pressure	affected by the back pressure subjected to break if built-up back pressure is too high
Vacuum Relief Valve 	Releases vacuum at pre-defined set pressure Used in water heater/tank 	used to protect equipment or piping system in the event of vacuum	affected by the back pressure subjected to break if built-up back pressure is too high

Check Valve 	Rotary or linear motion valve Pressure of the fluid opens the valve while backflow closes the valve Used in chemical and power plants 	Prevents backflow in the piping system Has very low pressure drop Fast closing, Minimizes disk slamming	Can't be used in rapidly fluctuating flow Seat tightness may deteriorate at low differential pressure
Multiport Valve 	Control the direction of a fluid flow Help clean or backflush the filter media Used for main processes 	Allows you to decide the direction of a fluid flow Has multiple ports Allows filter or backwash	More complicated to understand and repair Has greater potential for internal problems
Float Valve 	Used for regulating flow in tanks of liquid Used as large vat of an industrial chemical to the water tank in a toilet 	Small flow resistance Simple structure Good sealing performance Cost-effective for certain size and pressure	If the ball is too heavy, can cause irregular deformation of ring Torque will increase if ball is too large
Foot Valve	Used in suction tank	Prevents backward flow of water	Cannot be used in rapidly



Has a screen and threads on one end to be on the ends of a pipe



through pipe when the water pump is turned off

fluctuating flow
Seat tightness
may deteriorate
at low differential
pressure

Work Citation:

“Advantages & Disadvantages of Using Gate Valves” Industrial Valves, November 2, 2019

<https://industrialvalvesblog.wordpress.com/2016/06/22/advantages-disadvantages-of-using-gate-valves/>

“Ball Valve Advantages and Disadvantages” Plastinternational, November 2, 2019

<https://www.plastinternational.co.za/ball-valve-advantages-disadvantages/>

Dickers, Jessica “Check Valve Applications” PumpIndustry (February 17, 2016), Accessed November 5th, 2019

<https://www.pumpindustry.com.au/check-valve-applications>

“Centrifugal Pumps - Working, Applications & Types | Power Zone” Power Zone Equipment, Inc., November 1, 2019 <https://www.powerzone.com/resources/glossary/centrifugal-pump>

“Different Types of Valves used in Piping – A Complete Guide of Pipe Valves”, HardHat Engineer, November 1, 2019, <https://hardhatengineer.com/different-types-valves-used-piping/>

Mccabe , Warren L. *Unit Operations of Chemical Engineering* . 7th ed., McGraw Hill Education (India), 2014.

“Positive Displacement Pumps and Applications” Elprocus., November 1, 2019,

<https://www.elprocus.com/positive-displacement-pumps-and-applications/>

“Pump Types Guide - Find the right pump for the job”, PumpScout, November 1, 2019

<http://www.pumpscout.com/articles-scout-guide/pump-types-guide-aid100.html>

“Useful information on Side Channel Pumps” Michael Smith Engineers Ltd, Nov. 1, 2019, <https://www.michael-smith-engineers.co.uk/resources/useful-info/side-channel-pumps>

Student Work

Average

**Chemical Engineering Department
Prairie View A&M University**



**Pumps and Valves
CHEG 3023-P01
Dr. Shamim**

**Completed on
November 5th, 2019**

**Submitted by:
Clifton Collins**

Pump Type	Definition	Applications	Advantages	Disadvantages
Piston Pump  	A type of pump uses the reciprocating motion of a piston rod to move fluid along an axis through a cylinder-shaped chamber. As the piston moves through the cylinder, pressure builds up and forces the fluid through the pump. The fluid flowing through the pump pulsates due to the movement of the piston through the cylinder.	Used as hydraulic pumps to power heavy machinery, but they are also useful in smaller machines such as paint sprayers. Piston pump is larger, more robust versions of this pump type are used in oil production and other industrial applications	has a wide pressure range, can reach high pressures and the pressure can be controlled without an impact on the rate of flow Has a continuous rate of discharge Pressure changes and discharge rate have minimal effect on performance	cost more per unit to run The mechanical parts are prone to wear, so the maintenance costs can be expensive The valves must be resistant to abrasives for large solids to pass through
Gear Pump  	Gear pumps are a type of hydraulic pump. This type of pump includes two or more gears that create a vacuum force to drive the liquid within the pump. This type of pumps is classified into two types: Internal and External	a type of pump used to transfer liquids from one location to another. Gear pumps create fluid displacement via the meshing of the gears. Also commonly used in lubrication pumps for power transmissions in automobiles, heavy trucks, lawn care equipment, hydraulic lifts, and other machine tools	Gear pumps are excellent as metering pumps since they can control volume and flow rate of a variety of fluids. It handles an extensive range of viscosities. Output is controllable Easy to reconstruct, Cavitation are less sensitive	Interlocking gears can also be loud. The liquid should be free of abrasives

Rotary Pumps 	A positive displacement pumps whereby a “moving chamber” is formed between a pair of rotating elements (rotors) or between a single rotor and the pump housing.	Used in Refrigeration Heating and Air Conditioning. Also used as pumps carrying out high viscosity substances transfer such as lubricating oil	Flow is independent of pressure. You can change the flow without upsetting the pump’s efficiency. The pump can handle high viscosity fluids efficiently. The pump is self-priming You get a smooth pulse free flow of the liquid into the system	The efficiency is low, generally around 30%, better can amount to 50%. Vacuum degree is low, not only because this is limited by the structure design , but the more important thing is restricted by working liquid saturation vapor pressure
Rotary Vane Pump 	This pump is a positive-displacement pump that consists of vanes mounted to a rotor that rotates inside a cavity	Vane pumps are commonly used as high-pressure hydraulic pumps and in automobiles, including supercharging, power-steering, air conditioning and automatic-transmission pumps	Relief valves are required to protect the pump in case of sudden closure of delivery. They are not suitable for abrasive liquids. They require good seals. They require good filtration systems and foreign particle	The efficiency is low, generally around 30%, better can amount to 50%. Vacuum degree is low, not only because this is limited by the structure design , but the more important thing is restricted by working liquid saturation vapor pressure



can severely
damage pump

Centrifugal Pump



A mechanical device designed to move fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips.

Used in buildings for pumping the general water supply, as a booster and for domestic water supplies.

also used in fire protection systems and for heating and cooling applications

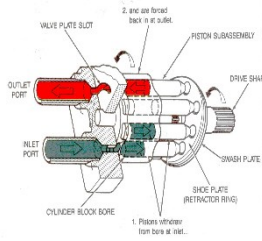
Used for pumping sewage and slurries. As there is no drive seal so there is no leakage in the pump. It can pump hazardous liquids. There are very less frictional losses.

They use rotation instead of suction to move water, and therefore have almost no suction power. Because of the magnetic resistance, there is some energy losses. Unexpected heavy load may cause the coupling to slip

Reciprocating Pump



Cont'd



a pump which uses a backward and forward movement to move a fluid. In a reciprocating pump, piston, plunger, or diaphragm moves backward and forward. A reciprocating pump is one in which the liquid follows the movement of the piston during suction and delivery strokes.

Wastewater treatment plants for contaminant removal

Soap and Manufacturing plants for raw materials and liquids

Reciprocating pumps in the food industry allow for the movement of ingredients from one vat to another, the transportation of liquids of various viscosities, and the delivery of water for food safety and sanitation

The oil and gas industry for the disposal, offshore oil, production, injection, feed, charge, steam generators, mainline, and field gathering

operates at high a higher efficiency (around 90%).

No priming needed.

Can deliver water at high pressure.

Can work in wide pressure range.

Continuous rate of discharge.

Reciprocating pumps require a lot of maintenance to continue functioning properly

It creates pulsations

The movement of the pistons can be violent enough, in normal operations, to cause the pump to damage itself over time

Positive Displacement (mono) Pump 	a pump that accomplishes the transfer of fluids by means of the mechanical action of gears, cams, screws, vanes or rotating pistons, the liquid being displaced by this means without the application of centrifugal force.	Used for pumping high viscosity fluids such as oil, paints, resins or foodstuffs. Preferred in any application where accurate dosing or high-pressure output is required	Pumps are ideal for applications where a constant flow is needed. Create medium to high pressure, and are often an excellent way to pump oils and other viscous fluids. PD pumps may also be needed for low flow and high-pressure combination, to move fluids containing fragile solids, or for other application niche	in some more complicated designs, fault-prone construction with valves. In oscillating positive displacement pumps vibration-free operation is only possible with complex mass balancing. Oscillating positive displacement pumps less suitable for high speeds
Submerged Suction Pump 	a type of centrifugal pump that operates while completely submerged Submersible centrifugal pumps operate by forcing water through a series of rotating impellers, powered by an electric motor.	Common in sewage applications, raw water pumping applications, and to remove storm water from structures like parking garages.	that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface Submersible pump is that it never has to be primed, because it is already submerged in the fluid	The seals can become corroded with time. When that happens, water seeps into the motor, rendering it useless until it is repaired. Seal makes the submersible pump a bit difficult to get into for repairs. One pump does not fit all uses

Perialistic (metering) Pump 	device used to pump precise amounts of liquids over a period of time	Metering pumps are in the chemical, water, food processing, and other industries where precise flow rate is essential. This includes tasks such as the chemical treatment of water in boilers for use in cooling towers, or when working potable water	easy to use and can operate efficiently even with dirty or thick liquids because there are no check valves. It can also handle higher back-pressures excellent suction	Due to constant squeezing, the tube wears out on a slow, consistent basis This can diminish the feed rate if the tube is allowed to deteriorate. The drive motor is under a constant load to keep squeezing pressure on the tube, causing more power usage.
---	---	---	--	---

Rotary Vane Pump



This pump is a positive-displacement pump that consists of vanes mounted to a rotor that rotates inside a cavity

Vane pumps are commonly used as high-pressure hydraulic pumps and in automobiles, including supercharging, power-steering, air conditioning and automatic-transmission pumps.

Relief valves are required to protect the pump in case of sudden closure of delivery.

They are not suitable for abrasive liquids.

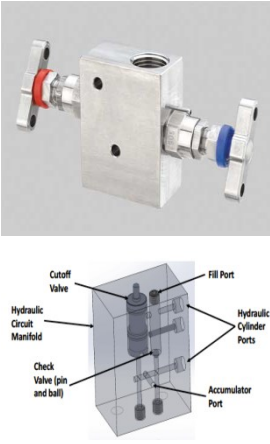
They require good seals.

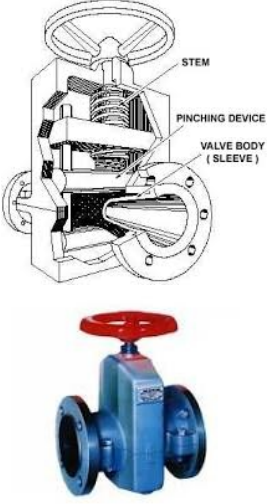
They require good filtration systems and foreign particle can severely damage pump.

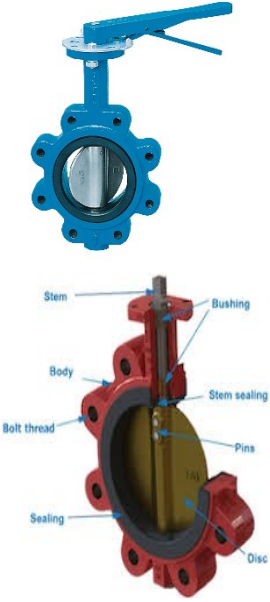
the efficiency is low, generally around 30%, better can amount to 50%

vacuum degree is low, not only because this is limited by the structure design , but the more important thing is restricted by working liquid saturation vapour pressure

Twin Screw Pump 	A screw pump, also known as a water screw, is a positive-displacement pump that use one or several screws to move fluids or solids along the screw axis. In its simplest form, a single screw rotates in a cylindrical cavity, thereby moving the material along the screw's spindle	design is widely used in refineries, tank terminals and chemical plants Also used for a variety of applications such as fuel-injection, oil burners, boosting, hydraulics, fuel, lubrication, circulating, feed	Wide range of applications Self-priming Pumped capacity proportional to speed Compact construction	Relatively high cost because of close tolerances and running clearances Performance characteristics sensitive to viscosity change High pressure capability requires long pumping elements
Axial Flow Pump 	An axial-flow pump, or AFP, is a common type of pump that essentially consists of a propeller in a pipe. The propeller can be driven directly by a sealed motor in the pipe or by electric motor or petrol/diesel engines mounted to the pipe from the outside or by a right-angle drive shaft that pierces the pipe	used to circulate fluids in power plants, sewage digesters, and evaporators Also used in flood dewatering and irrigation systems	Good for the high flow rate, low-pressure applications High discharge (flow rate) at a relatively low head Easily be adjusted to run at peak efficiency	Do not handle highly viscous fluids well Not suited for high-pressure applications

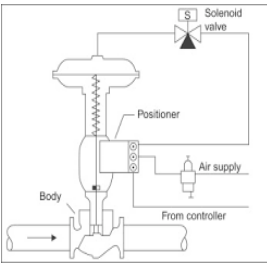
Valve Type	Definition	Applications	Advantages	Disadvantages
Plug valve 	Plug valves are valves with cylindrical or conically tapered plugs which can be rotated inside the valve body to control flow through the valve. The plugs in plug valves have one or more hollow passageways going sideways	Used where flow isolation is essential such as in acidizing, cementing, coiled tubing, fracturing, and sand control.	Quick quarter turn on-off operation. Minimal resistance to flow. Smaller in size than most other valves	Requires a large force to actuate, due to high friction. NPS 4 and larger valves requires the use of an actuator. Reduced port, due to tapered plug.
Manifold Valve 	A number of valves combined in one valve-body or -chamber. Each valve has a separate opening below it to which a pipe can be connected, but the chamber above the valves is common to all	used in hydraulics as well as pneumatics, and can be used to mount valves or to consolidate plumbing	Lightweight and compact size. Economical Leakage resistant and efficient. Convenient, neat and easily serviced	Non-repairable Cartridges. Used for Logistics. Is Non-standard cartridges Cost
Pinch Valve	A pinch valve is a full bore or fully ported type of control valve	Bulk and solids handling, Cement industry	Low & easy maintenance Low weight	Temperature range is limited Medium

	which uses a pinching effect to obstruct fluid flow	Wastewater industry, Chemical industry/Food industry Beverage industry, Ceramic-/Glass-/Plastic industry.	No clogging or dead spots Compact, simple, robust & straight through design Less air consumption Self-cleaning	operating pressure is limited Face to face length may be an issue when limited space for fitting the valve is available.
Relief Valve 	A relief valve or pressure relief valve (PRV) is a type of safety valve used to control or limit the pressure in a system	used in a wide range of specifications where pressure levels are critical for smooth operations such as oil and gas, petrochemical, and power generation using steam, air, gas or liquid.	Relieving pressure not affected by back pressure Can handle higher built-up back pressure Protects spring from corrosion	Bellows susceptible to fatigue/rupture May release flammables/toxics to atmosphere Requires separate venting system
Ball Valve	a one-way valve that is opened and closed by pressure on a ball which fits into a cup-	used in the oil and natural gas industry also find a place in many manufacturing sectors, chemical	Quick quarter turn on-off operation Tight sealing with low	Not suitable for sustained throttling applications In slurry or

	shaped opening. Used for flow and pressure control and shut off for corrosive fluids, slurries, liquids and gases.	storage, and residential uses	torque Smaller in size than most other valves	other applications, the suspended particles can cause wear, leakage, or valve failure
Butterfly Valve 	a valve consisting of two semicircular clappers hinged to a cross rib that permits fluid flow in only one direction	Cooling water, air, gases, fire protection etc. Slurry and similar services, Vacuum services, water and steam services. Compressed Air or Gas Applications	Easy and fast to open. Require less material due to their design. have less space requirements The reduced level of wear allows the useful life of the valve to be longer	A certain part of the disc always faces the flow, even when completely opened It has a poor sealing function Throttling by employing butterfly valves is restricted to low-pressure drop systems

Diaphragm Valve  The image shows two views of a diaphragm valve. The top view is an external perspective of a blue valve with a handwheel. The bottom view is a cross-section showing the internal components: a valve body, a diaphragm, and a cover. The diaphragm is a flexible material that separates the two flow paths, preventing contamination.	a valve opened or closed by pressure of or against a diaphragm	initially developed for industrial applications and pipe-organs. Later on the design was adapted for use in the bio-pharmaceutical industry by using compliant materials that can withstand sanitizing and sterilizing methods. What's more, sanitary diaphragm valves are specially designed with the highest standard for applications in manufacturing of medicine and food.	Simple structure, consisting of only three parts: a valve body, a diaphragm and a cover During the operation, the medium only contacts with the diaphragm, so the valve is not easily contaminated. Suitable for transporting corrosive, viscous liquids	Not suitable for larger pipe diameters Poor pressure resistance and temperature resistance
Gate Valve  The image shows two views of a gate valve. The top view is an external perspective of a grey valve with a handwheel. The bottom view is a cross-section showing the internal components: a gate, a body/bonnet connection, a seat, and packing. The gate is a sliding part that controls the extent of the aperture.	a valve with a sliding part that controls the extent of the aperture	used in demanding environments such as high temperature and high pressure environments. They are often seen in power plants, water treatment, mining, and offshore applications	Small fluid resistance, Sealing surface won't be eroded by the medium easily. Labor-saving operation. The flow direction of medium is not restricted, no disturbed flow, reducing the pressure.	It's easy to cause erosion and abrasion between the sealing surface; It's difficult for maintenance. The dimension is bigger; It needs certain space to open and a longer opening and closing time. The structure is relatively complex.

Globe Valve 	Globe valves are linear motion valves that are widely employed to stop, start and throttle flow	Cooling water systems Fuel oil systems Feedwater or chemical feed systems Boiler and main steam vents and drains Turbine lube oil system and others	Good shutoff capability Moderate to good valve throttling Easy to machine or resurface the seats Can be used as a stop-check valve	Higher pressure drop (compared to a gate valve) Requires greater force or a larger actuator to seat the valve
Needle Valve 	valves are widely used to accurately regulate the flow of liquids and gases at low flow rates. The fine threading of the stem and the large seat area allow for precise resistance to flow.	used in vacuum systems used in low-pressure hydraulic systems, chemical processing, and other gas and liquid services anywhere control or metering of steam, air, gas, oil, water or other non-viscous liquids is required	good flow control ability to allow high pressure ratings	Incompatibility with high-flow situations unable to make an educated guess about the needle's location
Solenoid Valve  Cont'd	A solenoid valve is an electromechanical device used for controlling liquid or gas flow. The solenoid valve is controlled by an electrical current, which is run through a coil. When the coil is energized,	used extensively in large number of devices that are used in various industries like refrigeration, air conditioning, automobiles, hydraulics, pneumatics	The external leakage can be completely blocked and the internal leakage can also be easily controlled The operation is simple and the price is low	Control signal must stay on during operation Solenoid valves have a difficult time with dirty or contaminated fluids/gases.

	a magnetic field is created, causing a plunger inside the coil to move.			
Check Valve 	Self-activating safety valves that permit gases and liquids to flow in only one direction. The purpose of a check valve is to prevent process flow from reversing in the system which could damage equipment or upset the process. They're classified as one-way directional valves	Can be seen in industries such as refining, petrochemical, chemical, etc., oilfield production, water, steam, refining petroleum, and viscous fluids. Also commonly found in waste-water management systems and in manufacturing.	Prevents backflow Maintains pressure. Can be used horizontally as well as vertically	Can't be used with pulsating systems. Closing element may slam close causing damage and excessive wear

Safety Thread in Unit Operations CHEG 3302

- **Operating Procedure**

CHEG 3023 Unit Operations

Assignment on Hydraulic Loss

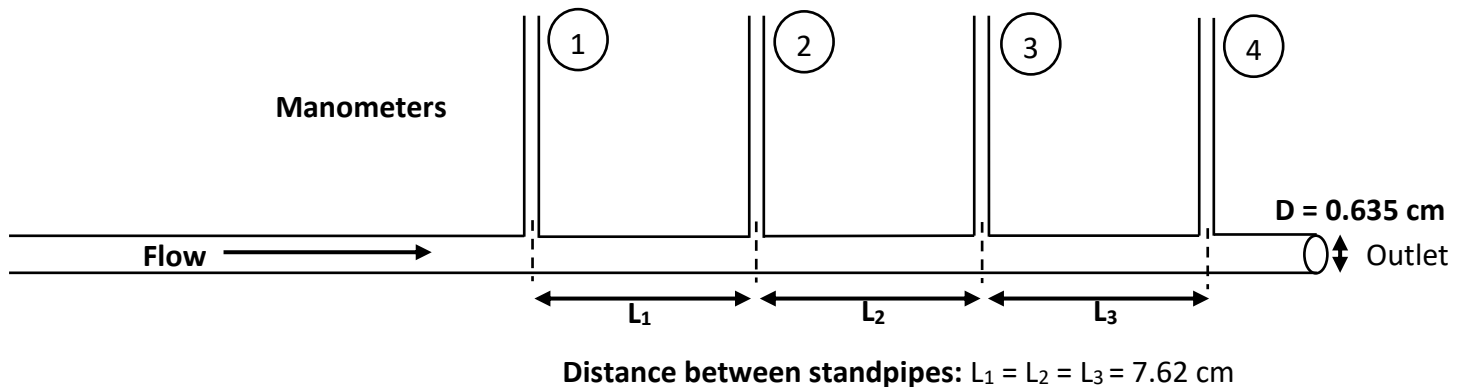
Name(s): _____

Fill in all sections – These are today's notes

Student Learning Objectives

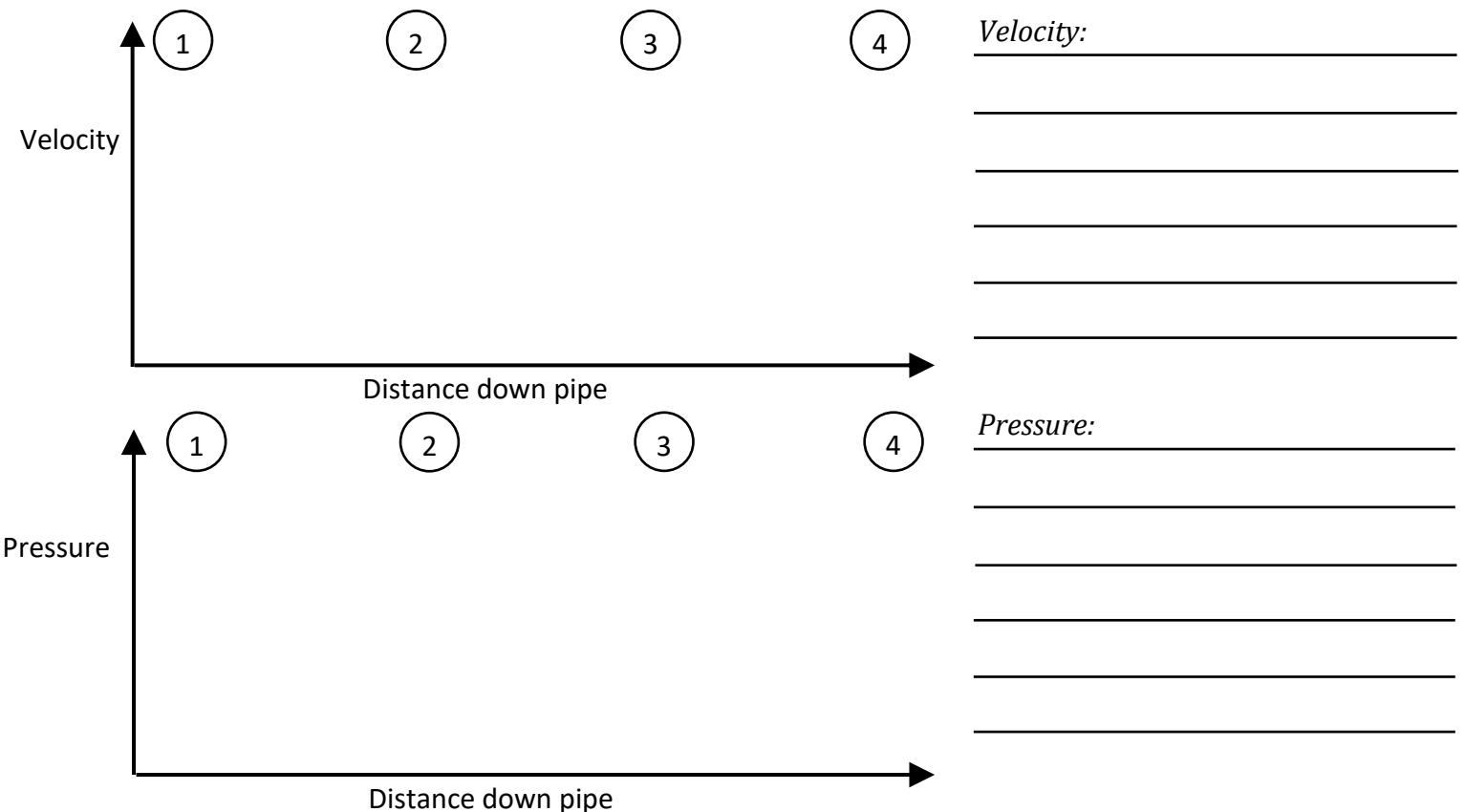
1. Use the continuity equation and mechanical energy balance to predict velocity and pressure trends in a pipe
2. Measure frictional head loss
3. Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss
4. Calculate theoretical head loss values and compare to measured head loss values
5. Demonstrate how/if gravity affects the velocity along the length of a tilted pipe

DLM Schematic and Dimensions



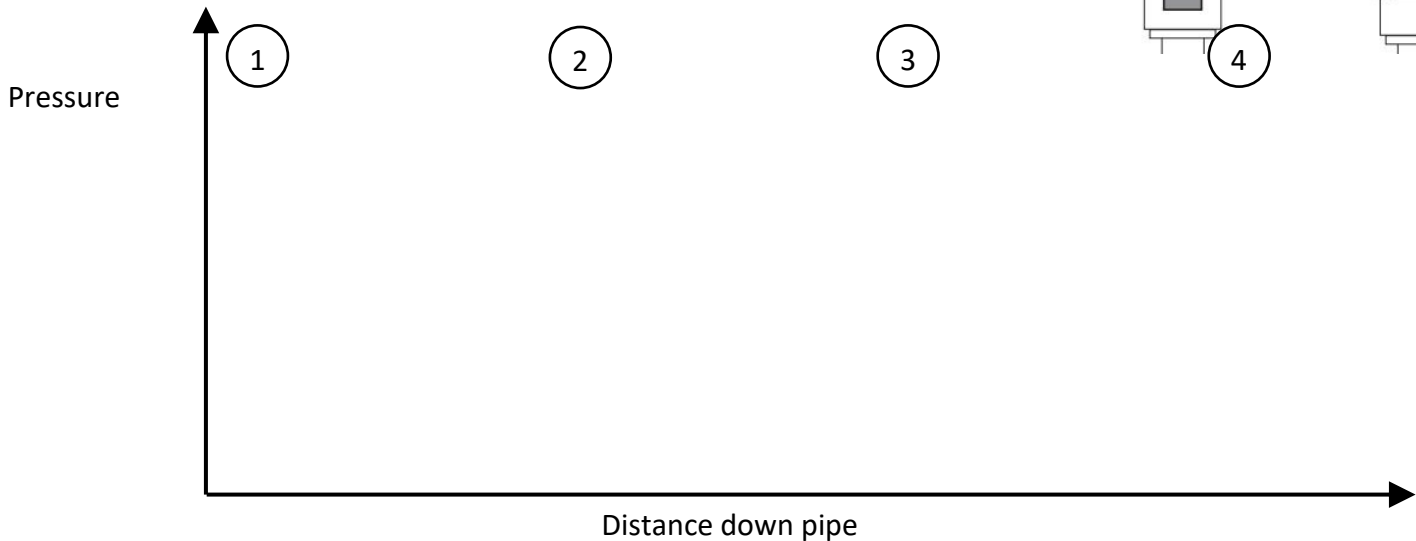
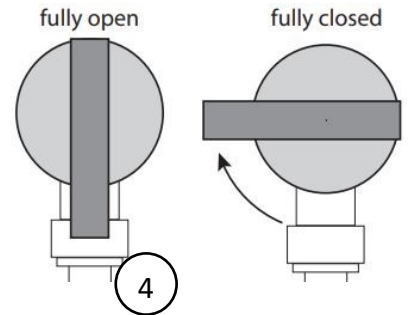
Before Assembling your DLM:

Draw lines for predicted velocity and pressure trends as water travels down the pipe. Explain your reasoning.



Velocity and Pressure Trends in a Pipe

1. Start pump with the valve fully open (see schematics). Remove bubbles from the manometers by squeezing the inlet tube.
2. Observe water heights in manometer tubes. Plot the pressure trend below. Remember that pressure is proportional to water column height.

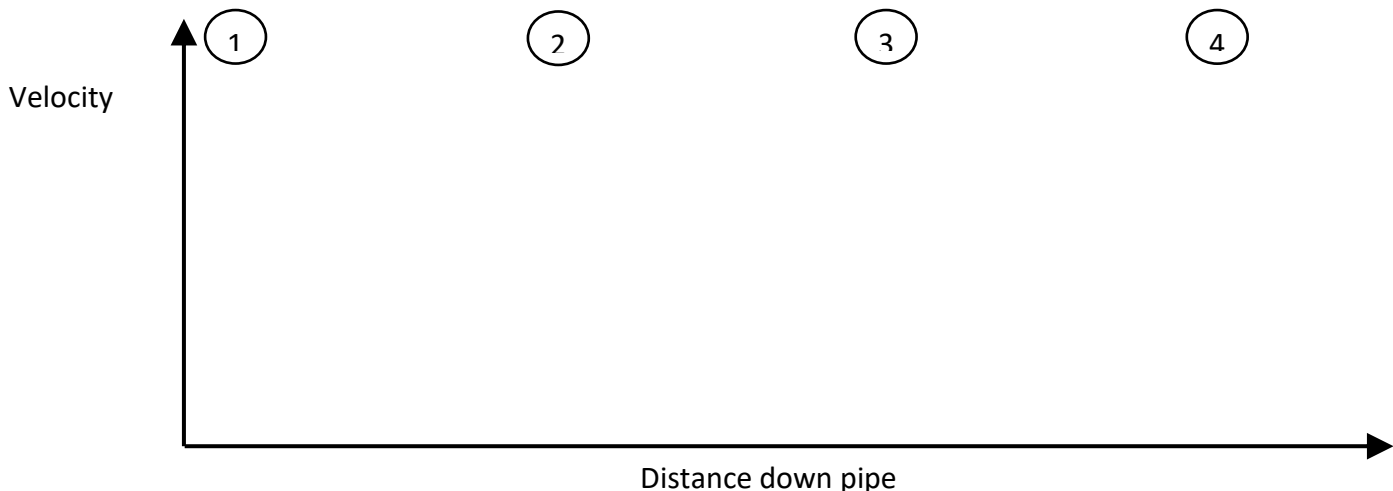


3. Discuss why you observe the pressure trend above. How does pressure vary with pipe length? How does pressure drop vary with pipe diameter? The equation below may help you understand.

$$\Delta P = \frac{fL\rho\bar{v}^2}{2D}$$

f = Darcy friction factor (defined in homework section), $\bar{v}$ = average fluid velocity, D = pipe diameter, L = pipe length, ρ = fluid density

4. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch “Flow tracing with bubbles (slow-motion cell-phone video),” located near the bottom of the page. Based on the speed of the bubbles as they move through the pipe, plot the velocity trend between points 1-4.



5. Discuss why you observe the velocity trend above. Does the velocity vary with pipe length? The continuity equation between two points, i and j , may help you understand.

$$\bar{v}_i A_{x,i} \rho_i = \bar{v}_j A_{x,j} \rho_j$$

$\bar{v}$ = average fluid velocity

A_x = cross sectional area

ρ = fluid density

6. The mechanical energy balance for steady, incompressible, one-dimensional flow in terms of energy per unit mass between two points, i and j , is given below:

$$\frac{P_i}{\rho} + \frac{\bar{v}_i^2}{2} + gZ_i + W_p = \frac{P_j}{\rho} + \frac{\bar{v}_j^2}{2} + gZ_j + h_L$$

where W_p is the pump work, if a pump or turbine exists between points i and j , h_L is the irreversible headloss, and $\frac{P}{\rho}$, $\frac{\bar{v}^2}{2}$, and gZ are the flow work, kinetic energy, and potential energy per unit mass, respectively.

Simplify the equation above between manometers 1 and 4 (note there's no pump between 1 and 4). Based on the simplified equation, why does the pressure change from manometer position 1 to 4?

Flowrate and Frictional Head Loss

7. a. Open the valve till water is not leaking from the top of manometer 1. Measure volumetric flow rate with a beaker and a cell phone timer. Record the water column heights at manometers 1 & 4
- b. Repeat twice by **partially closing** the valve to different positions and record the data in Table 1.

Table 1

Valve setting	t [sec]	V [cm ³]	h ₁ (cm)	h ₄ (cm)
Fully open				

Partially closed position (1)				
Partially closed position (2)				

8. Based on your data in Table 1, taking $h_1 - h_4$ as the pressure head loss, how do the velocity, related to the volumetric flowrate (V/t) divided by the cross-sectional area, and the Reynolds number affect the pressure loss?

Gravity and Flowrate

9. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch “Bubbles in a Tilted Pipe,” located at the bottom of the page. Based on the speed of the bubbles as they move through the tilted pipe, how does gravity affect fluid velocity as flow continues down the pipe? Discuss why velocity changes or remains constant.

Homework Problems

Due: _____

- Calculate and record the volumetric flow rate, velocity, measured pressure drop (head loss), and Reynolds number for each of the valve positions in Table 1 using data collected during class.

$$Re = \frac{\rho \bar{v} D}{\mu}$$

Valve setting	$\dot{V} = \frac{V}{t}$ [cm ³ /s]	$\bar{v} = \frac{\dot{V}}{A_x}$ [cm/s]	$\Delta P = \rho g(h_1 - h_4)$ [Pa]	Re
Fully open				
Partially closed position (1)				
Partially closed position (2)				

- The pressure drop in a section of pipe can be calculated as a function of the Darcy friction factor:

$$\Delta P = \frac{f L \rho \bar{v}^2}{2D}$$

where f is the Darcy friction factor shown below for laminar flow, as derived from first principles, and for turbulent flow using one of the common correlations.

$$\text{For laminar flow: } f = \frac{64}{Re}$$

$$\text{For turbulent flow in **smooth pipes**: } f = 0.0014 + \frac{0.125}{Re^{0.32}}$$

Note: For non-ideal, rough pipes, a friction factor correlation that includes a term to account for relative pipe roughness, $\frac{\epsilon}{D}$, should be used

Calculate the theoretical pressure loss between manometers 1 and 4 for each valve position in Table 1 using **both** the laminar and turbulent correlations for the friction factor.

Valve setting	ΔP_{theory} from $f_{laminar}$	ΔP_{theory} from $f_{turbulent}$	$\Delta P_{measured}$
Fully open			
Partially closed position (1)			
Partially closed position (2)			

- Which friction factor relationship gives values closest to your experimental values for each experiment? Discuss what you learn from using the applicable and non-applicable friction factor relationships in each case.

4. Summarize in 1-2 sentences what you learned for each of the learning objectives below.

- Use the continuity and mechanical energy equations to predict velocity and pressure trends in a pipe:
- Determine how to measure frictional head loss:
- Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss:
- Calculate theoretical head loss values for laminar and turbulent flow; compare to LCDLM measured head loss values:
- Demonstrate how/if gravity affects the velocity along the length of a tilted pipe:

Student Work

Above Average

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe – ChE

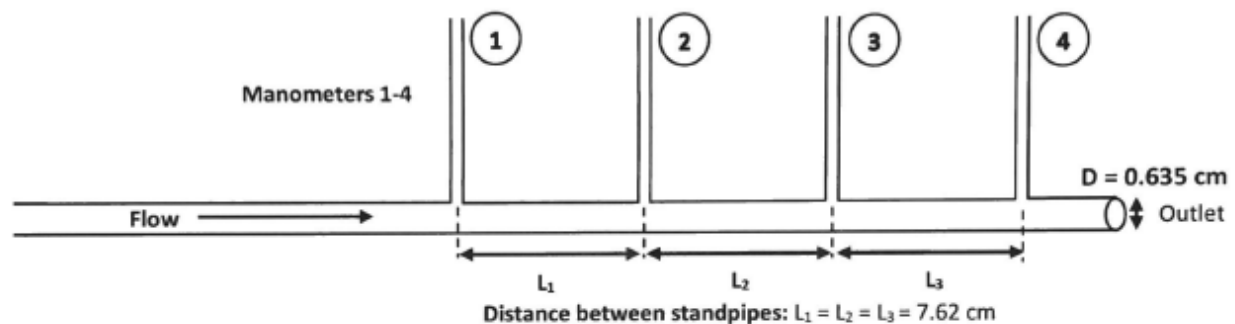
Name(s): Taylor Owens

Fill in all sections – These are today's notes

Student Learning Objectives

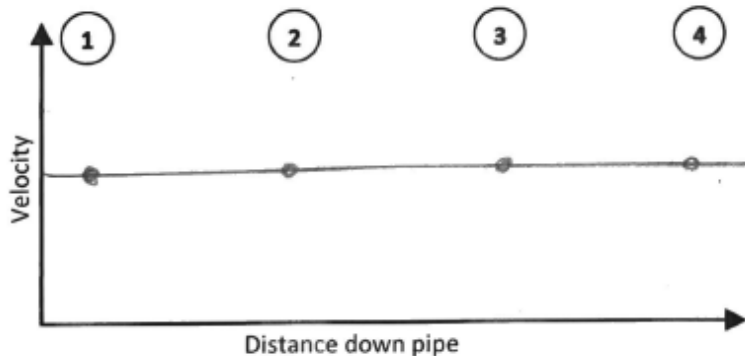
1. Use the continuity equation and mechanical energy balance to predict velocity and pressure trends in a pipe
2. Measure frictional head loss
3. Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss
4. Calculate theoretical head loss values and compare to measured head loss values
5. Demonstrate how/if gravity affects the velocity along the length of a tilted pipe

DLM Schematic and Dimensions



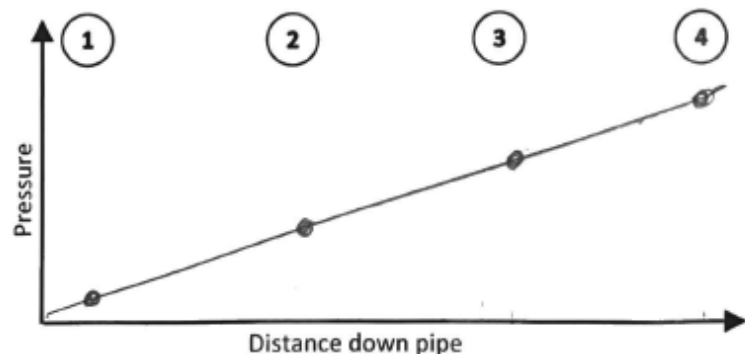
Before Assembling your DLM:

Draw lines for predicted velocity and pressure trends as water travels down the pipe. Explain your reasoning.



Velocity:

There will be no change in velocity b/c the pipe diameter is constant.



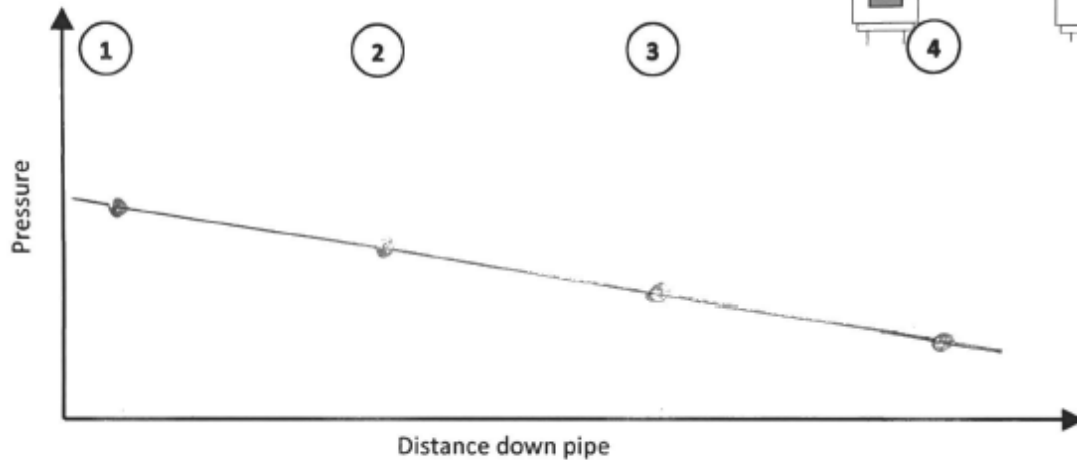
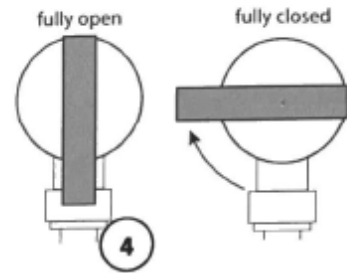
Pressure:

Pressure will increase to account for the increase in distance down the pipe.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe – ChE

Velocity and Pressure Trends in a Pipe

1. Start pump with the valve fully open (see schematics). Remove bubbles from the manometers by squeezing the inlet tube.
2. Observe water heights in manometer tubes. Plot the pressure trend below. Remember that pressure is proportional to water column height.



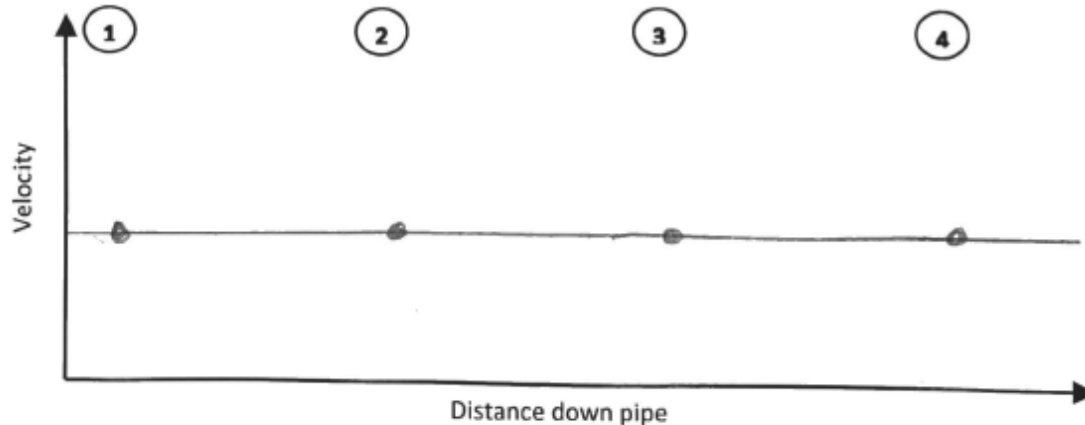
3. Discuss why you observe the pressure trend above. How does pressure vary with pipe length? How does pressure drop vary with pipe diameter? The equation below may help you understand.

$$\Delta P = \frac{fL\rho\bar{v}^2}{2D}$$

f = Darcy friction factor (defined in homework section), $\bar{v}$ = average fluid velocity, D = pipe diameter, L = pipe length, ρ = fluid density

The pressure decreased as the pipe length increased. This means that as L increases, the pressure decreases. Conversely, as D increases, pressure drop decreases because D is causing the ΔP to become smaller.

4. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch "Flow tracing with bubbles (slow-motion cell-phone video)," located near the bottom of the page. Based on the speed of the bubbles as they move through the pipe, plot the velocity trend between points 1-4.



Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe – ChE

5. Discuss why you observe the velocity trend above. Does the velocity vary with pipe length? The continuity equation between two points, i and j , may help you understand.

No velocity does not vary with pipe length, but rather with pipe diameter. This is because density and length between the two pipes will always be the same however if you increase the diameter, you increase the area, thus decreasing the velocity.

$$\bar{v}_i A_{x,i} \rho_i = \bar{v}_j A_{x,j} \rho_j$$

$\bar{v}$ = average fluid velocity

A_x = cross sectional area

ρ = fluid density

6. The mechanical energy balance for steady, incompressible, one-dimensional flow in terms of energy per unit mass between two points, i and j , is given below:

$$\frac{P_i}{\rho} + \frac{\bar{v}_i^2}{2} + gZ_i + W_p = \frac{P_j}{\rho} + \frac{\bar{v}_j^2}{2} + gZ_j + h_L$$

where W_p is the pump work, if a pump or turbine exists between points i and j , h_L is the irreversible headloss, and $\frac{P}{\rho}$, $\frac{\bar{v}^2}{2}$, and gZ are the flow work, kinetic energy, and potential energy per unit mass, respectively.

Simplify the equation above between manometers 1 and 4 (note there's no pump between 1 and 4). Based on the simplified equation, why does the pressure change from manometer position 1 to 4?

$\frac{P_1 - P_4}{\rho} = h_L$; Pressure changes because the headloss due to friction increases as the length of the pipe increases. This causes a decrease in pressure from point 1 to point 4.

Flowrate and Frictional Head Loss

7. a. Open the valve till water is not leaking from the top of manometer 1. Measure volumetric flow rate with a beaker and a cell phone timer. Record the water column heights at manometers 1 & 4
- b. Repeat twice by **partially closing** the valve to different positions and record the data in Table 1.

Table 1

Valve setting	t [sec]	V [cm ³]	h ₁ (cm)	h ₄ (cm)
Fully open	23.52	625	9.5	5.0
Partially closed position (1)	26.33	575	7.6	3.0
Partially closed position (2)	28.94	550	3.7	1.4

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe – ChE

8. Based on your data in Table 1, taking $h_1 - h_4$ as the pressure head loss, how do the velocity, related to the volumetric flowrate (V/t) divided by the cross-sectional area, and the Reynolds number affect the pressure loss?

As velocity decreased, the pressure loss increased. This is expected because of Bernoulli's principle. Also we were able to observe that a decrease in Reynolds number leads to a decrease in pressure loss

Gravity and Flowrate

9. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch "Bubbles in a Tilted Pipe," located at the bottom of the page. Based on the speed of the bubbles as they move through the tilted pipe, how does gravity affect fluid velocity as flow continues down the pipe? Discuss why velocity changes or remains constant.

Gravity caused more bubbles to flow through the pipe, but the velocity was still constant because the diameter did not change.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

Homework Problems

Due: 10/30/2020

- Calculate and record the volumetric flow rate, velocity, measured pressure drop (head loss), and Reynolds number for each of the valve positions in Table 1 using data collected during class.

$$Re = \frac{\rho \bar{v} D}{\mu} \quad \rho = \left(\frac{kg}{m^3} \right) \left(\frac{m}{s} \right) (m) \quad Re = \frac{(1000) \left(\frac{0.083}{s} \right) (0.025)}{0.001} = 20750$$

Valve setting	$\dot{V} = \frac{V}{t}$ [cm ³ /s]	$\bar{v} = \frac{\dot{V}}{A_x}$ [cm/s]	$\Delta P = \rho g(h_1 - h_4)$ [Pa]	Re
Fully open	26.57	83.91	441.45	5328.29
Partially closed position (1)	21.84	68.96	451.26	4378.96
Partially closed position (2)	19.00	60.01	225.63	3848.74

- The pressure drop in a section of pipe can be calculated as a function of the Darcy friction factor:

$$\Delta P = \frac{f L \rho \bar{v}^2}{2D}$$

where f is the Darcy friction factor shown below for laminar flow, as derived from first principles, and for turbulent flow using one of the common correlations.

$$\text{For laminar flow: } f = \frac{64}{Re}$$

$$\text{For turbulent flow in smooth pipes: } f = 0.0014 + \frac{0.125}{Re^{0.32}}$$

Note: For non-ideal, rough pipes, a friction factor correlation that includes a term to account for relative pipe roughness, $\frac{\epsilon}{D}$, should be used

Calculate the theoretical pressure loss between manometers 1 and 4 for each valve position in Table 1 using **both** the laminar and turbulent correlations for the friction factor.

Valve setting	ΔP_{theory} from $f_{laminar}$	ΔP_{theory} from $f_{turbulent}$	$\Delta P_{measured}$
Fully open	152.22 Pa	119.44 Pa	441.45
Partially closed position (1)	125.11 Pa	85.12 Pa	451.26
Partially closed position (2)	107.79 Pa	66.80 Pa	225.63

- Which friction factor relationship gives values closest to your experimental values for each experiment? Discuss what you learn from using the applicable and non-applicable friction factor relationships in each case.

Laminar gives the closest values, however neither were really close to the experimental values. The fact that laminar is closer is strange because our Reynolds # implies that we have turbulent flow. What I learned is that using the non-applicable friction factor will yield closer results than the applicable one.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

4. Summarize in 1-2 sentences what you learned for each of the learning objectives below.

- Use the continuity and mechanical energy equations to predict velocity and pressure trends in a pipe:

From continuity I learned how changing the pipe diameter directly impacts the velocity trends in a pipe. I also learned that frictional head loss is inversely related to pressure trends in a pipe.

- Determine how to measure frictional head loss:

You can measure frictional head loss by starting with the mechanical energy balance equation and simplifying it to fit your system. In our case, we were able to simplify the equation to the frictional head loss equals the change in pressure from i to j divided by density.

- Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss:

These three relate to frictional head loss because if you increase the pipe diameter, you increase Reynolds # and if you increase Reynolds #, you increase pressure loss, and an increase in pressure loss leads to an increase in frictional head loss. Also as you increase length of the pipe, you increase the frictional head loss due to the loss of pressure.

- Calculate theoretical head loss values for laminar and turbulent flow; compare to LCDLM measured head loss values:

I learned how Darcy's friction factor impacts the values through the utilization of Reynolds #. What I also learned is that the non-applicable theoretical value was closer to the measured value than the applicable value.

- Demonstrate how/if gravity affects the velocity along the length of a tilted pipe:

I learned gravity does not impact the velocity along the tilted pipe because the pipe diameter is still constant.

Student Work

Average

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

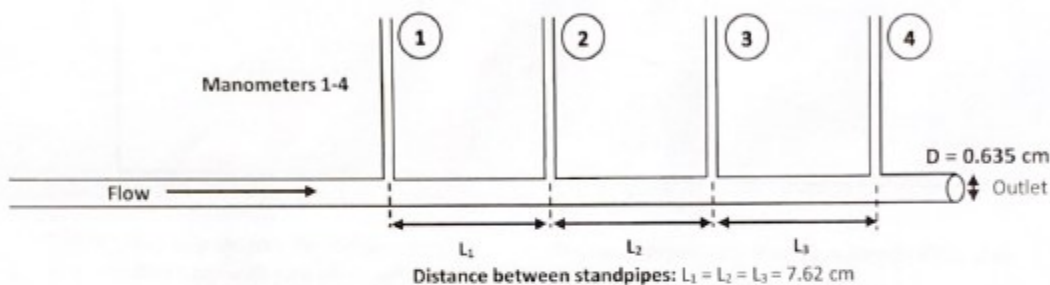
Name(s): Amiya Rogers

Fill in all sections - These are today's notes

Student Learning Objectives

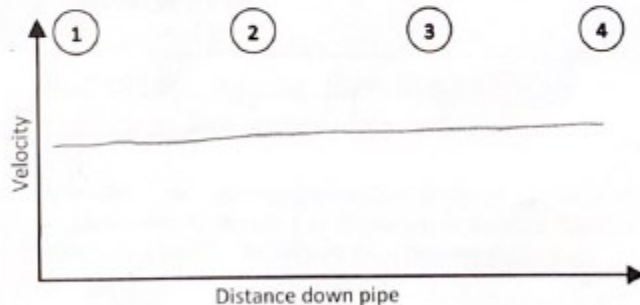
1. Use the continuity equation and mechanical energy balance to predict velocity and pressure trends in a pipe
2. Measure frictional head loss
3. Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss
4. Calculate theoretical head loss values and compare to measured head loss values
5. Demonstrate how/if gravity affects the velocity along the length of a tilted pipe

DLM Schematic and Dimensions

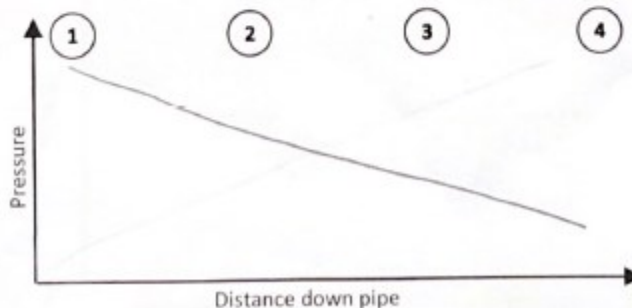


Before Assembling your DLM:

Draw lines for predicted velocity and pressure trends as water travels down the pipe. Explain your reasoning.



Velocity: The velocity will remain constant as water travels through the pipe because the diameter remains 0.635 cm throughout the length of the pipe.

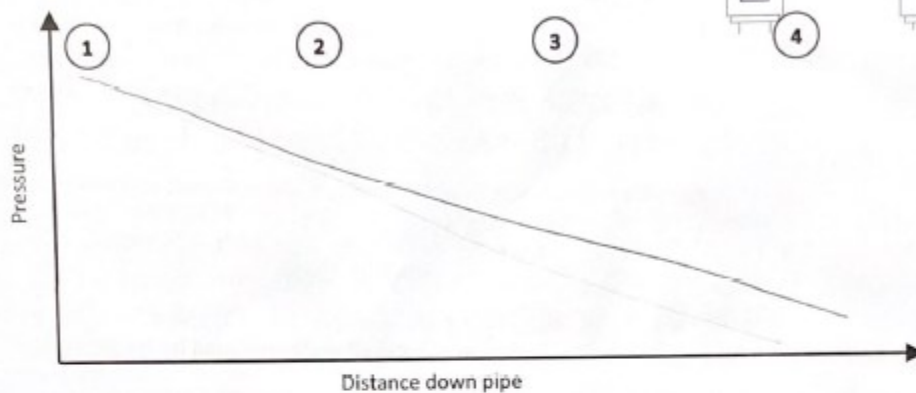
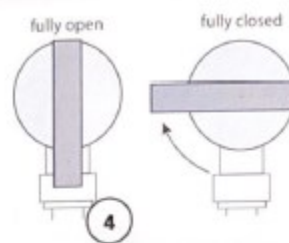


Pressure: Practically thinking, pressure cannot remain high or constant throughout a long pipe, so a change must happen. Pressure is higher when it first enters the pipe & decreases the longer the pipe is.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe – ChE

Velocity and Pressure Trends in a Pipe

1. Start pump with the valve fully open (see schematics). Remove bubbles from the manometers by squeezing the inlet tube.
2. Observe water heights in manometer tubes. Plot the pressure trend below. Remember that pressure is proportional to water column height.



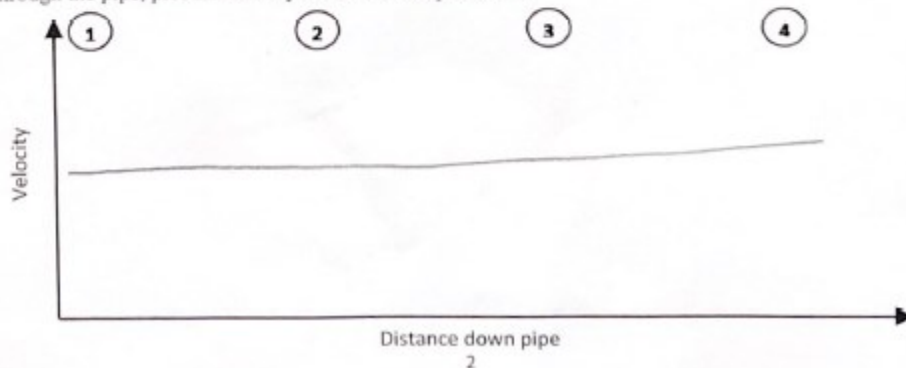
3. Discuss why you observe the pressure trend above. How does pressure vary with pipe length? How does pressure drop vary with pipe diameter? The equation below may help you understand.

$$\Delta P = \frac{fL\rho\bar{v}^2}{2D}$$

f = Darcy friction factor (defined in homework section), $\bar{v}$ = average fluid velocity, D = pipe diameter, L = pipe length, ρ = fluid density

Pressure decreases as the length of the pipe increases. Pressure increases as the pipe diameter decreases and as diameter increases, pressure decreases

4. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch "Flow tracing with bubbles (slow-motion cell-phone video)," located near the bottom of the page. Based on the speed of the bubbles as they move through the pipe, plot the velocity trend between points 1-4.



Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

5. Discuss why you observe the velocity trend above. Does the velocity vary with pipe length? The continuity equation between two points, i and j , may help you understand.

As long as diameter is constant, velocity across the pipe is also constant no matter what the length of the pipe is. If diameter increases, area increases making velocity decrease.

density is constant -2

$$\rho_i A_{x,i} v_i = \rho_j A_{x,j} v_j$$

$\bar{v}$ = average fluid velocity

A_x = cross sectional area

ρ = fluid density

6. The mechanical energy balance for steady, incompressible, one-dimensional flow in terms of energy per unit mass between two points, i and j , is given below:

$$\frac{P_i}{\rho} + \frac{\bar{v}_i^2}{2} + gZ_i + W_p = \frac{P_j}{\rho} + \frac{\bar{v}_j^2}{2} + gZ_j + h_L$$

where W_p is the pump work, if a pump or turbine exists between points i and j , h_L is the irreversible headloss, and $\frac{P}{\rho}$, $\frac{\bar{v}^2}{2}$, and gZ are the flow work, kinetic energy, and potential energy per unit mass, respectively.

Simplify the equation above between manometers 1 and 4 (note there's no pump between 1 and 4). Based on the simplified equation, why does the pressure change from manometer position 1 to 4?

The above equation is simplified to $\frac{P_i}{\rho} - \frac{P_j}{\rho} = h_L$. Pressure changes from the manometer position 1 to 4 due to the friction headloss increasing. As the length of the pipe increases, pressure decreases from point 1 to 4.

Flowrate and Frictional Head Loss

7. a. Open the valve till water is not leaking from the top of manometer 1. Measure volumetric flow rate with a beaker and a cell phone timer. Record the water column heights at manometers 1 & 4
- b. Repeat twice by **partially closing** the valve to different positions and record the data in Table 1.

Table 1

Valve setting	t [sec]	V [cm ³]	h_1 (cm)	h_4 (cm)
Fully open	23.62	425	9.5	5
Partially closed position (1)	20.33	576	7.4	3
Partially closed position (2)	28.94	550	3.7	1.4

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

8. Based on your data in Table 1, taking $h_1 - h_4$ as the pressure head loss, how do the velocity, related to the volumetric flowrate (V/t) divided by the cross-sectional area, and the Reynolds number affect the pressure loss?

Velocity decreases as the cross-sectional area increases due to diameter increasing. When the diameter increases, head loss reduces. Large Reynolds numbers result in low friction factors. Low Reynolds numbers result in high friction factors. The relationship between friction factor & head loss is directly proportional.

Gravity and Flowrate

9. Go to <https://labs.wsu.edu/educ-ate/tutorial-videos/> and watch "Bubbles in a Tilted Pipe," located at the bottom of the page. Based on the speed of the bubbles as they move through the tilted pipe, how does gravity affect fluid velocity as flow continues down the pipe? Discuss why velocity changes or remains constant.

Gravity does not affect fluid velocity as flow continues down the pipe. Since the diameter of the pipe is constant, velocity remains constant. If the diameter of the pipe increases, area increases, thus causing velocity to decrease due to the continuity equation.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

Homework Problems

Due: 10/30/2020

- Calculate and record the volumetric flow rate, velocity, measured pressure drop (head loss), and Reynolds number for each of the valve positions in Table 1 using data collected during class.

$$Re = \frac{\rho \bar{v} D}{\mu}$$

Valve setting	$\dot{V} = \frac{V}{t}$ [cm ³ /s]	$\bar{v} = \frac{\dot{V}}{A_x}$ [cm/s]	$\Delta P = \rho g(h_1 - h_4)$ [Pa]	Re
Fully open	20.67	83.90	441.45	8321.05
Partially closed position (1)	21.84	88.90	451.20	4378.90
Partially closed position (2)	19.00	59.99	225.03	3809.37

- The pressure drop in a section of pipe can be calculated as a function of the Darcy friction factor:

$$\Delta P = \frac{f L \rho \bar{v}^2}{2D}$$

where f is the Darcy friction factor shown below for laminar flow, as derived from first principles, and for turbulent flow using one of the common correlations.

$$\text{For laminar flow: } f = \frac{64}{Re}$$

$$\text{For turbulent flow in smooth pipes: } f = 0.0014 + \frac{0.125}{Re^{0.32}}$$

Note: For non-ideal, rough pipes, a friction factor correlation that includes a term to account for relative pipe roughness, $\frac{\epsilon}{D}$, should be used

Calculate the theoretical pressure loss between manometers 1 and 4 for each valve position in Table 1 using **both** the laminar and turbulent correlations for the friction factor.

Valve setting	ΔP_{theory} from $f_{laminar}$	ΔP_{theory} from $f_{turbulent}$	$\Delta P_{measured}$
Fully open	152.05 Pa	119.10 Pa	441.45 Pa
Partially closed position (1)	124.97 Pa	84.74 Pa	451.20 Pa
Partially closed position (2)	108.83 Pa	66.72 Pa	225.03 Pa

- Which friction factor relationship gives values closest to your experimental values for each experiment?

Discuss what you learn from using the applicable and non-applicable friction factor relationships in each case. The friction factor relationship that gives values closest to my experimental values is f for laminar flow. I learned that using non-applicable friction factor relationships will give us more larger results than applicable friction factor relationships.

Worksheet: Continuity and Hydraulic Loss in a Smooth Pipe - ChE

4. Summarize in 1-2 sentences what you learned for each of the learning objectives below.

- Use the continuity and mechanical energy equations to predict velocity and pressure trends in a pipe:

Due to the continuity equation, changing the pipe's diameter impacts the velocity. Due to the mechanical energy equation, I was able to determine that pressure is inversely related to head loss in a pipe.

- Determine how to measure frictional head loss:

I learned that frictional head loss can be measured using the Darcy equation. I also learned that Reynolds number is important when calculating head loss because it determines our friction factor.

- Demonstrate how Reynolds number, pipe length, and pipe diameter affect frictional head loss:

Reynolds number is inversely proportional to frictional head loss. Large Reynolds number results in small friction factor which ends in small head loss. Pipe length is directly proportional to head loss and pipe diameter is inversely proportional to head loss.

- Calculate theoretical head loss values for laminar and turbulent flow; compare to LCDLM measured head loss values:

As previously stated, I learned that Reynolds number impacts the value of friction factor. When calculating head loss, I learned that non-applicable friction factor relationships gives us larger results than applicable friction factor relationships.

- Demonstrate how gravity affects the velocity along the length of a tilted pipe:

Gravity does not affect the velocity along the length of a tilted pipe. This is because the pipe diameter is constant.

Assignment

Instructor: Dr. Nabila Shamim

Assistant Professor, Department of Chemical Engineering, Prairie View A & M University

ABET OUTCOME 6: An ability to develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions

Experiment 1

Flow rate Average velocity and Reynold's number

Water at 25oC is flowing in a circular pipe. The velocity of the flowing fluid was measured as a function of radial position. The data are summarized in the Table below.

Table 1: Velocity Radial Position data

Position, cm	Velocity, cm/s	Position, cm	Velocity, cm/s
0	10	0.6	6.4
0.1	9.9	0.7	5.1
0.2	9.6	0.8	3.6
0.3	9.1	0.9	1.9
0.4	8.4	1.0 (wall)	0
0.5	7.5		

1. Draw the schematic diagram of the process
2. Calculate the flowrate for each velocity
3. Calculate average velocity and Reynolds number if the fluid is water at 25oC.
4. Is the flow laminar or turbulent?
5. What is the shear force exerted at the pipe surface?

Grading Rubric

- | | |
|--|-----------|
| 1. Problem Statement | 5 Points |
| 2. Objectives | 5 Points |
| 3. Identify the problem (given information) | 5 Points |
| 4. Schematic diagram | 15 Points |
| 5. Formulation of the problem | 15 Points |
| ➤ Step by step show the solution algorithm that is equations that need to be used to solve the problem. | |
| 6. Use a spread sheet to analyze data to calculate above information
(Flowrate for each velocity, average velocity) | 25 Points |
| ➤ Present the raw data in a graphical form | |
| ➤ Explain your observation of the data | |
| ➤ Present the calculated data in tabular form | |
| ➤ Present the calculated data in graphical form
(clearly write the axes name and units) | |
| ➤ Explain your observation | |
| 7. Calculate Reynolds number? Is the flow laminar or turbulent | 10 Points |
| 8. Calculate the shear force exerted on the pipe surface? | 10 Points |
| ➤ Explain your observation | |
| 9. Discuss the results and Draw a conclusion based on your results | 10 Points |

Student Work



CHEG 3023 - Unit Operations Team 2

Utomwen Irabor

Chad Gardner

Oluwatoyosi Idowu

Franck Nangomoko

Shanelle Bryant

Instructor: Dr. Nabila Shamim

Experiment on Flow Rate, Average Velocity, and Reynold's Number

Introduction:

Chemical engineering has to do with industrial processes, where raw materials are processed or separated into useful products. With the application of physics, chemistry, and mathematical methodologies. Chemical engineering can be seen as both art and science. In Unit operations, the focus of study shifts and involves physical change or chemical transformation such as crystallization, filtration, polymerization, and other reactions. However, in this experiment, conducted for research purposes, we will examine in detail the motion of fluid within a circular pipe. We will do this to form an analysis of change in velocities at various positions within the pipe.

Problem Statement:

This experiment will focus on water at 25°C flowing in a circular pipe. The velocity of the flowing fluid was measured as a function of radial position incrementally ranging from the center of the pipe to the boundary layers of the pipe structure. To give an overview of this the velocities and radial positions are listed in the table below for convenience to analyze the volumetric flow rate, mass flow rate, average velocity, and Reynolds's number of the fluid i.e. water at each position.

add table name and number

Position, cm	Velocity, cm/s	Position, cm	Velocity, cm/s
0	10	0.6	6.4
0.1	9.9	0.7	5.1
0.2	9.6	0.8	3.6
0.3	9.1	0.9	1.9
0.4	8.4	1.0(wall)	0
0.5	7.5		

Objective:

The objective of this project is to calculate the flow rate for each velocity given in the table above, the average velocity, and Reynold's number of the fluid (water) at 25°C. In the course of this experiment, we will also determine if the flow of the fluid is laminar or turbulent while determining the shear force being exerted on the pipe's surface as a function of velocity. This project is a collaborative learning assignment, working in teams created in accordance with ABET outcome. To develop and conduct appropriate experimentation, interpret data, and use engineering judgment to draw conclusions. The Department of Chemical Engineering here at Prairie View A&M University highly implore us as students to conduct such approaches to any given situation

Identification of Given Information:

In this experiment, we are given radial positions of a circular pipe from the center of the pipe to the wall. We were also told that the velocity of the fluid from the center of the pipe changes with time. We have acknowledged the fact that, as we move from the center of the pipe mass flow rate decreases as velocity decreases. We are also given the temperature of water to be 25°C. The temperature of the fluid is significant to compute the viscosity (μ) of water. That way, we can conduct calculations for Reynold's number. Below is a schematic diagram displaying the decrease in velocity. Due to the units provided in the datasheet above we assumed that the density of water was ($1\text{g}/\text{cm}^3$) to maintain consistency of cgs units for ease of calculations.

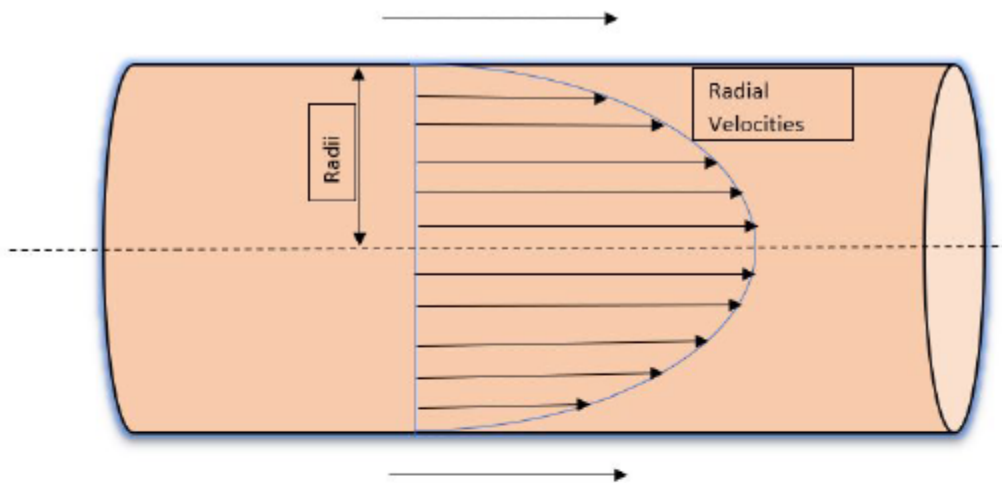


Figure 1: Schematic Diagram of Radial Positions and Velocities

Good

Other Assumptions:

To formulate an understanding or an approach to conducting this experiment a few assumptions had to be made.

- Steady-State Process
- Conservation of mass
- Incompressible fluid
- Newtonian fluid
- Constant viscosity
- No edge effect

Formulas: nicely presented next time give a table name and number

Equation	Equation	Units
Volumetric Flow rate	$= V' \times A$	$\frac{\text{cm}^3}{\text{s}}$
Cross-sectional Area	$A_{\text{CS}} = \pi r^2$	cm^2
Mass Flow rate	$\dot{M} = \rho \times V' \times A$	$\frac{\text{g}}{\text{s}}$
Reynold's Number	$\text{Re} = \rho \bar{V} D / \mu$	Dimensionless
Shear Stress	$= \frac{F}{A}$	$\frac{\text{N}}{\text{m}^2}$

Table 1. Equations utilized in course of calculation.

Spreadsheet Data:

Position, cm	Velocity, cm/s	Vol. Flow Rate (q), cm ³ /s	Area (S), pi*R^2
0	10	0	0
0.1	9.9	0.31086	0.0314
0.2	9.6	1.20576	0.1256
0.3	9.1	2.57166	0.2826
0.4	8.4	4.22016	0.5024
0.5	7.5	5.8875	0.785
0.6	6.4	7.23456	1.1304
0.7	5.1	7.84686	1.5386
0.8	3.6	7.23456	2.0096
0.9	1.9	4.83246	2.5434
1.0	0	0	3.14
		41.34438	

Table 2. Raw data and tabulated Volumetric Flow Rate and Area.

v(r) is the fluid velocity that flows through the small thickness delta r at radial location r then are
 $2 \cdot \pi \cdot r \cdot \text{deltar}$

Mass Flowrate ($\rho \cdot \dot{q}$), g/s	Average Velocity (g/s), cm/s	Shear Stress, N/m ²
41.34438	129.8213532	
	Reynold's Number ($D\bar{V}\rho/\mu$)	
	289.1344169	
	Re<2100 (Laminar)	

how did you calculate
shear stress? -6 shear
force exerted on surface

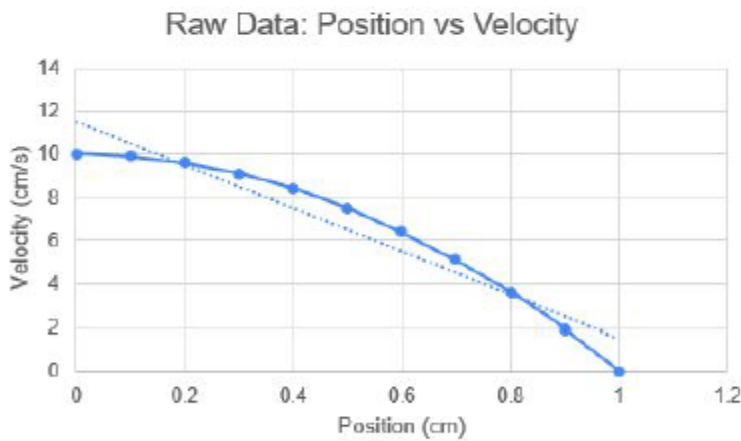
-2

average velocity is total flowrate over area
-5

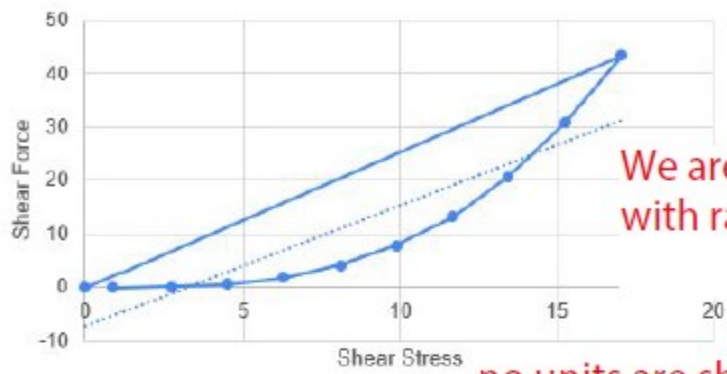
9.878	7.75423
11.674	13.1962896
13.47	20.724942
15.266	30.6785536
17.062	43.3954908
0	0

Flowrate of each Velocity (q)	$V(\pi)r^2$	Density of Water	1g/cm ³
Viscosity at 77F	0.898 cp	q	Volumetric Flowrate
		S	Cross Sectional Area πR^2
		Entire Radius	1.00
		Temperature (K)	298.15

Table 3. Calculated data and appropriate units.



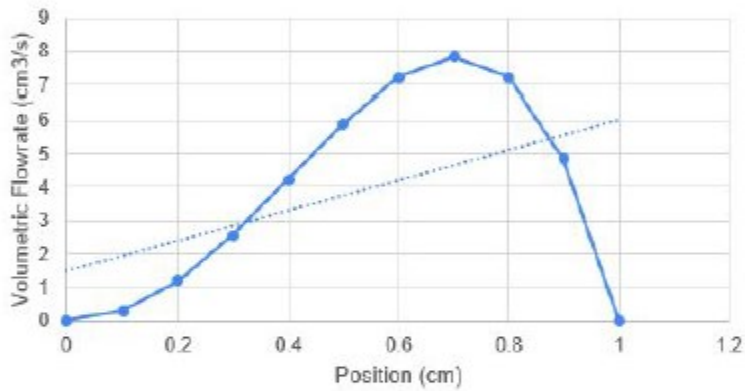
Calculated Data: Shear Stress and Shear Force



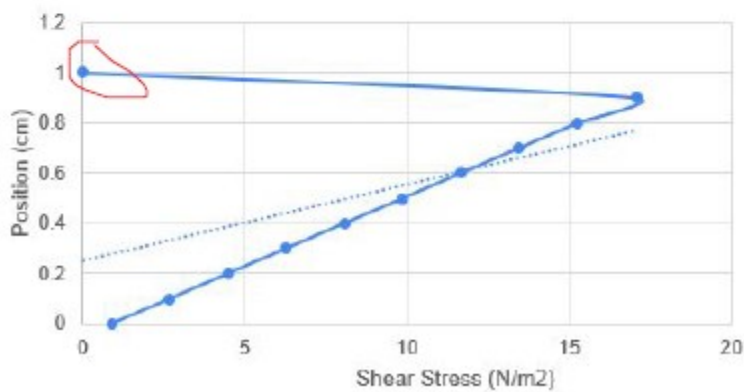
We are looking into changes with radial position

no units are shown -2

Calculated Data: Position vs Flowrate



Calculated Data: Position vs Shear Stress



Observations & Results:

A fluid can be defined as a substance that deforms continuously under applied shear stress regardless of magnitude. When approaching fluid mechanics, we need to know are the fluid properties such as density and viscosity. We also need to know the geometry and boundary conditions. Certain things can be assumed such as incompressibility, and continuum fluid that is, no quantum effect. The fluid molecule at the boundary surface does not move with the flow because the force of adhesion is greater than the force of cohesion.

To calculate the viscosity of water at 25°C, we utilized appendix 6 in the 7th edition of Unit Operations in Chemical Engineering. With the table, we interpolated to find the exact viscosity of water at 25°C which is 0.898 cP. From observing the trend of the shear force, as the radius increases, the force increases until we are at the wall of the circular path. At the wall, the shear force goes to zero. Based on our calculations for the Reynolds number, we can conclude that the flow is laminar since Reynold's number calculated was less than 2100 ($Re < 2100$).

Conclusion:

We were able to prove our assumptions by doing calculations and proving that they are true and that they make sense based on the data we were given. Having conducted this experiment, the overall flow of the fluid in the circular pipe is steady and of laminar motion. This is because it maintained the same magnitude and direction at every point in the flow and the flow is consistent with low velocities at their respective radial positions. This pipe also possesses smooth streamlining. As a result of the pipes' smooth lining, there are no turbulences, ripples, or eddies, or any form of unsteady movement within the pipe justifying a uniform flow.

Drawing from our knowledge and thorough understanding of Transport Phenomena and Unit-operations, we were able to prove that the shear stress and shear forces exerted within the

pipe would experience a change due to their respective radial positions in which they occurred as a function of their velocities.

add list of references and page numbers

Reactor Safety in Kinetics and Reactor Design CHEG 3306

Final Project on Reactor Design

- **Chemical Safety Information**

Final Project CHEG 3306
Spring 2022 Due Date May 2, 2022

Project objectives:

- To demonstrate your understanding of designing a packed bed reactor.
- Show that you can calculate the required design taking heat, pressure drop and changing physical properties into account.
- Design and create a plan of action that you will follow to achieve your goal.
- To reflect afterwards on your group's progress and judge how you followed your plan.

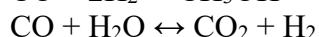
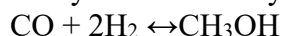
You are required to design a shell and tube packed-bed reactor for methanol synthesis. The complete problem statement follows.

1. Projects are to be tackled in groups, with one report per group. Each student will submit at the end of the project a confidential assessment of the relative contributions of the members of the group.
2. The methodology used in the design of the reactor must be clearly explained; all assumptions must be identified and evaluated; the results must be clearly presented and discussed. In particular you must have a section at the start of your report where you: "clearly explain the strategy you will follow to achieve the project's objective". Use bullet points showing the sequence of steps you planned.
3. Reports must be written in an acceptable and professional style and should not exceed 15 typed pages (including any appendices). Any polymath code you choose to include in part of your page limit. You must submit your report using Canvas.
4. All published information consulted must be appropriately referenced.
5. At the end you must have a section called "Reflection". Answer these 3 questions in the section:

- How accurately did our group stick to the plan (there is no penalty from deviating from your plan, but describe why you deviated).
- How would we go about the project differently if we could redo it?
- What did we learn from doing this project (bullet points are OK).

Problem statement

A new catalyst has been proposed for the synthesis of methanol from carbon monoxide and hydrogen gas. This catalyst is reasonably active between temperatures of 330 K to about 430 K. The reactions to be considered are:



The reactions are elementary and occur in a reactor containing tubes packed with a precious metal catalyst on a silica support. Heat is removed from the reactor by generating steam on the shell side of the tubes. The feed consists of 7/15 hydrogen gas, 1/5 carbon monoxide, 1/5 carbon dioxide, and 2/15 steam. The total flow rate is 300 mol.s⁻¹. The entering pressure may be varied between 1 atm and 160 atm and the entering temperature between 300 K and 400 K. A total tubular reactor volume of 2 m³ is to be used.

The following tasks should be completed:

1. Discuss the commercial application of this reaction in terms of the overall process, economics, process conditions, reactor types and configurations typically used, type of catalyst, typical conversion and end product usage.
2. Assuming isothermal and isobaric conditions, determine the entering conditions of temperature and pressure that will optimize the production of methanol. Hint: Do this by conducting several simulations at discrete combinations of T₀ and P₀. First try T₀ = 330 at P₀ = 40 atm, then try T₀ = 380 and P₀ = 1 atm)
3. Carry out a detailed reactor design of a shell and tube reactor for the optimal feed conditions determined in part 2. Pressure drop and non-isothermal effects are to be taken into account.

The shell side temperature can be controlled by adjusting the steam pressure and may be assumed constant at a value specified by you. Physical property estimation sources, techniques and assumptions should be clearly presented. The design should include the following:

- the reactor dimensions and number of tubes
- the reactor conditions; including composition, pressure and temperature profiles (as a function of reactor length).
- A mechanical sketch of the reactor should be included.
- **Not required:** mechanical design of the reactor, including specification of the reactor material of construction, shell and tube wall thickness and capital cost for the design.

4. Determine the effect of variations in:

- ratio of feed H_2 to CO ,
- ratio of feed H_2O to CO ,
- assumed heat transfer coefficient, U

5. All results must be presented in SI units throughout the report.

The following results should be tabulated in your report:

Inlet temperature [K]
Outlet temperature [K]
Inlet pressure [Pa]
Outlet pressure [Pa]
Maximum tube-side temperature [K]
Location from inlet of maximum temperature [m]
Methanol production rate [kg.s⁻¹]
Reactor length [m]
Total inlet concentration, CT0 at 330K
Rate constant, k1 at 330K
Equilibrium constant KC,1 at 330K
Rate constant, k2 at 330K
Equilibrium constant KC,2 at 330K
Heat of reaction for reaction 1 at 330K
Heat of reaction for reaction 2 at 330K

The following results for Reactor in and Reactor out in a tabular form must be presented

Flow [mol.s⁻¹]
Pressure [Pa]
Temperature [K]
CO (mole fraction)
H2
CO2
CH3OH
H2O

If you are using MATLAB, A working set of MATLAB files must be emailed to the instructor with submission of your final report. These MATLAB files must generate the final profiles used to obtain the flows, pressure, temperature and mol fractions in the above tables. Non-working code, or code that does not lead to the values in the table will lead to a penalty in the grade.

Additional problem information Thermodynamic and rate data T is in Kelvin, but $R = 1.987 \text{ cal.mol}^{-1} \cdot \text{K}^{-1}$. The subscript 1 refers to the methanol reaction, while subscript 2 refers to the water-gas shift reaction. $V = 40 \text{ dm}^3$

$$K_1 = 131667(0.001987T)^2 \exp \left[\frac{30620}{R} \left(\frac{1}{T} - \frac{1}{298} \right) \right] \left[\frac{\text{dm}^3}{\text{mol}} \right]^2$$

$$K_2 = 103943 \exp \left[\frac{9834}{R} \left(\frac{1}{T} - \frac{1}{298} \right) \right]$$
$$k_1 = 0.933 \times 10^{-6} \exp \left[2.5 \left(\frac{31400}{R} \left(\frac{1}{330} - \frac{1}{T} \right) \right) \right] \left[\left(\frac{\text{dm}^3}{\text{mol}} \right)^2 \text{s}^{-1} \right]$$
$$k_2 = 0.636 \times 10^{-6} \exp \left[\frac{18000}{R} \left(\frac{1}{300} - \frac{1}{T} \right) \right] \left[\frac{\text{dm}^3}{\text{mol.s}} \right]$$

Reactor equipment data

- Catalyst bed void fraction: 40%
- Catalyst density: 1600 kg.m⁻³
- Tube diameter (i.d.): 3.81 cm
- Overall heat transfer coefficient: 631 W.m⁻¹ .K⁻¹
- Tube diameter (o.d.): 4.20 cm
- Shell side water temperature: 373 K
- Catalyst particle size: 5mm
- Average gas viscosity, assumed constant over all temperature: 7.5×10^{-6} Pa.s
- Number of tubes in the heat exchanger: 250 tubes

Final Project Presentation Rubric



Account

Dashboard

Courses

Groups

Calendar

Inbox

History

Commons

Studio

Resources

Spring 2022

Home

Announcements

Syllabus

Grades

Zoom

Modules

LockDown Browser

A+ Attendance

People

Studio

Class Activity

Survey

PV Online Tutoring

Badges

Discussions

Assignments

Files

Quizzes

Pages

Faculty Alerts

Student Alerts

CHEG3306P01-2220-20594 > Assignments > Final Presentation on Project CHEG 3306

63 Students

Final Presentation on Project CHEG 3306 ▲

Published

Edit

Presentation Outline

- Problem Statement
- Introduction
- Project Objectives
- Reactor Design/Assumptions
- Methods & Calculations
- Chosen Catalyst
- Algorithms
- Polymath Code
- Results
 - Graphs (Give figure numbers)
 - Tables/Tabulated data
- Discussion
 - Safety concerns
- Conclusion
- References
- Q&A

Points100

Submittinga file upload

File Typespdf

Due	For	Available from	Until
May 10	Everyone	May 2 at 12am	May 10 at 11:59pm

**Final Project Presentation Slides –
Above Average**

DESIGN OF A SHELL AND TUBE REACTOR FOR METHANOL SYNTHESIS

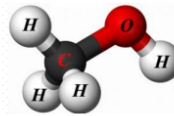
CHEG 3306 DR. SHAMIM

BY: JAZMAINE CARTER, DYNASTY STEPHENSON, EDGAR MENDOZA



1

INTRODUCTION: WHY METHANOL(CH_3OH)?



- Methanol is used to produce other chemical derivatives, which in turn are used to produce thousands of products that touch our daily lives, such as building materials, plastics, paints, and a variety of health and pharmaceutical products.
- Although it's a toxic and volatile chemical, an advantage is that it can be produced from multiple resources abundant in nature.
- Methanol is a clean-burning/biodegradable fuel with environmental/economic advantages which, make it an attractive alternative fuel for powering vehicles/ships, cooking food, and the heating industry.

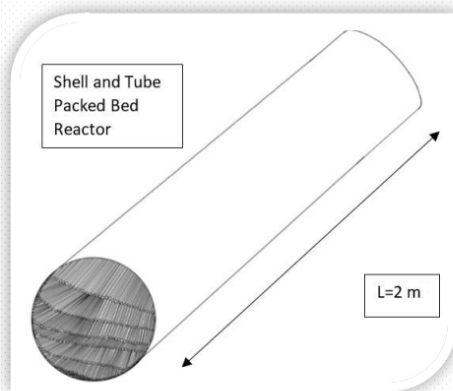
2

PROJECT OBJECTIVES:

- To demonstrate understanding of designing a packed bed reactor.
- Show that we can calculate the required design by taking heat, pressure drop, and changing physical properties into account.
- To design and create a plan of action that we would follow to achieve our goal.
- To reflect afterward on your group's progress and judge how you followed your plan.

3

REACTOR DESIGN & ASSUMPTIONS:



Design:

- Shell and tube
- Number of tubes 250
- Length of 2m
- Packed bed with metal catalyst

Assumptions:

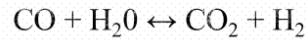
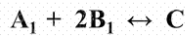
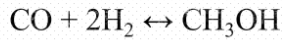
- The tubes use up all the space in the reactor and therefore we can consider it the overall area of the reactor.
- Assume isothermal, isobaric, and pressure drop conditions.

4

METHODS & CALCULATIONS: PROBLEM STATEMENT

A new catalyst has been proposed for the synthesis of methanol from carbon monoxide and hydrogen gas. This **catalyst** is reasonably active between temperatures of **330 K** to about **430 K**.

The reactions to be considered are:



- | | |
|--|--|
| <ul style="list-style-type: none"> • Elementary Reactions • Occur in reactor containing tubes packed with a precious metal catalyst. • Total reactor volume of 2m³ | <ul style="list-style-type: none"> • Entering pressure may be varied: <ul style="list-style-type: none"> ○ (101kPa – 16212 kPa) • Entering temperature between: <ul style="list-style-type: none"> ○ (300k – 400k) |
|--|--|

5

METHODS & CALCULATIONS CONT'D: GIVENS

• Catalyst active between ○ temperatures of 330K and 430K. • Feed consists of: ○ H₂(g) = 7/15 = .47 ○ CO (g) = 1/5 = .2 ○ CO₂(g) = 1/5 = .2 ○ H₂O (g) = 2/15 = .13 • FT = 300 mol /s • Po = 1 atm – 160 atm ○ = 101 kPa – 16212 kPa • To = 300K – 400K • Total tubular reactor volume ○ V = 2m³	Additional Problem Information • R = 1.987 cal / mol*K • $K_1 = 131667(.00198T)^2 \exp[30620/R(\frac{1}{T} - \frac{1}{298})]$ [dm³/mol]² • $K_2 = 103943 \exp[\frac{9834}{R}(\frac{1}{T} - \frac{1}{298})]$ • $k_1 = .933 \times 10^{-6} \exp[2.5(\frac{31400}{R}(\frac{1}{330} - \frac{1}{T}))][\frac{(\text{dm}^3)}{\text{mol}}]^2$ • $k_2 = .636 \times 10^{-6} \exp[\frac{1800}{R}(\frac{1}{300} - \frac{1}{T})][\frac{\text{dm}^3}{\text{mol}\cdot\text{s}}]$ Reactor equipment data • Catalyst bed void fraction (Φ) = 40% • Catalyst density (ρ_c): 1600 kg /m³ • Tube diameter (i.d.): 3.81 cm = .0381m • Overall heat transfer coefficient (U): 631W/m*K • Tube diameter (o.d.): 4.20cm = .042 m • Shell side water temperature: 373K • Catalyst particle size: 5mm = .005 m • Avg. gas viscosity (μ), assumed constant over all temperature: 7.5 x 10⁻⁶ Pa. s • Number of tubes in the heat exchanger: 250 tubes
---	---

6

METHODS & CALCULATIONS CONT'D:

Molar Mass:

- CO = 28.01 g/mol
- H₂ = 2.02 g/mol
- CO₂ = 44.01 g/mol
- H₂O = 18.02 g/mol

Flow Rates:

- FA = CO = (1/5)(300mol/s) = 60 mol/s
- FB = H₂ = (7/15)(300mol/s) = 140 mol/s
- FC = CO₂ = (1/5)(300mol/s) = 60 mol/s
- FD = H₂O = (2/15)(300mol/s) = 40 mol/s

For mass flow rate ($\dot{m}$):

- $\dot{m}_{H_2} = (.00202 \text{ kg/mol}) (140 \text{ mol/s}) = .29 \text{ kg/s}$
- $\dot{m}_{CO} = (.02801 \text{ kg/mol}) (60 \text{ mol/s}) = 1.7 \text{ kg/s}$
- $\dot{m}_{CO_2} = (.04401 \text{ kg/mol}) (60 \text{ mol/s}) = 2.6 \text{ kg/s}$
- $\dot{m}_{H_2O} = (.01802 \text{ kg/mol}) (40 \text{ mol/s}) = .72 \text{ kg/s}$

TOTAL $\dot{m}$: 5.31 kg/s

For Area of tubes:

$$A = \pi \left(\frac{D_i^2}{4} \right)$$

Since,
Di = .0381m
n = 250 tubes

Hence,

$$A = .285 \text{ m}^2$$

7

METHODS & CALCULATIONS CONT'D:

Overall area of Shell and tube reactor:

○ **Note:** we assumed the tubes occupy all the space inside the reactor and therefore we will consider it the overall area.

- Therefore, we can use, $A = \pi D_i L$

- Hence $L = \frac{A}{\pi D_i}$

- **L = 2m**

For β_o :

$$\beta_o = \frac{G(1-\Phi)}{\rho_o g c D p^{\Phi/3}} \left[\frac{150(1-\Phi)}{D p} + 1.75 G \right]$$

Hence,

$$\beta_o = \frac{2.7 \times 10^{-3} \frac{\text{kg}}{\text{m}^2 \text{s}} (1-\Phi)}{(1600 \frac{\text{kg}}{\text{m}^3}) (1 \frac{\text{kg m}}{\text{Ns}^2}) (.005 \text{ m}) (.064)^3} \left[\frac{150(.6)}{(.005 \text{ m})} + 1.75 (2.7 \times 10^{-3} \frac{\text{kg}}{\text{m}^2 \text{s}}) \right]$$

$$\beta_o = 4.4 \times 10^{-4} \frac{\text{Pa}}{\text{m}}$$

For α :

$$\alpha = \frac{2\beta_o}{A \rho_c (1-\Phi) P_o}$$

$$\alpha = \frac{2(4.4 \times 10^{-4} \frac{\text{Pa}}{\text{m}})}{(.285 \text{ m}^2) (1600 \frac{\text{kg}}{\text{m}^3}) (.6) (101325 \text{ Pa})}$$

$$\alpha = 4.5 \times 10^{-12} / \text{kg}$$

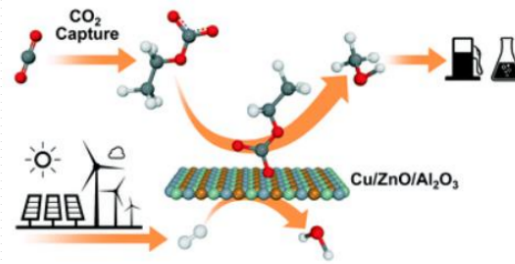
Ergun Equation: Isothermal case

$$\frac{dP}{dW} = \frac{-\beta_o}{A(1-\Phi)\rho_c} \frac{P_o}{P}$$

8

CHOSEN CATALYST:

- Type of Catalyst (Commercial Metal based-Catalyst)
 - Cu/ZnO/Al₂O₃
- Was developed in 1960 to find an efficient way to create methanol with the natural gasses CO₂ and H₂
- Active Pressures
 - 50 atm to 100 atm
 - 5066 kPa to 10132 kPa
- Properties
 - Particle size
 - Large surface area
- Components
 - 50% Aluminum
 - 50% Copper- Zinc Mixture



9

ALGORITHMS:

Mole Balance

$$\frac{dFA}{dW} = r'A$$

$$\frac{dFB}{dW} = r'B$$

$$\frac{dFC}{dW} = r'C$$

$$\frac{dFD}{dW} = r'D$$

$$\frac{dFE}{dW} = r'E$$

Rate Law

- $-r'A = k_1 C_A C_{B2} - k_1 C_C$
- $-r'D = k_2 C_A C_D - k_2 C_E C_B$

Relative Rates

- $r'B1 = 2(r'A1)$
- $r'C1 = -r'A1$
- $r'A2 = r'D2$
- $r'E2 = -r'D2$
- $r'B2 = -r'D2$

Net Rates

$$r'A = r'A1 + r'A2$$

$$r'B = r'B1 + r'B2$$

$$r'C = r'C1$$

$$r'D = r'D2$$

$$r'E = r'E2$$

Therefore,

$$r'A = -k_1 C_A C_{B2} - k_2 C_A C_D$$

$$r'B = (2) (-k_1 C_A C_{B2}) + k_2 C_A C_D$$

$$r'C = k_1 C_A C_{B2}$$

$$r'D = -k_2 C_A C_D$$

$$r'E = k_2 C_A C_D$$

Stoichiometry

$$CA = CTO \frac{FA}{FT} P$$

$$CB = CTO \frac{FB}{FT} P$$

$$CC = CTO \frac{FC}{FT} P$$

$$CD = CTO \frac{FD}{FT} P$$

$$CE = CTO \frac{FE}{FT} P$$

10

POLYMATH CODE:

```
Differential Equations: 6 Auxiliary Equations: 39 ✓
# Edgar Mendoza
# Dynasty Stephenson
# Jazmaine Carter

# Mole Balance
d(FA)/d(W) = rA # CO
W(0) = 0 # mol/s
W(f) = 1920
FA(0) = 60 # mol/s
d(FB)/d(W) = rB # H2
FB(0) = 140 # mol/s
d(FC)/d(W) = rC # CH3OH
FC(0) = 0 # mol/s
d(FD)/d(W) = rD # H2O
FD(0) = 40 # mol/s
d(FE)/d(W) = rE # CO2
FE(0) = 60 # mol/s

FT = FA + FB + FC + FD + FE

# Rate Law
r1 = KPRIME1 * (CA * CB ^ 2 - CC / K1)
r2 = KPRIME2 * (CA * CD - CE * CB / K2)

# Net Rates
rA = (-r1 - r2)
rB = (-2 * r1) + r2
rC = r1
rD = -r2
rE = r2

KPRIME1 = k1 / pb
KPRIME2 = k2 / pb
```

```
Differential Equations: 6 Auxiliary Equations: 39 ✓ Ready for solution
# Concentrations
CA = CTO * (FA / FT) * P / Po
CB = CTO * (FB / FT) * P / Po
CC = CTO * (FC / FT) * P / Po
CD = CTO * (FD / FT) * P / Po
CE = CTO * (FE / FT) * P / Po

# Given Data
mo = 5.31 # initial mass flow rate
gc = 1 # gravitational constant
vo = FTO / CTO # initial volumetric flow rate m^3/s
Po = 60 # Can vary as needed
po = 1600 # gas density ( kg/m^3)
R = 1.987
CTO = Po / ((8.2057 * 10 ^ -5) * T)
pb = 960 # bulk density
pc = 1600 # catalyst density
O = 0.4 # void fraction
id = 0.0381 # inner diameter (m)
od = 0.042 # outer diameter ( m)
n = 250 # Number of tubes in reactor for design
k1 = (0.933 * 10 ^ -6) * exp(2.5 * ((31400 / R) * ((1 / 330) - (1 / T))))
k2 = (0.636 * 10 ^ -6) * exp((18000 / R) * ((1 / 300) - (1 / T)))
K1 = (131667 * ((0.001987 * T) ^ 2)) * exp((30620 / R) * ((1 / T) - (1 / 298)))
K2 = (103942) * exp((9834 / R) * ((1 / T) - (1 / 298)))
Bo = 4.4 * 10 ^ -4 # (Pa/m)
A = 3.17E-11 # unit(1/kg) at 1Pa
d(p)/d(W) = -(Bo / Ac * (1 - O) * pc) * (T / To) * (FT / FTO) * p
p(0) = 1
Ac = n * 3.14 * (id ^ 2 / 4) # Cross sectional area of reactor
To = 330 # initial temperature entering the reactor (K)
P = 60
T = 300
FTO = 300
```

11

RESULTS:

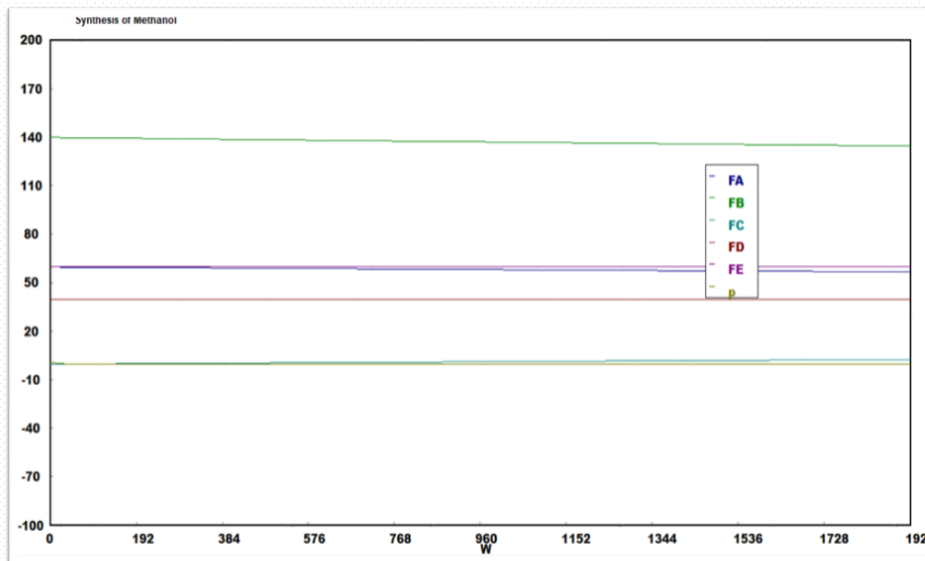


Figure 1

- P constant at
 - 3040kPa
- T = 320K
 - none optimal case

12

RESULTS CONT'D:

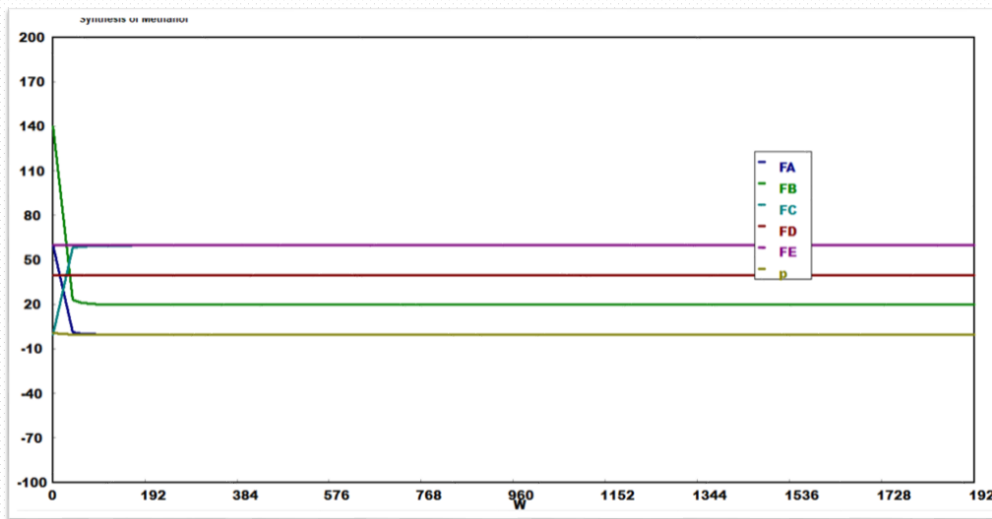


Figure 2

- P constant at 4053 kPa
- T = 345K
- None optimal case

13

RESULTS CONT'D:

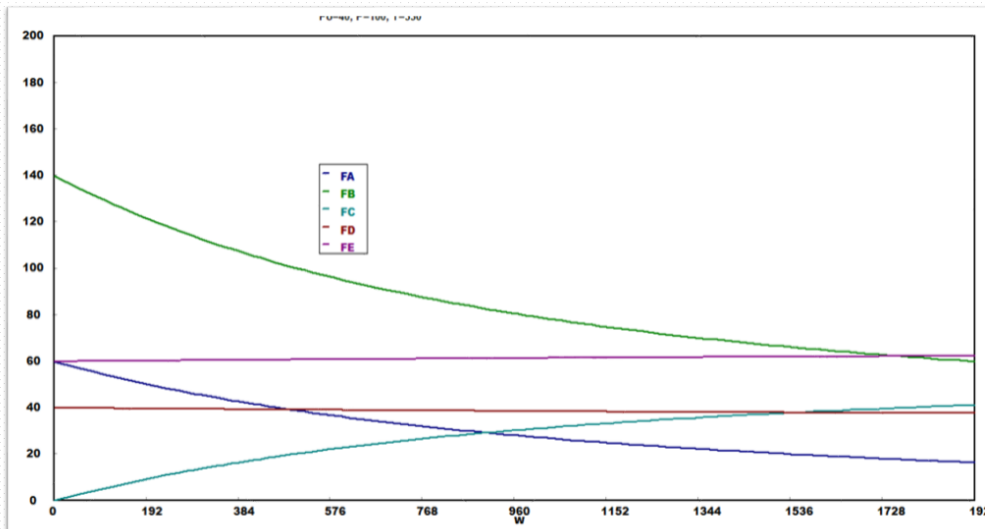


Figure 3

- $P_o = 4053$ kPa
- $P = 10132$ kPa
- T = 330K

14

RESULTS CONT'D:

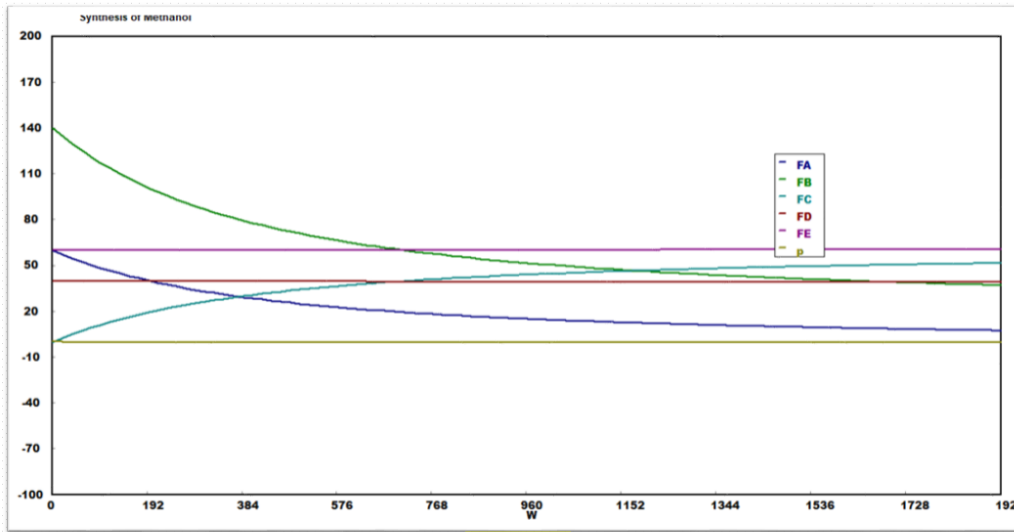


Figure 5

- P constant at
 - 4053 kPa
- T = 330 K
- Chosen parameters for optimal case

15

RESULTS CONT'D:

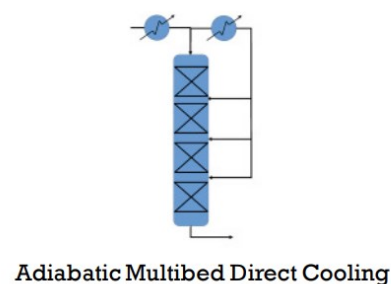
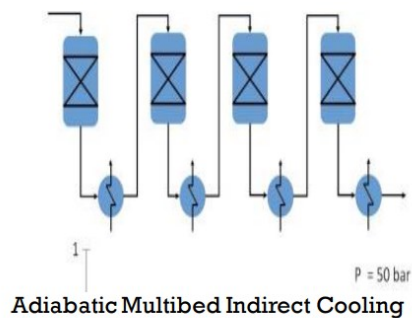
	In Reactor	Out Reactor
Flow (mol.s-1)	300	183.9
Pressure (Pa)	40	60
Temperature (K)	330	330
CO (mole fraction)	0.2	0
H ₂ (mole fraction)	0.47	0.24
CO ₂ (mole fraction)	0.2	0.05
CH ₃ OH (mole fraction)	0	0.71
H ₂ O (mole fraction)	0.13	0

Table: 1

Inlet Temperature (K)	330
Outlet Temperature (K)	360
Inlet Pressure (Pa)	40
Outlet Pressure (Pa)	60
Maximum tube-side Temperature (K)	375
Methanol production rate (Kg/s)	0.6
Reactor Length (m)	2.0
Total inlet concentration at 330K	1477.17
Rate Constant, k ₁ at 330K	9.33×10^{-3}
Equilibrium constant K _{C, 1} at 330K	375.95
Rate constant, k ₂ at 330K	9.9×10^{-6}
Equilibrium constant K _{C, 2} at 330K	20770
Heat of reaction for reaction 1 at 330k	-48.98
Heat of reaction for reaction 2 at 330K	-19.51
Stoichiometric feed H ₂ to CO	2:1
Stoichiometric feed H ₂ O to Co	1:1
heat transfer coefficient, U (W/m ² *K)	631

Table: 2

16



DISCUSSION:

Economics:

- Global climate change
- Flooding
- Desertification

Overall Process:

- Reaction of carbon monoxide with hydrogen
- Reaction of carbon dioxide with hydrogen
- Water-gas shift reaction
- Have a stoichiometric feed ratio of 2:1 (efficient)

Reactor Types and Configuration Commonly Used:

- Adiabatic Multi bed Reactor with Indirect Cooling
- Adiabatic Multi bed Reactor with Direct Cooling

17

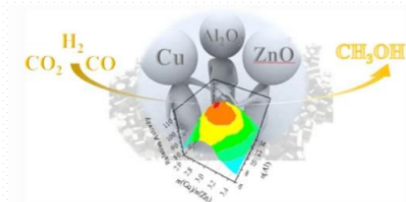
Typical Conversions:

There are 2 steps in Methanol Synthesis

- Reaction 1: $\text{CO} + 2\text{H}_2 \leftrightarrow \text{CH}_3\text{OH}$
- Reaction 2: $\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{CO}_2 + \text{H}_2$
- Reaction 1, carbon monoxide reaction with hydrogen in a hydrogenation reaction producing methanol.
- Reaction 2, carbon monoxide reacts with water and produces carbon dioxide and hydrogen gas. These steps are efficient for the making of methanol.

End-Product Usage:

- A few products that uses Methanol
- Plastics
- Paints
- Car parts
- Fuel cells
- Boilers
- Cook stoves,
- Clean energy resource to fuel cars, trucks, ships, and so much more



18

SAFETY CONCERNS:

- Methanol is highly flammable and toxic
- It can cause permanent blindness with direct contact of 10 mL
- Eye Irritation
- Poison the nervous system if highly concentrated
- Optic Nerve Damage
- Can be absorbed through skin
- Coma
- Death
- Drowsiness/Fatigue
- Headache
- Dizziness
- Can be harmful and long-lasting effects on sea life
- A mixture of methanol vapor and air = explosive

19

CONCLUSION:

- In conclusion, we were asked to design a shell and tube packed-bed reactor for methanol synthesis
- As a group, we were able to stick to our original plan from start to finish by breaking down the problem given, successfully using Polymath, and discovering useful research.
- With our group successfully able to complete our project objectives, there wouldn't be huge differences in approach to go about the project.
- The project was very informative with learning about methanol synthesis through intense research and trial and error moments with polymath.
- Made improvements with our calculations, correct formulas, clarifications with the rubric, and schematic.
- This project helped with our time management, problem-solving, and overall teamwork.
- It was a great learning experience and will be useful for **senior design** in the upcoming future.

20

REFERENCES:

- Bellotti, D., et al. "Economic Feasibility of Methanol Synthesis as a Method for CO₂ Reduction and Energy Storage." Energy Procedia, Elsevier, 15 Mar. 2019.
<https://www.sciencedirect.com/science/article/pii/S1876610219307684>.
- Borisut, Prapatsorn, and Aroonsri Nuchitprasittichai. "Methanol Production via CO₂ Hydrogenation: Sensitivity Analysis and Simulation-Based Optimization." Frontiers, Frontiers, 1 Jan. 1AD,
<https://www.frontiersin.org/articles/10.3389/fenrg.2019.00081/full>.
- Fujita, Shin-ichiro, et al. "Preparation of a Coprecipitated Cu/ZnO Catalyst for the Methanol Synthesis from CO₂ - Effects of the Calcination and Reduction Conditions on the Catalytic Performance." Applied Catalysis A: General, Elsevier, 5 Feb. 2001,
<https://www.sciencedirect.com/science/article/pii/S0926860X00006165>
- "Methanol Synthesis." Methanol Synthesis - an Overview | ScienceDirect Topics,
<https://www.sciencedirect.com/topics/chemical-engineering/methanol-synthesis>
- Water, Leon G.A. van de, et al. "Understanding Methanol Synthesis from CO/H₂ Feeds over Cu/CeO₂ Catalysts." Journal of Catalysis, Academic Press, 26 May 2018,
<https://www.sciencedirect.com/science/article/pii/S0021951718301763>.
- Zhang, Yulong, et al. "A High Activity Cu/ZnO/Al₂O₃ Catalyst for Methanol Synthesis: Preparation and Catalytic Properties." Applied Catalysis A: General, Elsevier, 1 June 1998,
<https://www.sciencedirect.com/science/article/pii/S0926860X96003626>.

21

THANK YOU!

• Questions?



22

Safety Assignment in Kinetics and Reactor Design CHEG 3306

Discussion on Runaway Reaction

- **Accident Investigation**
- **Chemical Safety Information**

Discussion on Chemical Safety CHEG 3306

☰

CHEG3306P01-2220-20594 > Pages > Chemical Safety

63 Student View

📄 Imr

Spring 2022

Home

Announcements

Syllabus

Grades

Zoom

Modules

LockDown Browser

A+ Attendance

People

Studio

Class Activity

Survey

PL Online Tutoring

View All Pages

Published

Chemical Safety

Chemical process safety must be an integral part of a chemical engineer's training. Watch the videos to impart a chemical process safety mindset and understand how to prevent major industrial accidents.

Silent Killer: Hydrogen Sulfide Release in Odessa, Texas

<https://www.csb.gov/videos/> 

Runway Reactions

A thermally unstable reaction system which exhibits an uncontrolled accelerating rate of reaction leading to rapid increases in temperature and pressure.

Runaway: Explosion at T2 Laboratories

<https://www.csb.gov/videos/runaway-explosion-at-t2-laboratories/>

Discussion on Runaway Reaction

Above average

Discussion 2 Runaway Reaction: Oluwatumininu Alade

What is runaway reactions?

A runaway reaction is a thermally unstable reaction system which exhibits an uncontrolled accelerating rate of reaction leading to rapid increases in temperature and pressure.

A typical example of a thermal runaway reaction always begins with an exothermic reaction. The surplus heat raises the temperature of the reaction mass, which causes the rate of reaction to increase. A practical example of the runaway reaction is the 1947 Texas City disaster from overheated ammonium nitrate. If the heat removal system is not able to remove as much heat as the reaction is producing then temperature of the reaction mixture starts increasing. If the rapid increase of temperature or pressure is not controlled properly then it can cause damage to the equipment, surroundings and Human lives

chemical reactivity hazards and material properties:

Any chemical reaction which has a possibility to runaway under certain conditions should be studied very well and the knowledge of the reaction and reaction mechanism should be properly used to assess the risks involved in the process to deal with the hazards to control it by designing adequate control systems and heat removal systems or to not allow such a condition to ever happen by designing adequate operational procedures and proper training schemes.

1. A runaway reaction and reactor explosion occurred in a resins production facility that killed one worker and injured four others. To control the reaction rate, an operating procedure called for the slow addition of one of the raw materials to the reactor. The runaway was triggered when the raw materials and catalysts were improperly charged to the reactor simultaneously, followed by heat addition.
2. A massive explosion and fire occurred at an agricultural chemical packaging facility in Arkansas, killing three firefighters and injuring a fourth. The likely cause was a supersack of azinphos-methyl (an insecticide) being placed near a hot compressor exhaust pipe.
3. Five workers were killed when a blender exploded. The blender was used to mix several dry powders, including aluminum powder and sodium hydrosulfite. The likely cause of the explosion was the unintentional introduction of water into the blender, possibly through a leaking water-cooled seal.

Chemical Reactivity Hazards:

Chemical reactivity hazards can be manifest through materials which become chemically unstable for a variety of reasons, intended chemical reactions that get out of control for a variety of reasons or unintended chemical reactions that take place due to accidental mixing of chemicals that are normally separate.

Chemical reactivity hazards still exist even if a plant doesn't intentionally run chemical reactions.

Chemical reactivity hazards still exist even if a plant doesn't intentionally run chemical reactions.

There are different types of chemical reactivity hazards and they include:

1. Asphyxiant Chemical Examples: Carbon monoxide and cyanide.
2. Corrosive Chemical Examples: Sulfuric acid and sodium hydroxide.
3. Irritant Causing Chemical Examples: nickel chloride and chromic acid.
4. Allergen Causing Chemical Examples: Chlorine and alkalis

Material properties can be classified variously including: chemical, physical, intensive, extensive, etc..

Some properties are listed below:

Reactivity

Thermal Conductivity

Malleability

Tensile strength

Density

Compressibility

Melting point.

Electrical conductivity (resistivity)

Thermal expansion.

Corrosivity etc..

Pressure relief and venting

A relief valve or pressure relief vent is a type of safety vent used to control or limit the pressure in a system; pressure might otherwise build up and create a process upset, instrument or equipment failure, or fire especially for exothermic reactions. Pressure relief systems are usually used at chemical sites as a safety measure. It is important that they are sized correctly so that they would function effectively if needed. The venting systems protect process vessels against various relief cases including fire and runaway chemical reactions. Pressure relief is used to protect a process vessel or reactor from a pressure excursion. It is often the last line of defense when other systems such as fire prevention and process cooling have failed. There are various causes of overpressure, such as external fire and runaway reaction, which need to be considered.

Discussion on Runaway Reaction

Below Average



Paper View 

A runaway reaction is a thermally unstable reaction that causes an uncontrollable accelerating rate of reaction leading to an increase in pressure and temperature.

This runaway reaction can occur if you overcharge a VRLA battery. If overcharged, the additional current would result in electrolysis which would then lead to more heat being dissipated. That alone would cause an increase in temperature.

Some material properties in regard to being hazardous are it's toxicity, explosiveness, flammability, and corrosiveness.

A pressure relief vent is a safety valve used to control or limit the pressure in a system. Some examples of this are safety valves and relief valves. These are used to release a substance from a boiler or a pressure vessel.

Safety Assignment in Equilibrium and Separation Processes

CHEG 3305

- **Accident Investigation**

Discussion post on Chemical Safety CHEG 3305



Account

Dashboard

Courses

Groups

Calendar

Inbox

History

Commons

Studio

Resources

CHEG3305P02-2220-20592 > Assignments > Discussion 3 Chemical Safety board Video

Spring 2022

Home

Announcements

Syllabus

Grades

Zoom

Quizzes

Modules

LockDown Browser

A+ Attendance

People

Studio

Class Activity

Survey

PV Online Tutoring

Badges

Office 365

Discussions

Rubrics

Collaborations

BigBlueButton

Files

Pages

Outcomes

Student View

Immersive Reader

Discussion 3 Chemical Safety board Video

Publish

Edit

Related Items

Peer Reviews

For any accident, there are almost always multiple root causes. If any of the root causes did not occur, then the accident would not occur.

If the root causes are not identified and resolved, the accident investigation is only identifying the symptoms – this will not prevent the accident from occurring again.

Discussion topic

1. You are assigned to investigate a case.

- a. Identify all root causes for the accident.
- b. Identify ways to eliminate root causes.
- c. Make final recommendations on how to prevent.

Finally, give a general statement

- d. Why you should know about process safety?

2. Once the discussion is complete you will be assigned to review two of your peers' discussions.

- a. Review the discussion and make comments.

You can choose any of the case history given below or a new one. Please add the information source from where (example book, journal, or link) you have selected the case.

Some case studies:

- Texas City Refinery explosion
- the ammonium nitrate explosion in West Texas
- 2015 Torrance accident
- TransCanada's Pipeline Bursts in Northern Alberta
- Failed Pipe hanger

Points

100

Submitting

a file upload

Activate Windows

Go to Settings to activate Windows.

Discussion on Chemical Safety CHEG 3305

Above Average

Name: Chad Gardner

Course: CHEG 2043

Professor: Dr. Nabila Shamim

Discussion post:

The incident of concern for this assignment will investigate a lack of proper safety procedures that were not met, regarding the Packaging Corporation of America, Deridder, Louisiana Pulp and Paper mill plant explosion on February 8, 2017. According to OSHA (Occupational Safety and Health Administration), three contract workers were climbing down from an elevated pipe rack when what's called a foul condensate tank, exploded. The blast hit the employees and tossed their bodies 200 yards away killing all three. A link will be posted below this page to a CSB (Chemical Safety Board) video to provide an overview on what transpired.

Root Causes:

- In this incident there were more than one root causes that may have led to the explosion that occurred during an annual shut down conducted by the company to perform maintenance, inspections, and upgrades. A water piping attached to and above the foul condensate tank required welding due to a portion of the piping exposed to the atmosphere due to a crack.
- Another root cause was due to the lack of communication pertaining the department that was responsible for overseeing the residual turpentine within the tank that required removal to a recovery system, where a valve connecting the two units remained closed during the months leading up to the explosion. Vapors are common within these tanks above the liquid and are likely flammable and so the valve connecting the two units would have been essential in stripping the residual turpentine from the foul condensate tank.
- An additional possible root cause stem from the design of the tank that had relief valve at the top exposed to the atmosphere while the contract workers conducted hot work also known as welding above the tank. It is believed that sparks from the welding process ignited the flammable vapor escaping from the relief valve due to low pressure within the tank to prevent a vacuum from causing damage to the vessel.

Ways to eliminate root causes:

- One way of eliminating any of these root causes would be applying a process safety management system to the foul condensate tank that utilizes non-condensable gases along with further recommendations of process hazard analysis, which would have provided comprehensive assessment of potential hazards.

- Another way was down to the lack of communication amongst the departments surrounding the foul condensate tank on taking decisive action regarding responsibility of overseeing operations to and from the tank.

Final recommendations:

- One recommendation would be installing an alarm system that would alert operators whenever the relief was open to atmosphere due to low pressure to prevent a vacuum from causing damage to the foul condensate tank.
- Installing oxygen analyzers to alert workers whenever dangerous amounts of air was in the tank to prevent combustion with the flammable vapor inside the foul condensate tank.
- Possibly reduce oxygen levels in entering the tank whenever the relief valve is activated by adding an inert gas so that flammable air does not form.
- Designing a safer model tank that could withstand full vacuum operations that would not damage the tank itself eliminating the need for a relief valve.

In closing, process safety is very important in any plant that handles hazardous materials. It is necessary in maintaining safe work-related practices or any operational practices within a plant to prevent a disaster. It is essential in managing complex chemical operations by applying good designing principles and engineering.

<https://www.youtube.com/watch?v=j4iv4HvrfSU>

Assignment: Discussion 3 Chemical Safety board Video

Course: Spring2021_CHEG3043Y02-2120-27449
Student: Chad Gardner
Score: 93.0
Account: Prairie View A&M University

Jessica Rhone: Nice detailed review of the incident and final recommendations that should be implemented to prevent the incident from occurring again. (Apr 4, 2021 at 12:26am)

Chinenye Ihe: Wow, that's quite unfortunate. Working in industries that require you to be in plants can be very dangerous. I absolutely agree with your recommendations. Communication plays an integral part when it comes to safety, and my observation from doing this assignment is that in every case there was a lack of communication. (Apr 4, 2021 at 8:25pm)

Discussion on Chemical Safety CHEG 3305

Average

Separations Discussion 3 Texas City Refinery Explosion

A. Identify all root causes for the accident

The main cause of the Texas City Refinery explosion was the overfilling of the raffinate splitter tower and blowdown drum releasing hot hydrocarbons. However, there are a number of things that lead up to these actions. For starters, the level indicator calibration was outdated, which resulted in inaccurate reading of the liquid. The usage of informal procedures, ignoring the first high-level alarm, and the second high-level alarm being faulty also caused this explosion. If the alarms weren't ignored/broken, people would have been made aware of the situation. Next, the day supervisor missed the morning briefing which led them to instruct others to resume start-up. If the day supervisor had been to the meeting, he would have known they weren't to continue filling the tanks. Another root cause for the accident was an experienced supervisor leaving the plant due to a family emergency, and didn't find an adequate replacement. This left the board operator alone to overview the isomerization (ISOM). Finally, the pressure relief was obsolete and a vehicle was parked near the blowdown which then caused the overall explosion.

B. Identify ways to eliminate root causes

Majority of these root causes could have been avoided by following procedures, updating machinery, and effective communication. For example, the day supervisor who missed their morning briefing and the supervisor who left due to personal reasons could have communicated better in those situations. If the machinery had been updated, the level indicator had been working and the pressure relief wouldn't have caused the vapor to go into the atmosphere. Lastly, following the procedures and guidelines in place like not ignoring high-level alarms and not finding a replacement for someone's absence, could have eliminated a few causes.

C. Make final recommendations on how to prevent

I would recommend changing the company's leadership. In situations like this, the problem doesn't only lie with those present. The company's leadership allowed these actions to continue because they weren't taken seriously. The company should have taken certain precautions in regards to the safety of its workers and those in the surrounding areas. Also, I would recommend implementing safety leadership. Someone or a group of people to observe and document the safety rules that are being violated. As these things are being documented, monthly meetings can be held for staff to learn from their mistakes. This learning opportunity would decrease the number of major and minor accidents within the company.

D. Why you should know about process safety ?

Process safety should be known because it provides knowledge on how to operate systems safely. It helps to prevent and control events that have the potential to harm others. As I previously stated, learning opportunities would help to decrease accidents and process safety can also be considered a learning experience. Many won't be able to know what can harm others unless they have a prior knowledge and understanding of process safety. The more workers know about process safety and the potential dangers of the work space, the safer the work environment will be because of it.

Source: https://www.icheme.org/media/14611/lpb275_pg04.pdf

Assignment: Discussion 3 Chemical Safety board Video

Course: Spring2021_CHEG3043Y02-2120-27449

Student: Kennedi Henderson

Score: 90.0

Account: Prairie View A&M University

Meredith Meyer: Hi Kennedi,

I like how you clearly identified what the root causes, but you also explained how different events lead to those 2 main root causes. I also like how you talked about how safety starts from the top down, and that the leadership in the company is ultimately responsible for setting the tone of safety in the company. I also did the Texas City explosion so I agree with you on the root causes. I also agree with you on the fact that we need to know about process safety because it helps teach people what to do to prevent accidents from happening. (Apr 4, 2021 at 9:24pm)

Utomwen Irabor: Hey Kennedi. I would like to add that to help reduce root causes Company owners show put in more effort to reduce overburdened or overworked employees and ensuring that there are always experienced supervisors on sight. The employee on the day of this particular day left on a short note to address pressing issues and no one was put in place by the previous supervisor or higher-ups. (Apr 4, 2021 at 11:45pm)

SENIOR DESIGN & PROFESSIONALISM II CHEG 4482

Homework 3 on HAZOP Analysis

- **Hazard Analysis**

1. Senior Design & Professionalism II Spring 2020: Home Work 3

2. March 30, 2020

3. Due: April 9, 2020

You will be graded based on your ability to apply hazard screening and/or risk analysis to your design. Include minutes of meetings and confidential evaluation of group members on forms previously provided. Clarity of presentation is essential if you are to avoid losing points.

Prepare the P&ID for a section of your process (for example, reactor, distillation column or the feed section of your process to either the reactor or distillation column/absorber unit) showing **the control scheme to ensure safe operation of the unit. Carry out a HAZOP analysis of the section of the process selected. Include the HAZOP table as shown below.** Please read the presentation files that will be sent to you to aid you to complete this assignment.

DEPARTMENT OF CHEMICAL ENGINEERING
SENIOR DESIGN & PROFESSIONALISM II CHEG 4482
COURSE ASSESSMENT GRADING & OUTCOME
ASSESSMENT SHEET FOR SPRING 2019 SEMESTER

Student Learning Outcome: An ability to carry out hazard screening/risk analysis to a process.

Assignments that test competency in this area include preparing of the P&ID for sections of a process showing the control scheme to ensure safe operation of the unit, and carrying out a HAZOP analysis of the sections.

Name: _____

Title of Assignment: _____ Due Date _____

Competency Area	Points Assigned	Points Received
1. Ability to prepare a P&ID from the process flow diagram (PFD)	20	
Students are able to prepare the P&ID for sections of a process	20	
2. Ability to carry out a HAZOP analysis	80	
Students are able to prepare a control scheme to ensure safe operation of the plant	30	
Students are able to carry out Safety Reviews; Hazards, operability and inherent safe (including the use of Safety Data Sheets) or HAZOP analysis	50	
Total	100	

Hazard and Operability (HAZOP) Study

Flexibility, reliability and safety are integrated in a hazard and operability (HAZOP) study. Safety integrated with equipment protection because equipment failures usually lead to hazards. The solutions to safety and equipment protection require similar techniques involving alarms, shutdowns etc.

A hazard and operability study is carried out to identify potential malfunction due to deviations from design conditions and the design intention. It is based on a set of “key words” and “guide words” which focus on possible deviations. The HAZOP analysis is based on qualitative and semi-quantitative analysis and requires P & I diagrams.

A HAZOP study is carried out for a reactor as follows:

Select the reactor /vessel

Explain the general intention of the vessel and the lines connected to it (for example the vessel is reactor for isomerization of glucose to fructose)

Select a line to the vessel

Explain the intention of the line (line xyz is to convey glucose at 303 K and 1 bar from AB to CD at 2000 kg/h)

Apply a guide word

Develop a meaningful deviation

Examine possible causes

Examine possible consequences

Detect hazards or operating problems

Make a suitable record

Repeat 6 – 10 for all meaningful deviations derived from the Guide Word

Repeat 5 – 11 for all Guide Words

Repeat 3 – 12 for each line/heating system for example/vessel

Keywords include: Flow, Pressure, Temperature, Concentration, Hydrogenate, oxidize, purge etc. Guidewords include: No or NOT; MORE, LESS; REVERSE etc

HAZOP Table

Line 4: To convey glucose at 303 K and 1 bar from AB to CD at 2000 kg/h

Property word or Keyword	Guideword	Deviation	Cause	Consequence	Action
Flow	No		Catalyst bed blocked	???	????
	More				
	Less				

Student Work

Prairie View A&M University
Roy G. Perry College of Engineering
Department: Chemical Engineering



CHEG 4248 – P02
Senior Design and Professionalism II
Homework 3
Group: Dada Team 2
Completed: April 7, 2022

Submitted by:
Chinenye Ihe
Utomwen Irabor
Shimere Gregory
Willie Connor

Submitted to:
Dr. Emmanuel Dada

Distillation Column

Distillation columns are used to separate mixed feed streams. The distillation column highlighted in Table 1 has a feed stream in the center of the column because the mixed feed is coming in at the bubble point temperature. The column is operating at 3 atmospheres. Assume the column is isobaric and ideal then it will follow Raoult's law. The temperature changes in the column, with temperature ranges from 342 – 461.5 kelvin. The feed stream to be separated is Hydrogen peroxide, Methanol, Propylene oxide, and Water. From the material balance, the inlet flowrate is 36782 lb/hr, Propylene oxide, our desired product is leaving the distillate of the column at 27,836 lb/hr, while the rest of inlet stream leaves from the bottom of the column at 8,945 lb/hr. The light key in the process is propylene oxide because it is more volatile, and it has the lowest boiling point. The heavy key is water. Because hydrogen peroxide has a boiling point lower than water, hydrogen peroxide will leave with water from the bottom of the still column.

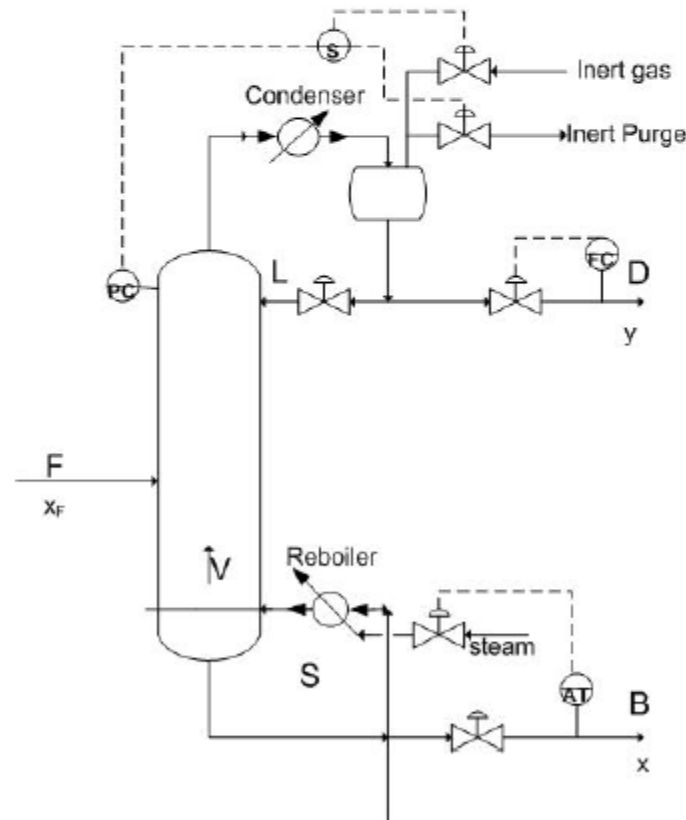


Figure 1: A P & ID illustration with Reflux-boil up control scheme

The Piping and Instrumentation diagram above showcases our distillation column. It contains a feed stream, bottom, distillate, reflux, product, vapor-liquid mix, reboiler, and cooling water. We can use the degrees of freedom analysis to define the variables in our system and reveal where the critical sensors for process control should be located. According to Woolf et al., the degree of freedoms analysis can help minimize the design of too many sensors, actuators, and valves (3).

Woolf also added that, “in the reflux-boil up configuration, the distillate composition and bottoms composition are the control variables. The reflux flow and the heat input control are the manipulated variables, which allow control of the liquid and vapor flowrates in the column” (3).

HAZOP & Safety Analysis

Table 1: HAZOP for distillation column

Parameters	Guide words	Deviation	Problem Causes	Consequences	Recommendations
Flow	No	No flow	- Pipe blockage - Control valve shut - Valves fail - Tube leakage and blocking - Pump failure	- Column dry out - Possible dangerous concentration - No operation	- Install low level alarm - Check maintenance procedure and schedule - Make bypass - Emergency plant shut down
	Less	Less flow	- Pipe blockage - Control valve shut - Valves fail - Tube leakage and blocking - Pump failure	- Column dry out - Changes in product quality	- Install low level alarm - Check maintenance procedure - Make bypass - Emergency plant shut down
	More	More flow	- Control valve is fully opened - Increase pumping capacity - Control valves failure	- Flooding in the column - Changes in product quality - Temperature decrease - Rise in bottom liquid level	- Install high level alarm - Check maintenance procedure and schedule - Install control valves - Install flow indicator - Make bypass
Pressure	High	High pressure	- Vapor pressure high - Pressure indicator controller fail	- Low efficiency of separation - Rupture of column or other related equipment	- Install high pressure alarm - Install pressure relief valve

				Product loss	
	Low	Low pressure	Vapor line leakage	- Low efficiency of separation - Loss of products	Install pressure indicator
Temperature	High	High temp	- Instrumentation failure - More steam flows - Exchanger tube failure - High steam pressure - Cooling water in condenser failure. - Reboiler control failure - Heating medium leak into process	- Separation cannot be done - Changes in product quality - Column flooding - Film boiling in column and reboiler - Phase effect - Pressure changes	- Install temperature indicator controller - Instruct operator on procedure - Attention to heat input and output control
	Low	Low temp	- Instrumentation failure - Less steam flows - Loss of heating (steam leakage) - Low steam pressure and temperature - Ineffective isolation	- Pressure change - Product loss - Changes in product quality - Ineffective separating process - Phase effect	- Install temperature indicator - Instruct operator on procedure - Upgrade isolation - Attention to heat input and out control

References

- [1] Libretexts. (2021, December 4). *6.5: Ode and Excel model of a simple distillation column*. Engineering LibreTexts. Retrieved April 7, 2022, from [https://eng.libretexts.org/Bookshelves/Industrial_and_Systems_Engineering/Book%3A_Chemical_Process_Dynamics_and_Controls_\(Woolf\)/06%3A_Modeling_Case_Studies/6.05%3A_ODE_and_Excel_model_of_a_Simple_Distillation_Column](https://eng.libretexts.org/Bookshelves/Industrial_and_Systems_Engineering/Book%3A_Chemical_Process_Dynamics_and_Controls_(Woolf)/06%3A_Modeling_Case_Studies/6.05%3A_ODE_and_Excel_model_of_a_Simple_Distillation_Column)
- [2] *Pacific Northwest National Laboratory | PNNL*. (n.d.). Retrieved April 7, 2022, from https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-25077Rev2.pdf
- [3] *Piping and Instrumentation Diagrams - Location of Controls and Standard Control Structures*. University of Michigan, 3 Dec. 2021, <https://eng.libretexts.org/@go/page/22384>.

**CHEG 4312-P01: Process Safety
Engineering Fundamentals**

Syllabus



SYLLABUS

CHEG 4312-P01: Process Safety Engineering Fundamentals Syllabus

General Course Information

Information Item	Information
Instructor:	Dr. Emmanuel Dada
Section # and CRN:	P01 CRN 20561
Office Location:	C.L. Wilson 201 B
Office Phone:	936-261-9968
Email Address:	eadada@pvamu.edu ; emmanuel.dada@ymail.com
Office Hours:	Virtual: MWF 10:00 a.m. – 2:00 p.m.
Mode of Instruction:	Lecture
Course Location:	New Electrical Engr Bldg 139
Class Days & Times:	T R 11:00 a.m. – 12:20 p.m.
Catalog Description :	(3-0) Credit 3 semester hours. This course addresses multiple aspects of Chemical Process Safety and Loss Prevention, but 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. Course emphasizes quantitative engineering analysis, based on application of mass and energy balances, fluid mechanics of liquid, gas, and two-phase flow, heat transfer and the conservation of energy, mass transfer, diffusion and dispersion under highly variable conditions, reaction kinetics, process control, and statistics. Techniques for performing process hazard analysis, risk assessment, and accident investigations are introduced, including the review of several significant incidents in the chemical processing industry.
Prerequisites:	Senior standing in the Chemical Engineering major
Co-requisites:	None
Required Text(s):	A. Crowl and Joseph F. Louvar, 'Chemical Process Safety: Fundamentals with Applications', Prentice Hall 4th edition. Pearson Education, Inc. 2019 or newer edition.

Recommended Text(s):	1. Trevor Kletz, "What Went Wrong? :Case Histories of Process Plant Disasters and How They Could Have Been Avoided", Fifth Edition, Elsevier Inc. 2009 ISBN: 978-1-85617-531-9 2. Introduction to Process Safety for Undergraduates and Engineers; Center for Chemical Process Safety of the AIChE, Ny, NY, 2016:ISBN: 978-1-118-94950-4 3. Access to Learning Resources: (i) Access to Center for Chemical Process Safety (CPS) , Chem On Demand; and Safety in Chemical Engineering Education (SACHE) : www.aiche.org (ii) Chemical Safety Board: http://www.csb.gov (iii) Mary Kay O'Connor Process Safety Center: http://psc.tamu.edu/symposia/2012-sym
-----------------------------	--

REQUIRED SACHE CERTIFICATION PROGRAM:

SACHe certificates are available at <http://www.aiche.org/academy/courses/sache/sache-certificate-program> (undergraduate students with aiche membership can access these course for free. Graduate students have to register as member of AIChE for free access. Membership dues for graduate student is \$50.00. To renew or become an AIChE student member, visit www.aiche.org/students to review status.

PVAMU Library:

phone: (936) 261-1500;

web: <http://www.tamu.edu/pvamu/library/>

University Bookstore:

phone: (936) 261-1990;

web: <https://www.bkstr.com/Home/10001-10734-1?demoKey=d>

Course Goals or Overview:

The goal of this course is to introduce students to principles of chemical process safety and quantitative methods for risk analysis and loss prevention.

Course Outcomes/Objectives

At the end of this course, the student will have achieved and demonstrated the following 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 balance, fluid mechanics of liquid, gas, and two-phase flow, 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.

Course Requirements & Evaluation Methods

This course will utilize the following instruments to determine student grades and proficiency of the learning outcomes for the course. The course has been designed to ensure that students acquire a solid grounding in ability to apply the knowledge of mathematics, science, and engineering and ability to identify, formulate, and solve engineering problems.

Computer Assignments – self-explanatory assignments, including web based training. Videos, and DVDs

Homework Exercises – written assignments, often in letter report format, designed to supplement and reinforce course material. The letter report format serves to develop and demonstrate an ability to communicate effectively in written mode.

Quizzes – announced or surprise in-class assignments to promote student accountability

Partial Tests – the objective is determining concept development and problem-solving skills. .

3

Final Examination and/or Project Reports & Presentations at the discretion of the instructor

Grading Matrix (*points will vary at the discretion of the instructor.*)

Instrument Total

Homework, Computer Assignments & Quizzes 30%

Partial Exams (Mid-term, etc) and/or Projects Reports&Presentation at the discretion of the instructor 40%

Final Exam and/or Project Reports & Presentation at the discretion of the instructor 30%

Penalty for lack of participation -10%

Total 100%

**Extra credit may be assigned by instructor as optional but available to all.

Grade Determination:

A = 90 – 100pts;

B = 80 – 89pts;

C = 70 – 79pts;

D = 60 – 69pts;

F = 59pts or below

Program Outcomes

Data Used to Show

Student Proficiency in Measured Program Outcomes

1. Samples of student work in a Binder
2. Spreadsheet showing student performance and class average
3. End of Semester Course Assessment report

Course Procedures

Textbook Policy

Students must acquire the textbook if listed as “required” on the course syllabus. The textbook must be acquired by the 10th class day. Students are not allowed to share textbooks with other students who are currently registered in the same class. Failure to acquire (or show proof of purchase) the required textbook by the 10th class day will result in the student being administratively dropped from the course. The University will assess financial obligations for the course to the student as with any other dropped class according to the fee schedule. In addition, your financial aid may be affected by the subsequent registration action(s).

Go to <http://www.pvamu.edu/pages/195.asp> for the Roy G. Perry College of Engineering Textbook Policy.

Conduct:

1. Students will conduct themselves in a manner that is respectful to their fellow classmates and the instructor at all times.
2. **Cell phones, ipads and smart phones or similar electronic devices MUST** be turned off and stowed away during class time. Students are **NOT** allowed to leave class to answer cell phones or use these devices except for an emergency with the permission of the instructor. .
3. Students caught using ipads and smart phones or similar electronic devices during exams will receive **ZERO** for the exam and be subject to sanctions as stipulated under **Academic Misconduct**.
4. Students should be prepared to stay in the classroom for the duration of the exam. Students who have any condition that may require them to leave the exam room should make prior arrangements with the Instructor. Students who decide to leave the exam room for any other reason must handover their exam paper and consider the exam over for them.
5. Programmable calculators are **NOT** allowed in class.

6. Students should dress professionally and are **NOT** allowed to wear caps/hats in class.
7. Students are NOT allowed to bring food to the classroom or eat in class
8. Arrive to class prepared to discuss lesson with your project binder.
9. eBooks and/or Internet access are not allowed during class exams.

Submission of Assignments:

□□ All assignments are due by default one week after being given, unless otherwise stated. *All homework assignments are due directly to the Instructor, prior to the start of class or the assignment will not be accepted. All homework assignments and exams should be written on one side of the page only, and should use the appropriate cover sheet, with the name, assignment title and date. All pages should be numbered. Failure to use the correct format will result in the assignment grade being reduced by 20%.*

Exam Policy

Exams should be taken as scheduled. No makeup examinations will be allowed except under documented emergencies (See Student Handbook).

4

LECTURE OUTLINE & SAMPLE TOPICS (subject to changes by the instructor.)

TOPIC (Hours)

Introduction - Process Safety Management (3)

Failure

Management Responsibility, Policy

Hazard Identification

Hazard Assessment

Hazard Control

Introduction to Process Safety Engineering, Loss Prevention

Application of Fundamental Engineering Principles

Teamwork 1

Toxic Materials - Introduction 2

Dose and Response Curves

Threshold Limit Values and Permissible Exposure Levels

Application of Engineering Principles - Problems

Introduction to Hygiene 3

MSDS's

Monitoring Volatile Toxicants, etc.

Liquid Vaporization Rates - Exposure during vessel filling

Ventilation

Applications - Problems

Source Models 3

Applications of Fluid Mechanics to Leakage of Liquid and Gas

Through Holes, Pipes, and Fittings

Evaporation, Flashing, and Boiling

Two Phase Flow
Applications - Problems
Toxic Release and Dispersion 3
Dispersion Models
Pasquill-Gifford Plume and Puff Models
Computer Applications
Fires and Explosions 3
Flammability of liquids and vapors
Minimum Oxygen Concentration, Ignition
Explosions - Detonations and Deflagrations
Blast Damage
Applications - Problems
Fire and Explosion Protection and Prevention 3
Inerting, Purging Static Electricity
Explosion Proof Equipment
Ventilation, Sprinklers
Applications - Problems
Reliefs 2
Location, Types, Systems
Knockout Drums
Flares
5
Scrubbers, Condensers
Applications - Problems
Relief Sizing 3
Spring Operated, Rupture Discs
Design for Liquid, Vapor, Two-Phase Flow
Venting for Dust and Vapor
Thermal Expansion
Applications - Problems
Hazard Identification 2
Checklists, DOW Fire and Explosion Index
HAZOP
Safety Reviews
Application - Problems
Risk Assessment 3
Probability Theory
Interactions between units
Event Trees
Fault Trees
Accident Investigations 2
Procedures
Diagnosis
Recommendations
Term Project Presentations 6
Examinations 3

Total Hours: 42

6

University Rules and Procedures

Disability statement (See Student Handbook):

Students with disabilities, including learning disabilities, who wish to request accommodations in class should register with the Services for Students with Disabilities (SSD) early in the semester so that appropriate arrangements may be made. In accordance with federal laws, a student requesting special accommodations must provide documentation of their disability to the SSD coordinator.

Academic misconduct (See Student Handbook):

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with your Student Handbook, especially the section on academic misconduct. Students who engage in academic misconduct are subject to university disciplinary procedures.

Forms of academic dishonesty:

1. Cheating: deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not mastered; giving or receiving aid unauthorized by the instructor on assignments or examinations.
2. Academic misconduct: tampering with grades or taking part in obtaining or distributing any part of a scheduled test.
3. Fabrication: use of invented information or falsified research.
4. Plagiarism: unacknowledged quotation and/or paraphrase of someone else's words, ideas, or data as one's own in work submitted for credit. Failure to identify information or essays from the Internet and submitting them as one's own work also constitutes plagiarism.

Nonacademic misconduct (See Student Handbook)

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. Such incidents will be adjudicated by the Dean of Students under nonacademic procedures.

Sexual misconduct (See Student Handbook):

Sexual harassment of students and employers at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating this policy will be subject to disciplinary action.

Attendance Policy:

Prairie View A&M University requires regular class attendance. Excessive absences will result in lowered grades.

Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in assignment of a grade of "F". Absences are accumulated beginning with the first day of class.

Student Academic Appeals Process

Authority and responsibility for assigning grades to students rests with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the Undergraduate Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

Changes:

Course evaluation, grading scales and outline can be changed by the instructor. Such changes shall be communicated to the students.

Video Conferencing Etiquette

When using Zoom, WebEx or other video conferencing tools, confirm the visible area is tidy, clear of background clutter, inappropriate or offensive posters, and other distractions. Ensure you dress appropriately and avoid using high traffic or noisy areas. Stay muted when you are not speaking and avoid eating/drinking during session. Before class session begins, test audio, video and lighting to alleviate technology issues. **Technical Support**

Students should go to the [Password Reset Tool](#) if they have password issues. The page will provide instructions for resetting passwords and contact information if login issues persist. For other technical questions regarding eCourses, call the Center for Instructional Innovation and Technology Services (CIITS) at 936-261-3283 or email ciits@pvamu.edu.

Communication Expectations and Standards

Emails or discussion postings will receive a response from the instructor, usually in less than 48 hours. Urgent emails should be marked as such. Check regularly for responses.

Discussion Requirement

Online courses often require minimal to no face-to-face meetings. However, conversations about the readings, lectures, materials, and other aspects of the course can take place in a seminar fashion. This will be accomplished by the use of the discussion board. The exact use of discussion will be determined by the instructor.

It is strongly suggested that students type their discussion postings in a word processing application such as Word and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-andgrammar check functions in word

processing applications. Once the post(s) have been typed and corrected in the word processing application, copy and paste to the discussion board.

COVID-19 Campus Safety Measures

To promote public safety and protect students, faculty, and staff during the COVID-19 pandemic, Prairie View A&M University has adopted policies and practices for the Fall 2020 academic term to limit virus transmission. Students must observe the following practices while participating in face-to-face courses and course-related activities (office hours, help sessions, transitioning to and between classes, study spaces, academic services, etc.):

- **Self-monitoring** - Students should follow CDC recommendations for self-monitoring. Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.
- **Face Coverings** - Face coverings (cloth face covering, surgical mask, etc.) must be properly worn in all non-private spaces including classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource and support offices, and outdoor spaces where 6 feet of physical distancing is difficult to reliably maintain.
- **Physical Distancing** - Physical distancing must be maintained between students, instructors, and others in course and course-related activities.
- **Classroom Ingress/Egress** - Students must follow marked pathways for entering and exiting classrooms and other teaching spaces. Students should leave classrooms promptly after course activities have concluded, should not congregate in hallways and should maintain 6-foot physical distancing when waiting to enter classrooms and other instructional spaces.
- **Face-to-face Class** - To attend a face-to-face class, students must wear a face covering (or a face shield if they have an exemption letter). If a student refuses to wear a face covering, the instructor should ask the student to leave and join the class remotely. If the student does not leave the class, the faculty member should report that student to the Office for Student Conduct for adjudication. Additionally, the faculty member may choose to teach that day's class remotely for all students.

- **COVID-19 Guidelines for Student Conduct Adjudication** - The mandatory COVID-19 Training/Certification taken by all students serves as the 1st Warning for violation of COVID-19 Guidelines.

- 1st incident: upon review of Incident Report and finding of responsibility
— Conduct Probation
- 2nd incident: upon review of Incident Report and finding of responsibility
— Suspension
- Consult the Code of Student Conduct in the Student Planner or [Student Conduct website](#) for additional information on Conduct Probation and Suspension.

- **Personal Illness and Quarantine** - Students required to quarantine must participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities. Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence. To receive an excused absence, students must provide appropriate documentation to the Office for Student Conduct, studentconduct@pvamu.edu.

CHEG 4312-P01: Process Safety Engineering Fundamentals

Homework Assignment

- **HAZOP study**
- **Process Safety**

92%

CHEG 4132 –P01 Homework # 3 Due April 5, 2022

Team 3: Amiya Rogers, Taylon Owens, Xavier Williamson, Nathan Warren, Franck Nangomoko, Ruel Wright, Willie Conner

11-3. A heat exchanger is used to heat flammable, volatile solvents, as shown in Figure 11-15. The temperature of the outlet stream is measured by a thermocouple, and a controller valve manipulates the amount of steam to the heat exchanger to achieve the desired set point temperature.

- Identify the study nodes of the process.
- Perform a HAZOP study on the intention "hot solvent from heat exchanger."
- Recommend possible modifications to improve the safety of the process.

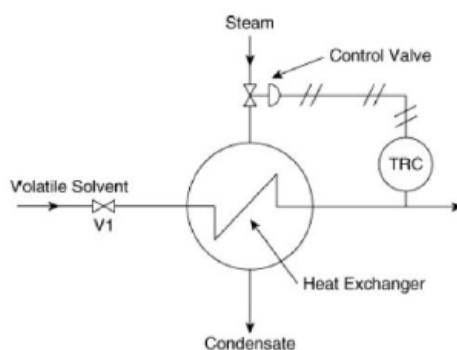


Figure 11-15. Volatile solvent heating system.

a. Nodes

1. Cold Inlet to Heat Exchanger
2. Hot Outlet from Heat Exchanger
3. Heat Exchanger Itself
4. Temperature Control Valve
5. Steam Stream
6. Condensate Stream

b. HAZOP

Item	Study Nodes	Process Parameters	Deviations	Possible Causes	Possible Consequences	Action Required
1A	Hot solvent from exchanger	Flow	No	1. Valve closed 2. Feed line blockage 3. Solvent supply exhausted	1. There will be no hot solvent exiting from the heat exchanger which will affect later processes. 2. Same as above 3. Same as above	1. Make sure the valve fails open 2. Have regular maintenance checks 3. Install flowmeter to check
1B	Hot solvent from exchanger	Flow	Reverse	1. The inlet solvent has low pressure 2. Failure of inlet solvent source resulting backward flow.	1. No flow of hot solvent from heat exchanger. 2. Heat exchanger overheated	1. Install pressure indicator. 2. Install Check valve
1C	Hot solvent from exchanger	Flow	Less	1. Partially open valve 2. Flow of cold solvent low 3. Supply of cold solvent is low 4. Partial blockage	1. Less output of hot solvent may affect downstream 2. Same as 1 3. Same as 1 4. Same as 1	1. Open valve fully 2. Check for line leads 3. Install flowmeter 4. Clear blockage

1D	Hot solvent from exchanger	Flow	More	1. Valve failure at inlet 2. Excessive flow at inlet	1. Pressure buildup 2. Damage to equipment downstream	1. Recalibrate flow meter 2. Insert relief/mitigation stream
2A	Hot solvent from exchanger	Temperature	Less	1. Malfunction of thermocouple 2. Lower than the acceptable thermocouple temperature range	1. Flow of solvent from heat exchanger below desired temperature 2. Loss of material as desired products are not achieved	1. Install low temperature alarm. 2. Regular maintenance and inspection of the temperature controller
2B	Hot solvent from exchanger	Temperature	More	1. Malfunction of thermocouple. 2. Too high to be detected by thermocouple temperature range	1. Flow of solvent from heat exchanger above desired temperature 2. Over pressure occurs as more solvent changes to vapor	1. Install relief valve. 2. Install high temperature alarm
3A	Hot solvent from exchanger	Pressure	More	1. Excessive flow at the inlet 2. Control valve failure	1. Burst / Rupture (Explosion) 2. damage to Downstream equipment	1. Relief System / Mitigation System 2. Recalibrate flow meter or install pressure indicators
3B	Hot solvent from exchanger	Pressure	Less	1. Control valve failure. 2. Leakage in pipe	1. Reverse Flow 2. Loss of solvent	1. Install pressure indicator. 2. Install check valves

c. Recommendations

1. Ensure that each node has a backup operation plan in place to ensure that the downstream and upstream operations are not impacted.
2. Implement pressure relief valves to ensure there is a way to release pressure built up in the system.
3. Regularly check and maintain the quality of equipment to ensure that the system operates as intended.
4. Focus on the material hazards in the process. Understanding the hazards of the materials used greatly reduces the risk of unexpected accidents or damage to equipment.