Unit 2: Fundamentals of material balances on non-reactive processes

Reminders

- Homework 1 is due on September 6 via Canvas

Announcements

Office Hours:
Posted here and on the Canvas homepage.

Day	Time	Location	Personnel
Monday	4 – 5PM	AW Smith 147	Duval
Tuesday	1 -2 PM	AW Smith, 152	TA
Wednesday	3:30 – 4:30 PM	AW Smith, 147	Duval
Thursday	2:30 – 3:30 PM	AW Smith 152	TA

Helpful sections of the book: Chapter 4 (pages 83- 104)

Learning Objectives

- After this week, students should be able to:
  - Name and describe three types of reactors
  - Distinguish between transient and steady state
  - Write the general rule for conservation of mass
  - Outline the general procedure for solving material balances
  - Apply the general procedure for material balances on single-unit processes to solve for:
    - Unknown mass fraction or mole fraction
    - Unknown mass flowrate or molar flowrate

Types of reactors

- **Batch** reactors
  - Reactants are fed to reactor at the beginning of the process. Products are removed later. No mass crosses system boundary.
- **Continuous** reactors
  - Reactants and products continuously flow in/out of the reactor
- **Semi-batch** reactors
  - Partly batch or partly continuous

Batch reactors

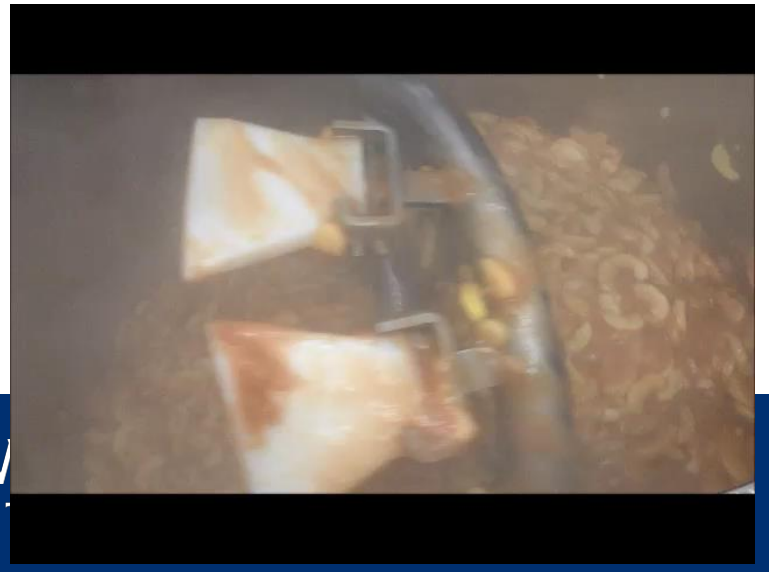
- Beverage fermentation
  - Beer
  - Wine
  - Soy sauce
  - Vinegar
- Pharmaceuticals
  - Vaccines
  - Protein-based therapies
  - Medicine
- Food production

Batch reactors in action

LEE INDUSTRIES
Processing Perfection.

Batch reactors in action

LEE INDUSTRIES
Processing Perfection.



Continuous reactors

- Large scale-food production
  - Blending processes (ketchup, dog kibble)
  - Polymer extruders

- Commodity chemical production
  - Distillation columns
  - Packed-bed reactors
  - Scrubbers
  - Chromatography
  - Membrane separations

Semi-batch reactors

- Polymerization reactions
- Exothermic reactions
  - Diluting acids

Steady-state vs. transient processes

Remember our process variables:

- If they DO NOT change with time for a given continuous process, it is said to be at **steady state**

- If they DO change with time for a given continuous process, it is said to be **transient**

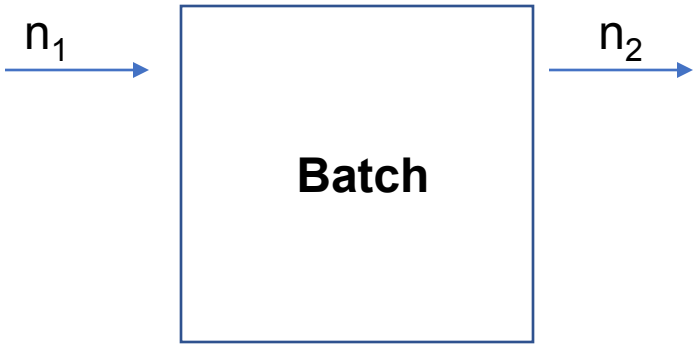
In-class examples

1. Diluting HCl
2. Continuously distilling ethanol
3. Making strawberry jam

Extra information if you still need help with…

Batch vs. Semi-batch vs. Continuous

Batch vs. Semi-batch vs. Continuous



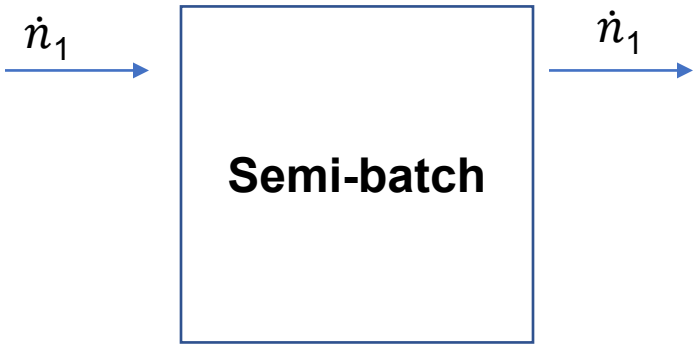
Criteria

- All reactants are added at the same time (before process occurs)
- Some process occurs (mixing, reaction, etc.)
- All products are removed after process is complete

Criteria

- Reactants and products are continuously flowing in and out of the system while the process is happening
- Mass can reside within the reactor (residence time), BUT there is no accumulation of mass and therefore the process CAN run indefinitely

Batch vs. Semi-batch vs. Continuous



Criteria

- Reactants and products are continuously flowing in and out of the system while the process is happening
- Mass is accumulated within the reactor or depleted from the reactor such that the process CANNOT run indefinitely without adjusting a feed or product stream flowrate

Criteria

- Reactants and products are continuously flowing in and out of the system while the process is happening
- Mass can reside within the reactor (residence time), BUT there is no accumulation of mass and therefore the process CAN run indefinitely

Unit 2: Fundamentals of material balances on non-reactive processes

Reminders

- Homework 1 is due on Friday, September 6

Announcements

- Homework 2A will be assigned on Friday, September 6

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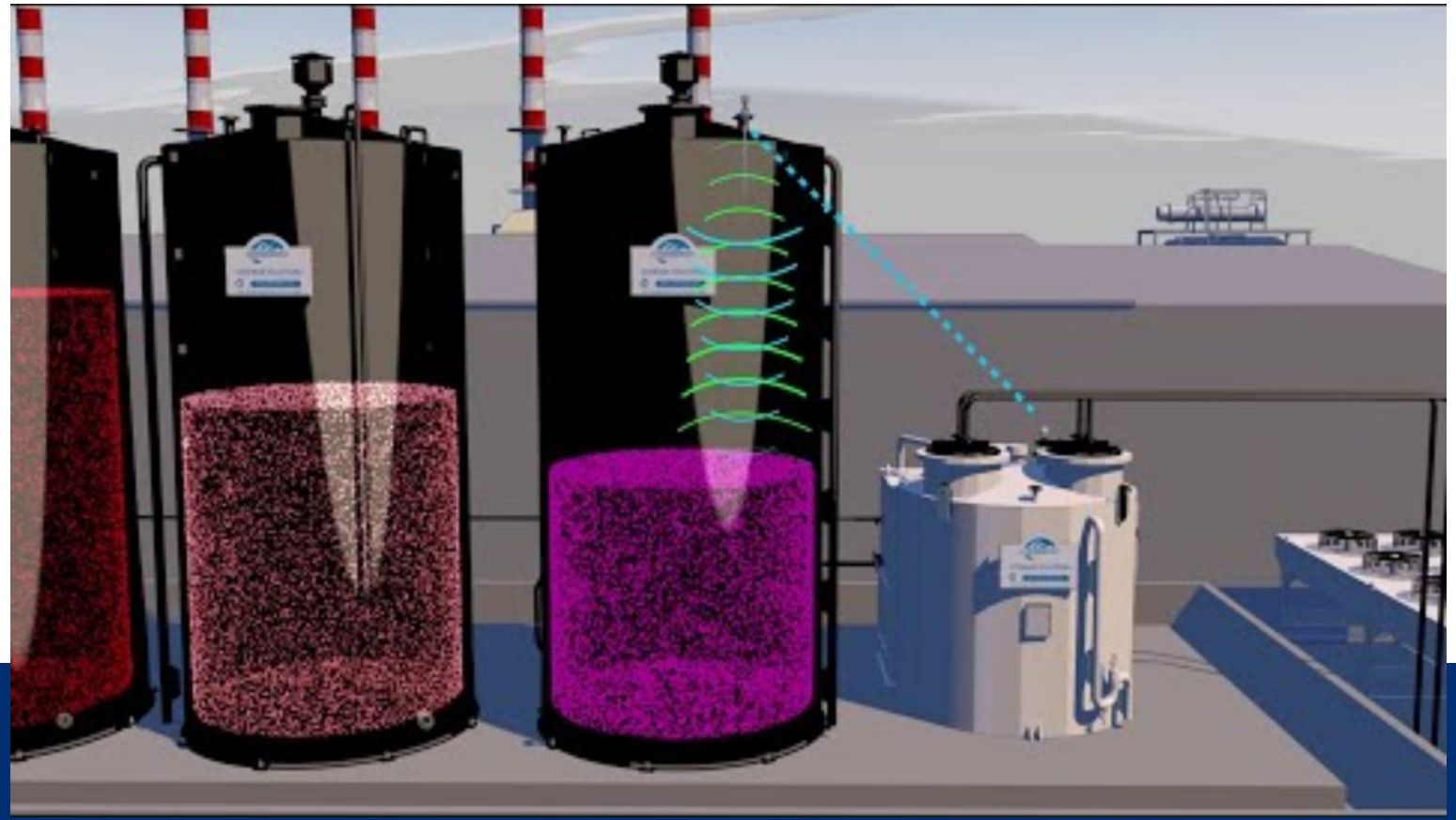
Helpful sections of the book: Chapter 4 (pages 83- 104)

Learning Objectives

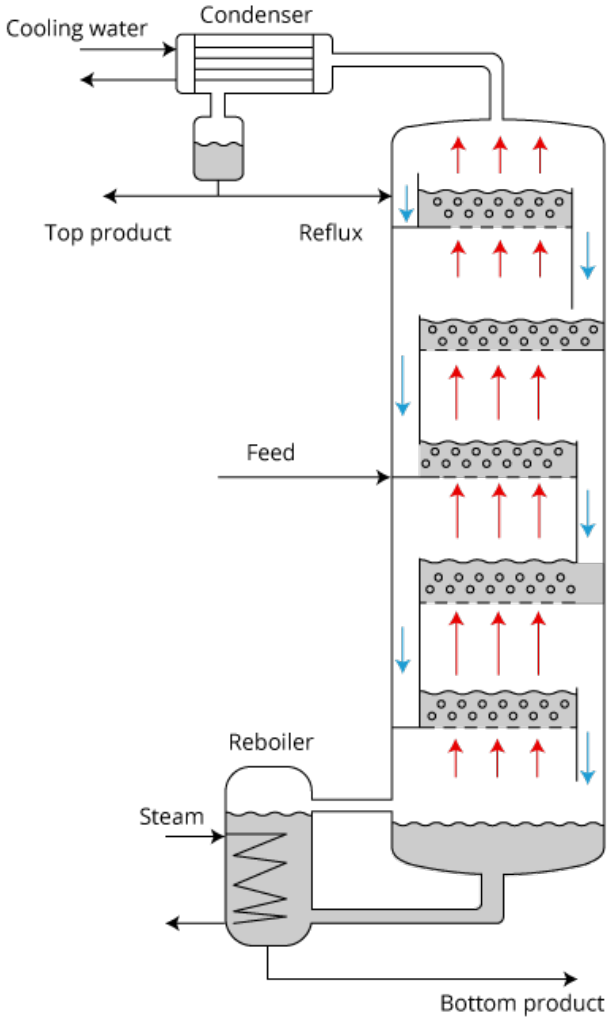
- After this week students should be able to:
  - Name and describe three types of reactors
  - Distinguish between *transient* and *steady state*
  - **Write the general rule for conservation of mass**
  - **Outline the general procedure for material balances**
  - **Apply the general procedure for material balances on single-unit processes to solve for an unknown mass fraction, mole fraction, molar flow rate or mass flow rate**

Example 1: Diluting acid

- Companies often purchase concentrated acid then dilute it on site. **Why?**



Example 2: Continuously distilling ethanol



- **Distillation columns** use heat to separate mixtures of liquids with different boiling points

- Commonly used to increase alcohol content in fermented liquors
- Boiling point of EtOH: 78 °C
- Boiling point of water: 100 °C

Unit 2: Fundamentals of material balances on non-reactive processes

Reminders

- Homework 2A is due on September 13

Announcements

- Homework 1 grades & solutions are posted in the Unit 1 Module
- Regrade requests are now open – see syllabus for details

Office Hours:

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Helpful sections of the book: Chapter 4 (pages 83- 104)

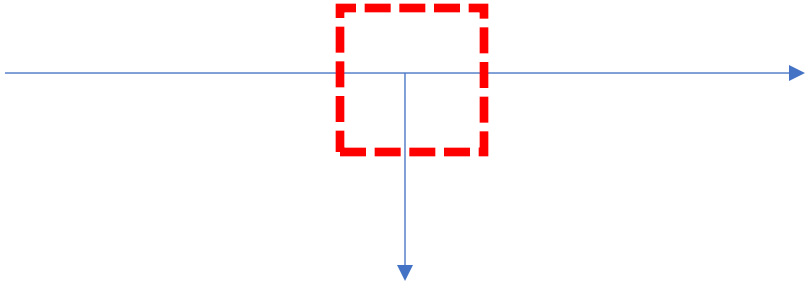
Finish the strawberry jam example from last class

Learning Objectives

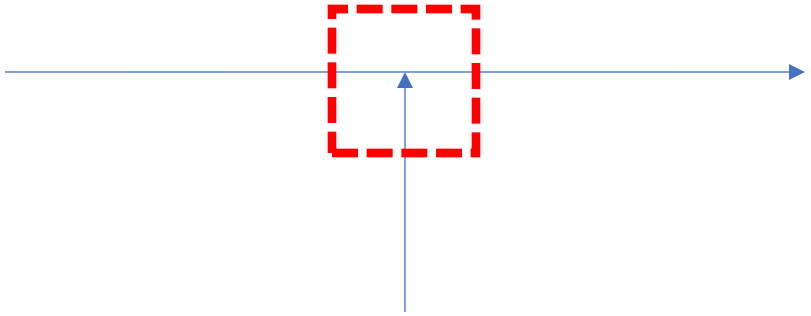
- After this next week students should be able to:
    - Apply the general procedure for material balances on **multi-unit** processes with **recycle and bypass streams**

New terminology

Splitting point: where 1 stream becomes 2 streams

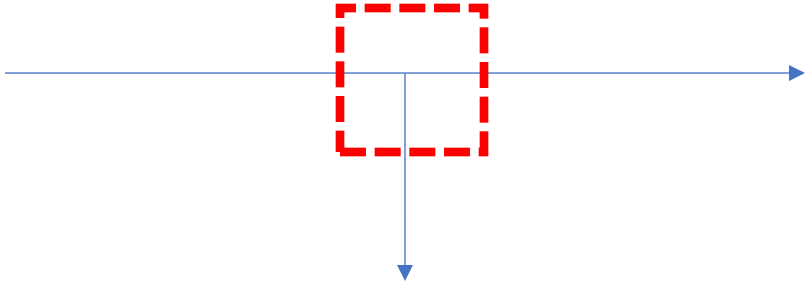


Mixing point: where 2 or more streams become 1 stream

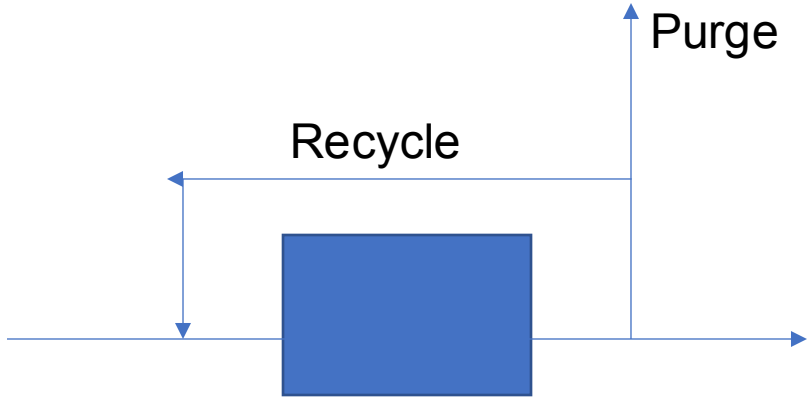


New terminology

Splitting point: where 1 stream becomes 2 streams



Purge: when a a portion of the recycle stream is split and leaves the system

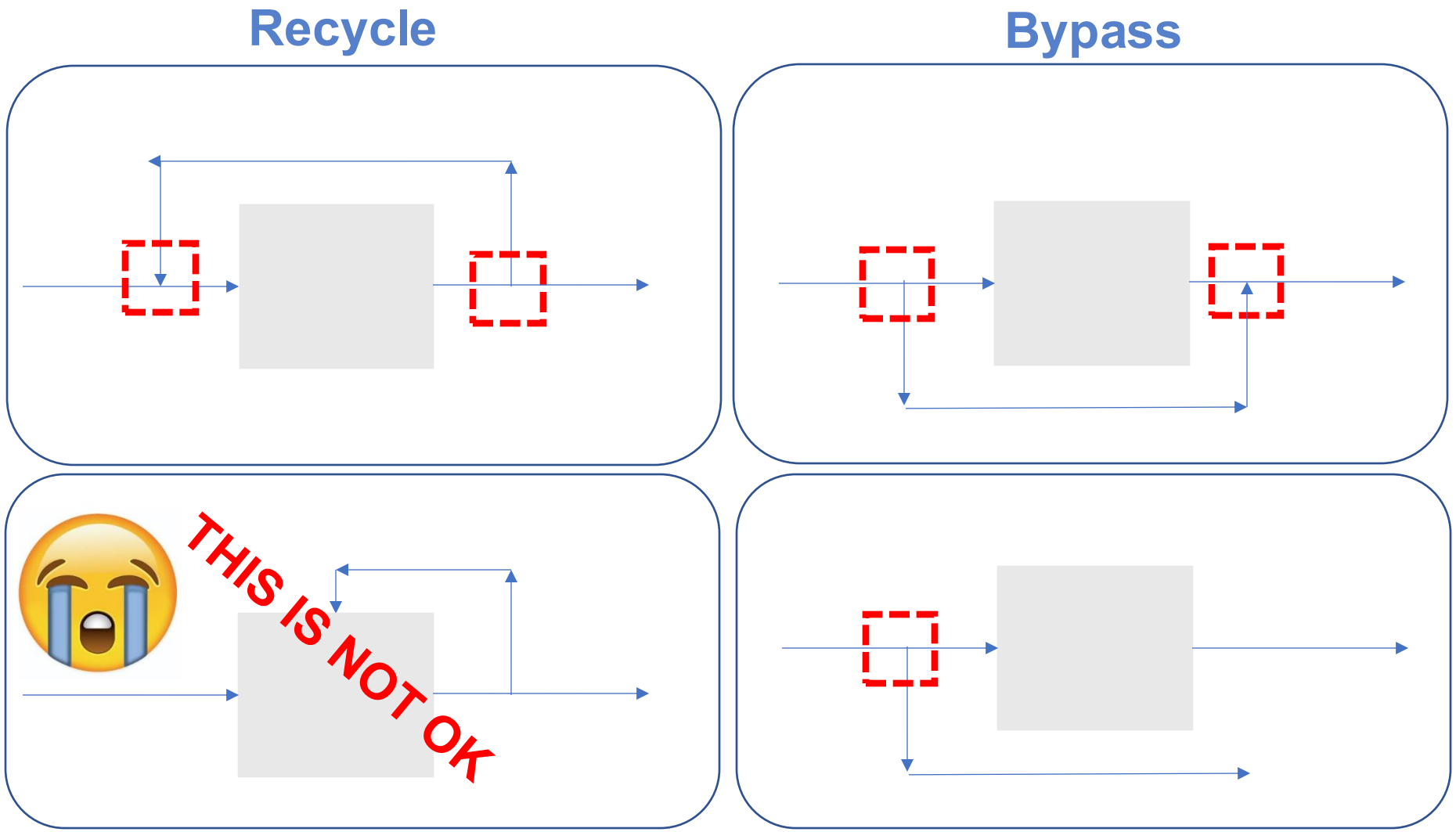


Recycle vs. Bypass

- Recycle
  - Dilute a stream
  - Circulate a working fluid
  - Recover a catalyst
  - Reuse unreacted components

- Bypass
  - Circumvent a unit operation
  - Overflow condition for safety

Recycle vs. Bypass



In-class examples

- Air conditioning
- Combined sewer overflow

Example 4: Air conditioning

Unit 2: Fundamentals of material balances on non-reactive processes

Reminders

- Homework 2A is due on September 13
- Homework 1 regrade requests are open on Canvas

Announcements

- AIChE Panel in class on Friday, September 20

Office Hours:

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Helpful sections of the book: Chapter 4 (pages 83- 104)

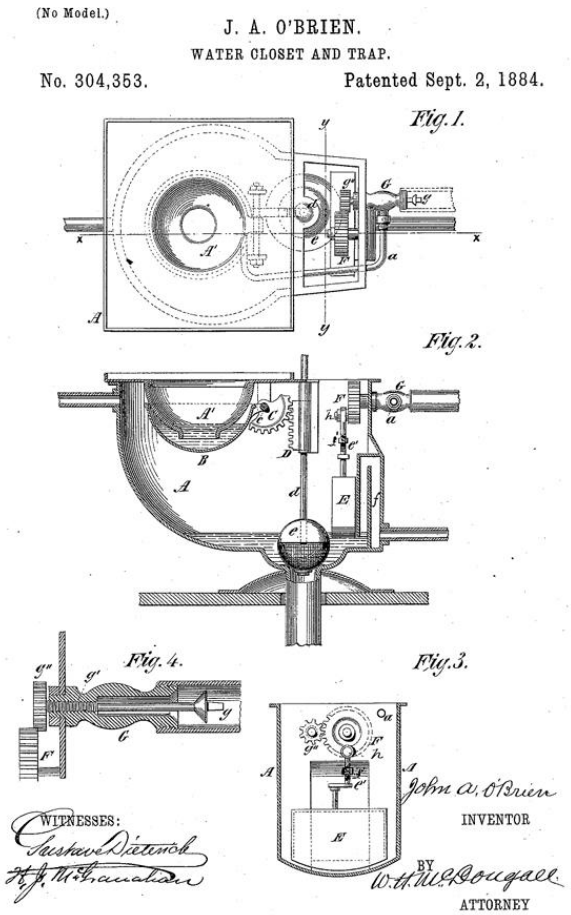
Learning Objectives

- After this week students should be able to:
    - Apply the general procedure for material balances on **multi-unit** processes with **recycle and bypass streams**

In-class examples

- Air conditioning (finish this one first)
- Combined sewer overflow

What do these have in common?


(No Model.)

J. A. O'BRIEN.

WATER CLOSET AND TRAP.

No. 304,353. Patented Sept. 2, 1884.

Fig. 1.

Fig. 2.

Fig. 4.

Fig. 3.

WITNESSES:

John A. O'Brien

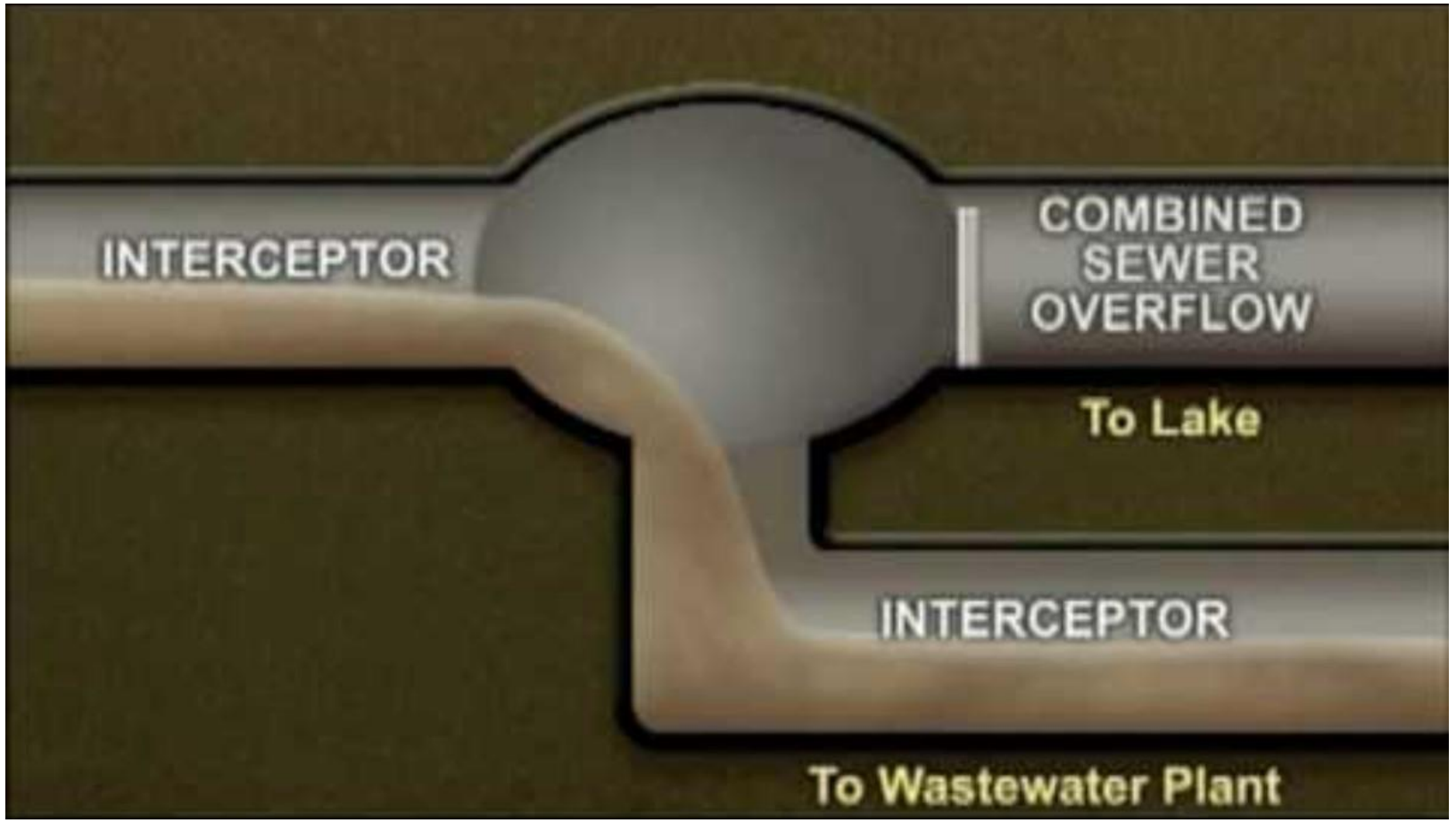
INVENTOR

BY

ATTORNEY

What do these have in common?

Combined sewer systems



Monday, September 7, 2020

- The third wettest day on record in Cleveland history.
- Flash floods across the city.
- Video of Edgewater beach