Engineering Economics and Problem Solving, 4N4, 2014

Tutorial/Assignment 6

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AIM: *To gain comfort with process drawings, and apply your knowledge of process operability learned so far*

Engineers use process drawings to efficiently and clearly describe process designs. It is the basic document for any facility, and captures some of the most concentrated information. It is used for HAZOP and safety studies (the next topic in the course). It is the document that will be reviewed and approved by government authorities, such as the local municipality, or provincial authority.

Question 1

Some quick and easy questions based on downloading and using the free Chapter 1 of the textbook by Turton *et al*. Answer these questions, in the context of the phthalic anhydride project for this course.

1. *page 9*: what does `T-702` mean on our phthalic anhydride process flow diagram?
2. *page 9*: what does `V-702` mean on our phthalic anhydride process flow diagram?
3. *page 11*: what does `E` in `E-706` mean?
4. *page 13*: what typical temperature range is cooling water fed at to a heat exchanger?
5. *page 13*: cooling water that has been used in a heat exchanger gets heated up. Why do we have an upper limit on the return temperature back to the cooling water tower? (don't just copy the answer, research what it actually means)
6. *page 21*: what does P&ID stand for?
7. *page 22*: does a P&ID tell you how long a piece of pipe is that connects two units?
8. *page 24*: draw a line that indicates an instrument is recorded by a pneumatic signal. What does "pneumatic" mean?
9. *page 24*: draw the symbol for flow measurement on a pipe, where that flow is also indicated to the operators out in the plant, and digitally recorded in the control room
10. *page 23*: take a careful look at the P&ID on page 23. Remember how in tutorial 5 you were recommended to start drawing the diagram for our phthalic anhydride plant? The P&ID diagram you see on this page 23 is a greatly enhanced diagram; this is the level of the drawing we will expect to see your group having mostly completed at the group meetings in early November, and fully completed in your final report.

Question 2

We now move to using another P&ID for the tutorial: drawing PID-2A in Woods's *Process Design and Engineering Practice* (see the last page of this tutorial). This drawing is typical of drawings used in engineering practice.

1. Overview of the process
   (a) Identify the main feed and product streams on the drawing.
   (b) Why are the distillation towers called "depropanizer" and "debutanizer"?
2. Piping and valves and sensors
   (a) What symbols are used for pumps? What general class of pumps is used in this process?
   (b) Why does the pipe size change from the inlet and outlet of `E-25`?
   (c) Find valve `FV-1`.
      - Is this an automated control valve or a "hand" valve?
      - Why are all of the other valves located around `FV-1`?
   (d) What is the size of the pipe between `F-26` and `FV-1`? - What is a typical velocity value for liquid in a pipe? (*hint* the answer is in the current set of notes for the course) - What is a typical velocity value for gas in a pipe?
   (e) What is `PSV-1`?
   (f) What type of valve body is used in `FV-4`? (Globe, ball, needle, etc.)
3. Pumps
   (a) Find pump `F-26`.
      - What are the items shown in the outlet pipe from the pump?
      - What provides the power to the pump?
   (b) Pump `F-27` is located after `V-30`. Why does the drawing specify that `V-30` must be 4.5 m above ground level?
4. Process equipment

   a. How many theoretical trays exist in the debutanizer? c. Why is `TC12` controlling the temperature of a tray in the debutanizer? Describe the principle behind why this manipulated and controlled variable selection. d. What type of reboiler is provided in the debutanizer? (kettle, thermosyphon, pumped circulation, etc.) e. Find heat exchanger `E-24`.
   - Why is steam entering and water leaving?
   - What is the meaning of the box with "`T`" inside?

Question 3

In the introduction to Operability we looked at 5 categories of reasons why our process will not operate at the "base case": (a) deliberate changes, (b) disturbances, (c) model error, (d) equipment breakdowns, and (e) human error.

In the context of the phthalic anhydride (PA) flowsheet, please give 4 very specific examples in each of the 5 categories.

Question 4

Let's understand the operating window better with an examples from the PA flowsheet.

Streams 5 and 6 are blended to obtain stream 7, as can be seen conceptually in this diagram (note that flow 5 and 6 in the actual flowsheet would be varied based on upstream flows, but for now, we assume we can manipulate these flows).

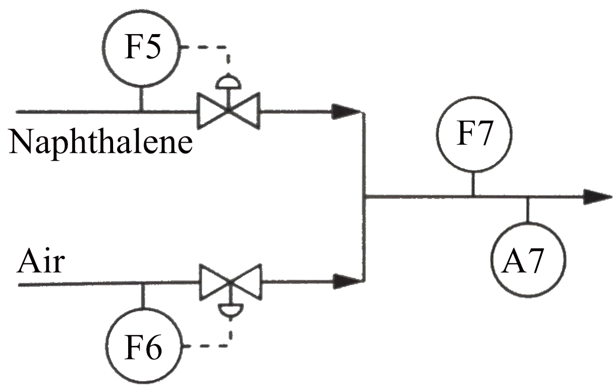
As given in the project handout, stream 5 is pure naphthalene, and stream 6 is only air. Our aim is to develop an operating window: we would like to know the ranges of flowrate `F7` on the one axis, and composition (mass fraction) of naphthalene, `A7` on the other axis over which the system can operate. This is important, so we can know the composition and flows entering the reactor `R-701`.

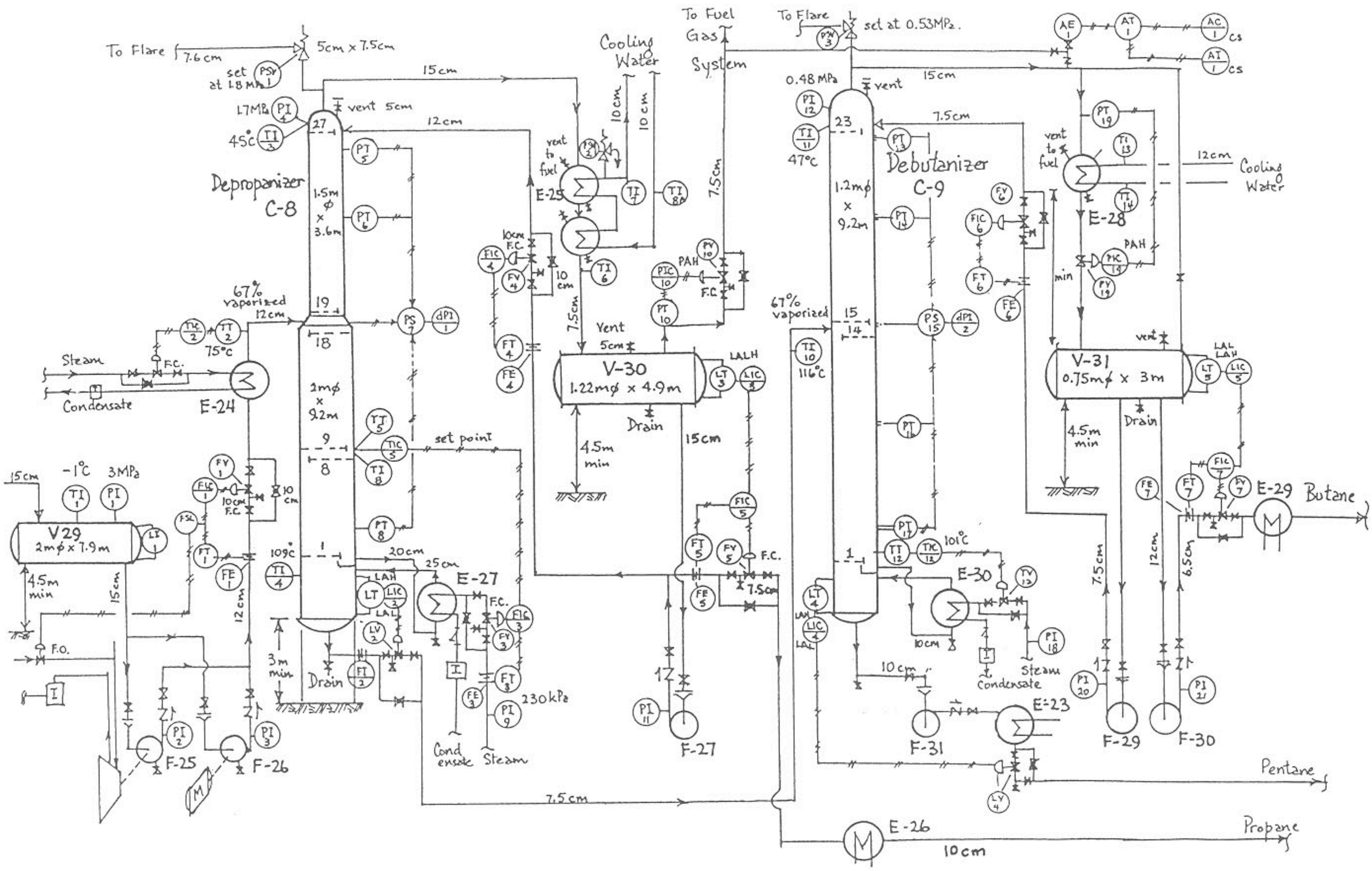
Assume flowrates of `F5` can vary between 0 and 20 tonnes/hour, and that flowrates `F6` can be between 50 and 150 tonnes per hour.

To help you understand the window's bounds, start by answering these questions:

- what is the highest total flow possible?
- what is the lowest total flow possible?
- what is the highest mass fraction possible?

Draw on this 2-D plot the region of feasible operation.





PID–2A Depropanizer/Debutanizer