EngrD 2190 – Lecture 27

Concept: Graphical Models for Mass Balances

Context: Operating Lines for Distillation, cont'd.
The McCabe-Thiele Method.

Defining Question: What is the range of valid liquid+vapor mixtures for a distillation feed stage?

Read Chapter 5 pp. 423-431.
Dimensional Analysis & Dynamic Scaling

Lecture Friday 11/7 is cancelled

Lecture is cancelled to accommodate the distillation lab session.

Although your lab session will not be Friday 11/7 9:05-9:55 a.m.
The cancelled lecture allows for the lab session
without increasing the net contact hours.

Distillation lab sessions will commence Thursday 11/13.
Sign-up for a 50-minute lab session.
Two homework teams per session.

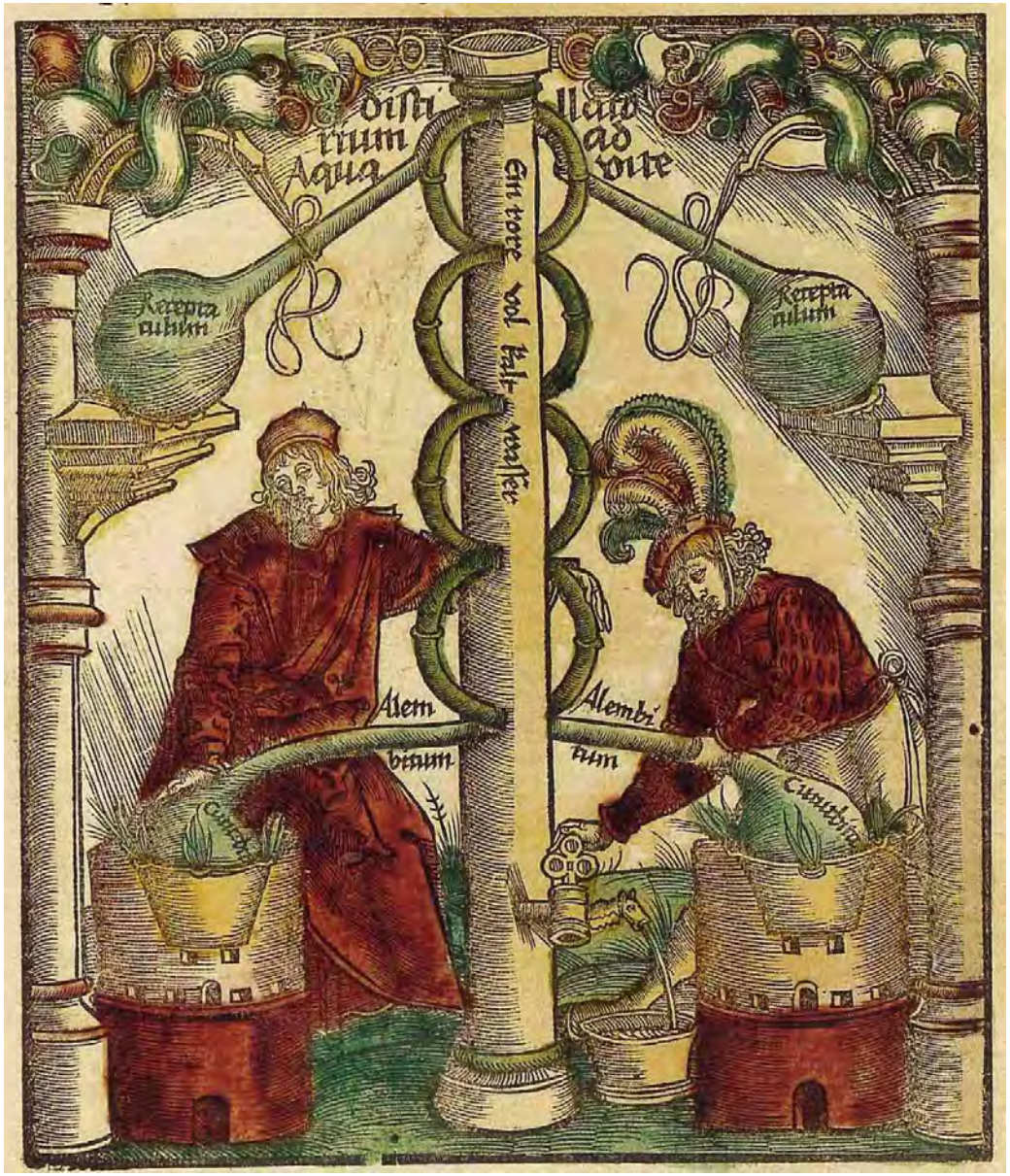
Submit Homework 7 (due Friday 11/7) by delivering
to the EngrD 2190 mailbox outside 116 Olin Hall.

Homework

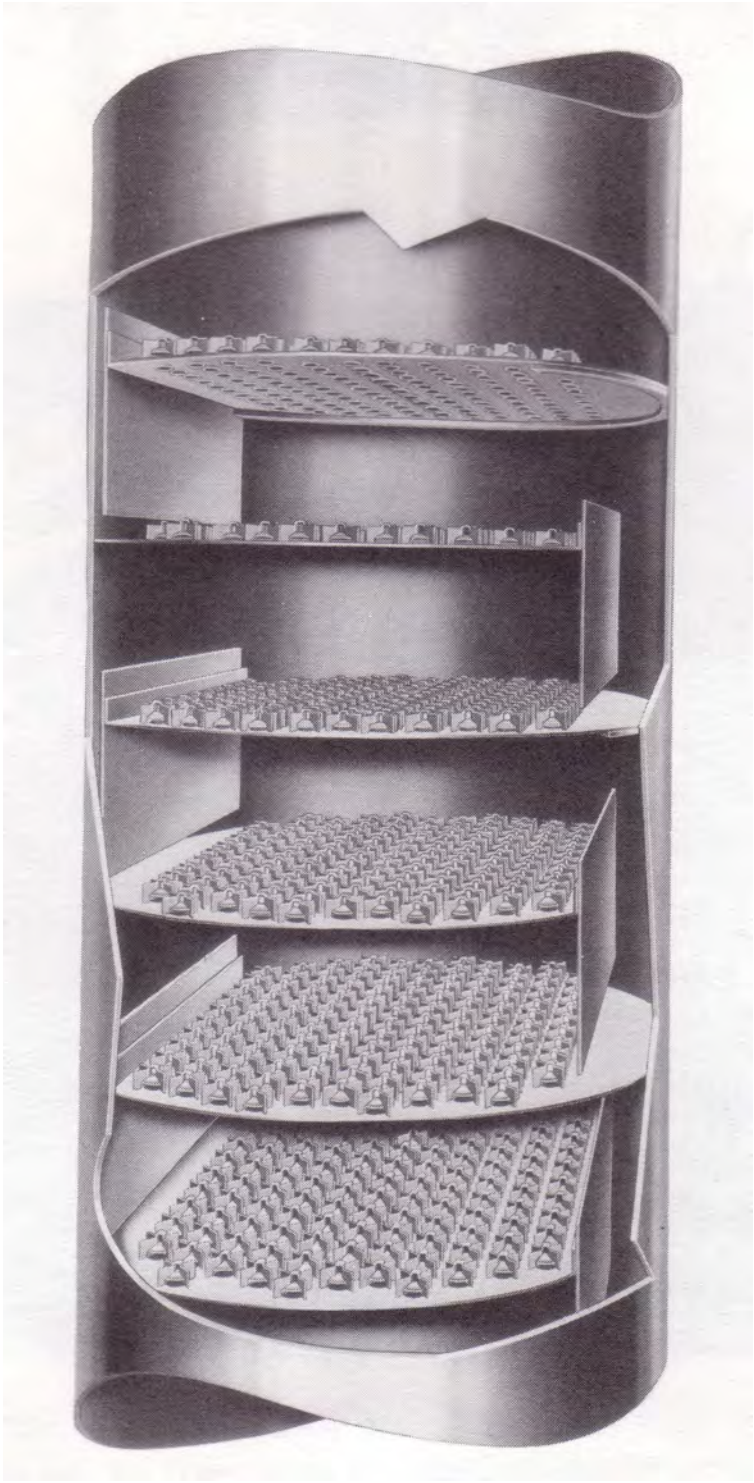
- Homework 8 due Friday 11/14.
  4.67 & 4.68 analysis of distillation columns.
  4.108 design with distillation columns.
  4.103 design with ternary diagrams.

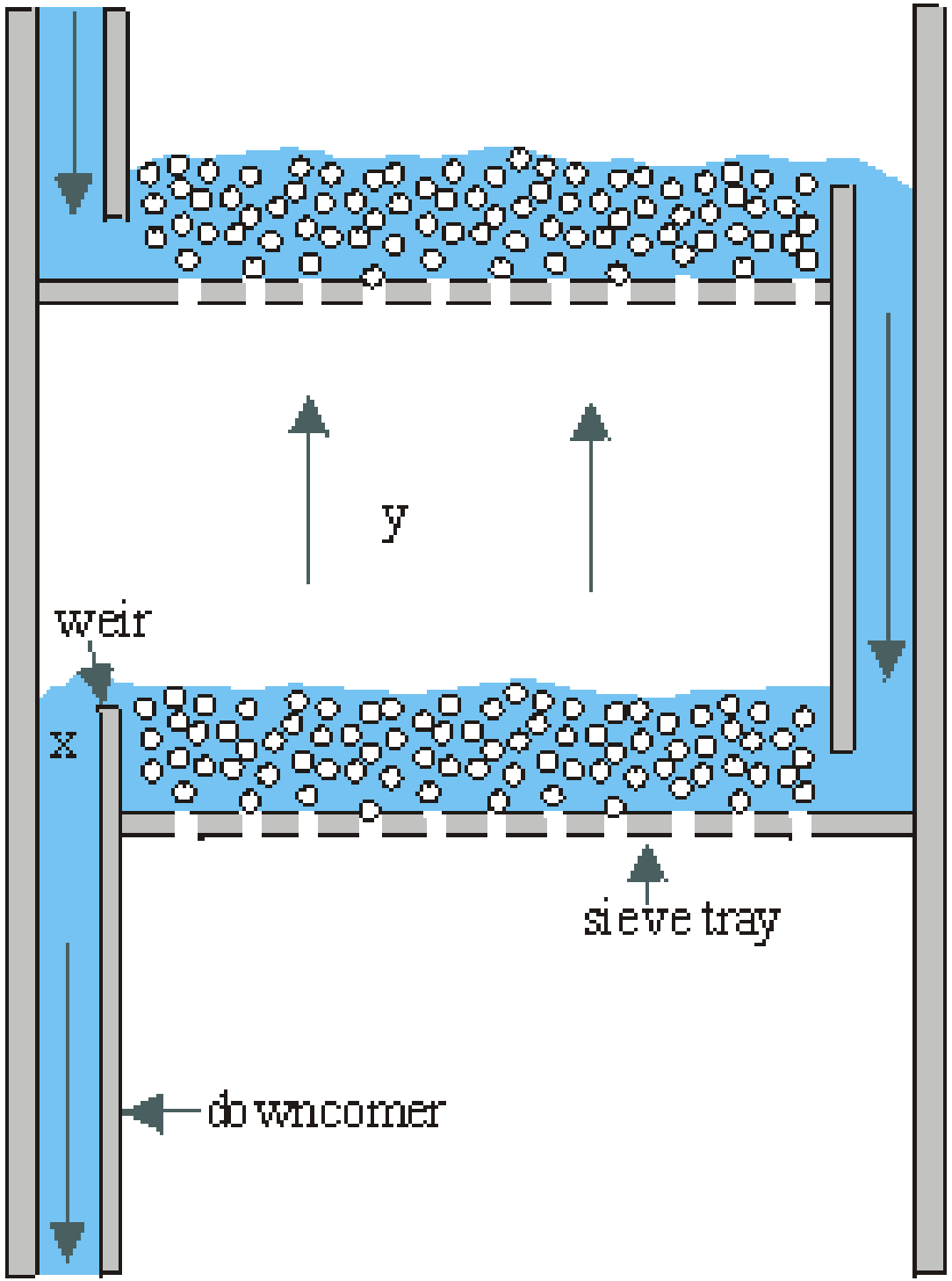
Download blank graphs and phase data from EngrD 2190 homepage:
Textbook→ Textbook Graphs and Figures →
Graphs for Chapter 4 Exercises.

Homework is your chief means of assessing your command of the material.



Liber de arte Distillandi, by Hieronymus Brunschwig, 1527.

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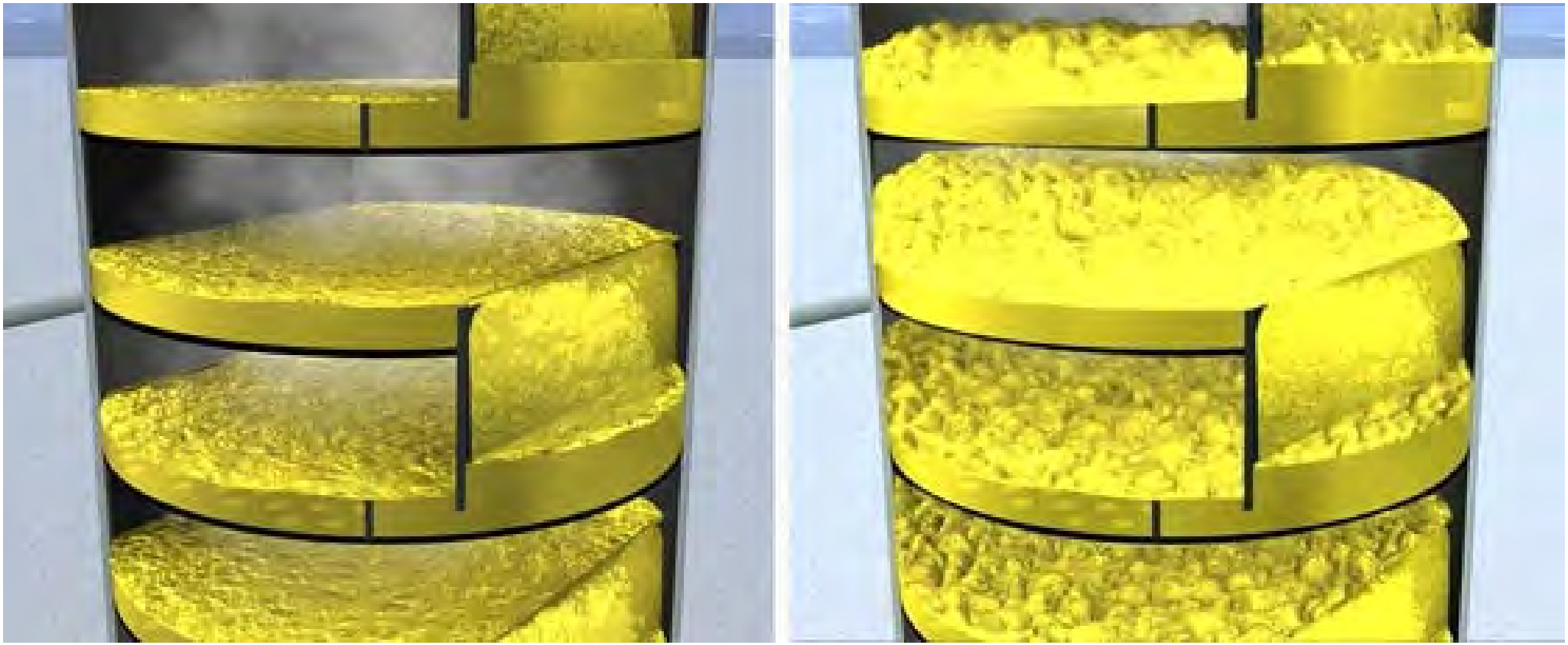


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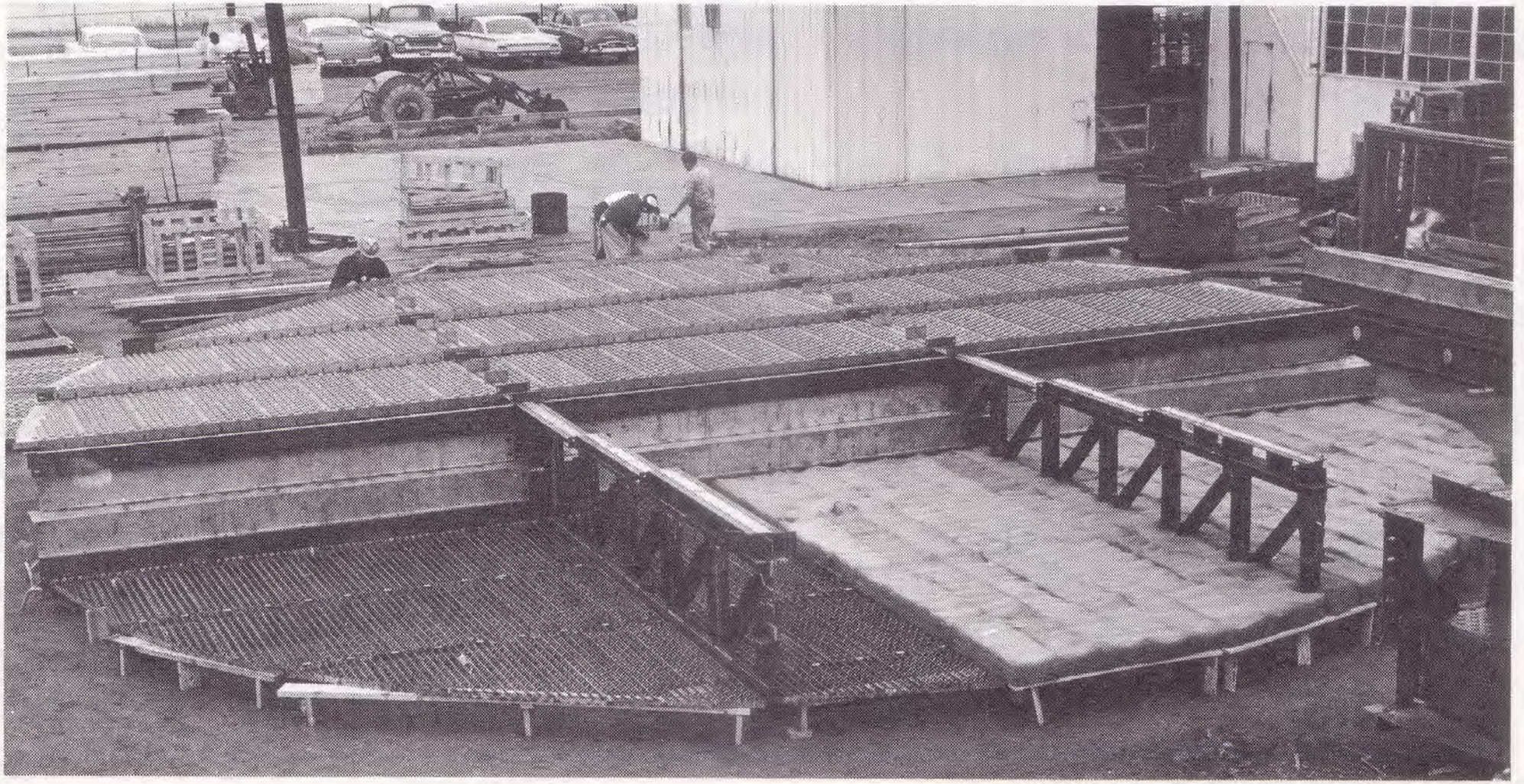



LLGO
19

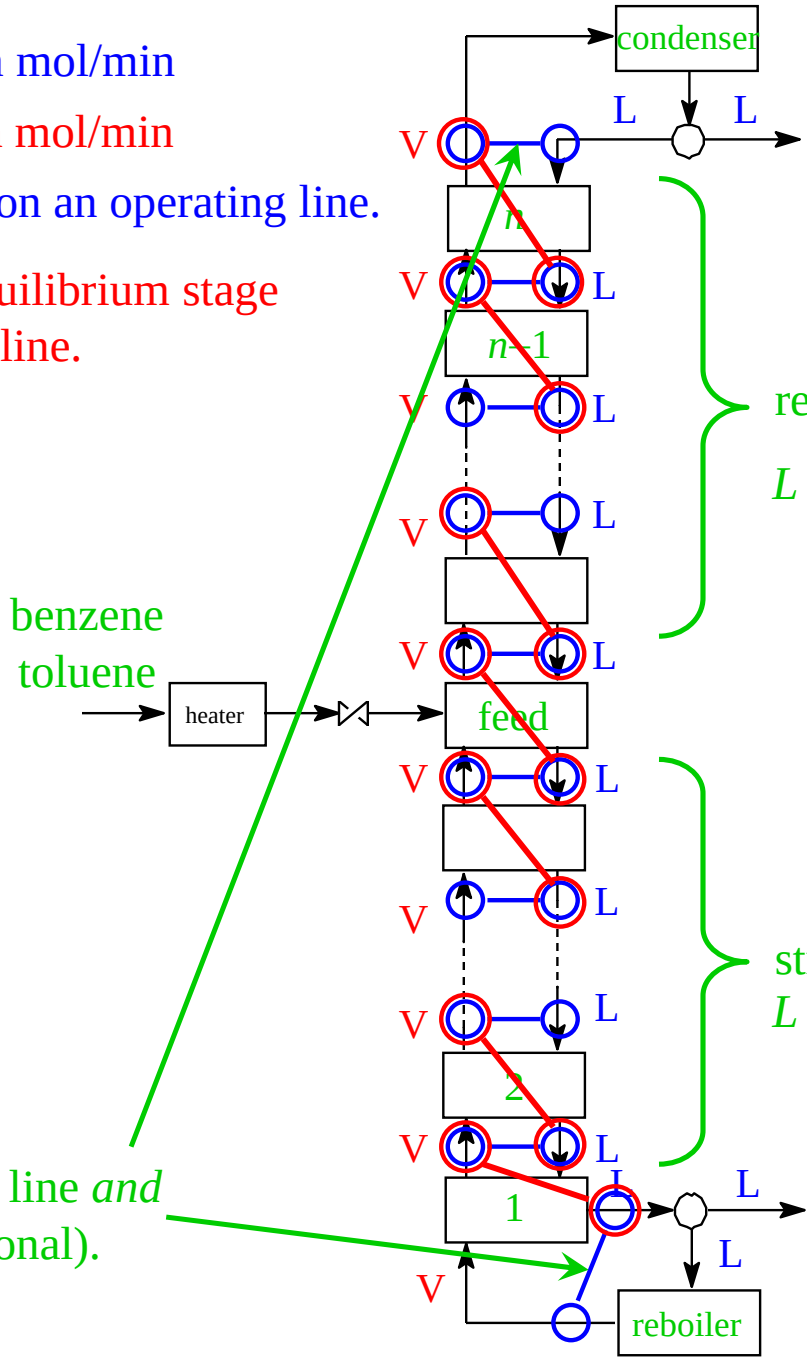
A Distillation Column

$L \equiv$ liquid flow rate, in mol/min

$V \equiv$ vapor flow rate, in mol/min

Adjacent *x*-*y* pairs are on an operating line.

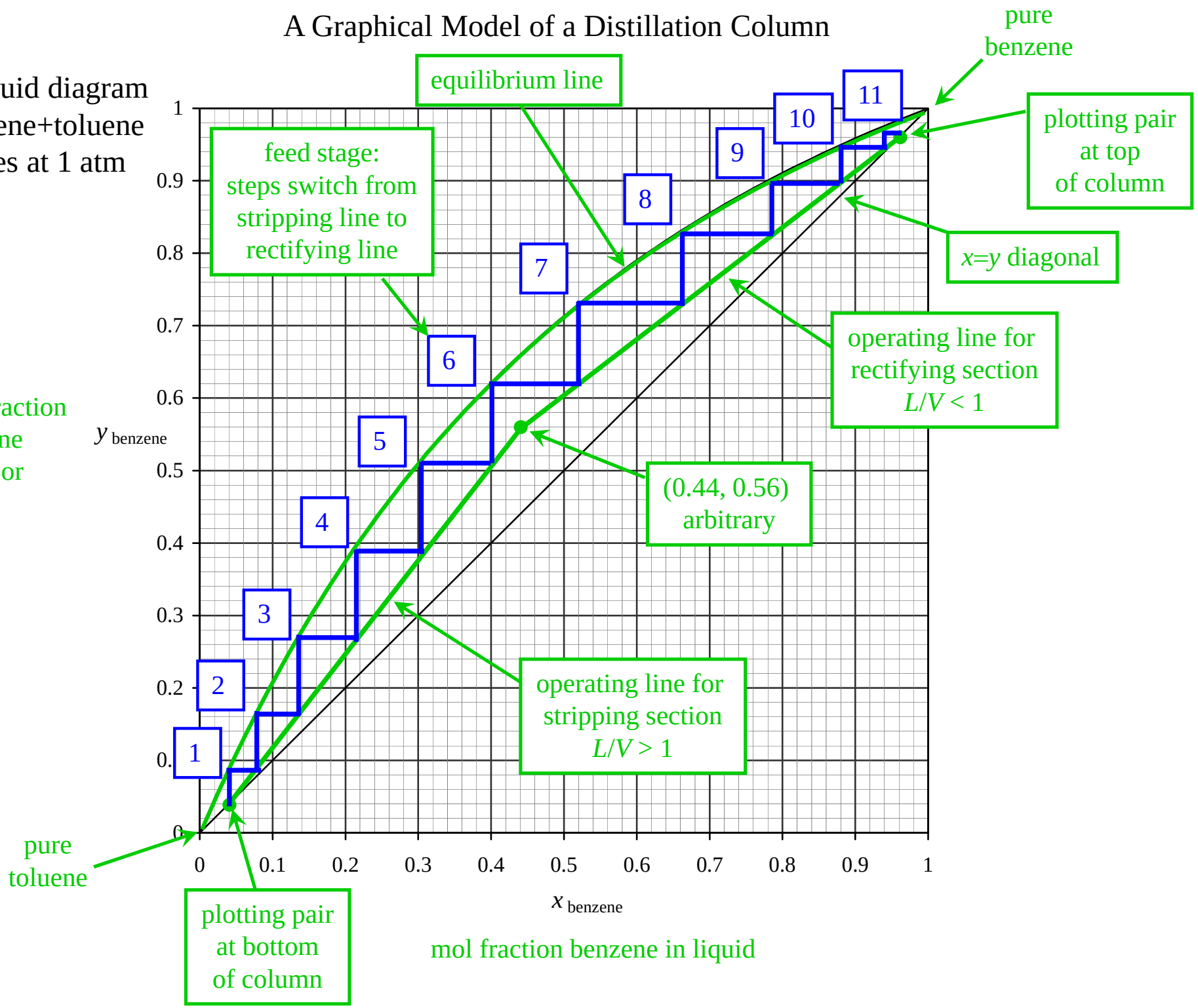
x-*y* pairs leaving an equilibrium stage are on the equilibrium line.



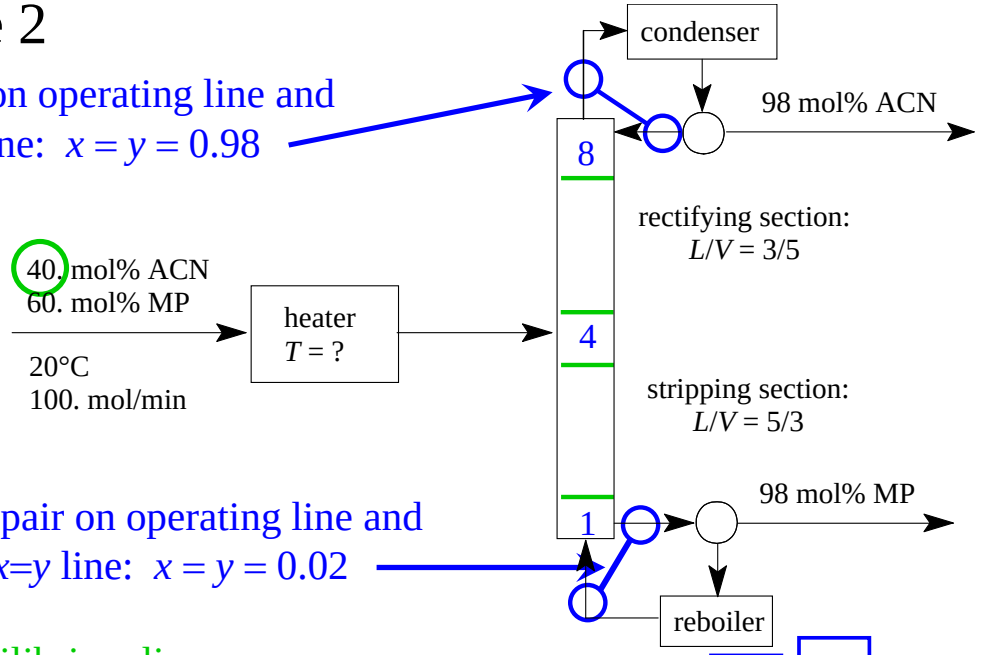
x-*y* pair on operating line *and* on *x*=*y* line (the diagonal).

A Graphical Model of a Distillation Column

vapor-liquid diagram for benzene+toluene mixtures at 1 atm



Distillation Example 2



x-y pair on operating line and on *x*=*y* line: $x = y = 0.98$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{3}{5} \times \frac{0.10}{0.10} = \frac{0.30}{0.50}$$

x: $0.98 - 0.50 = 0.48$

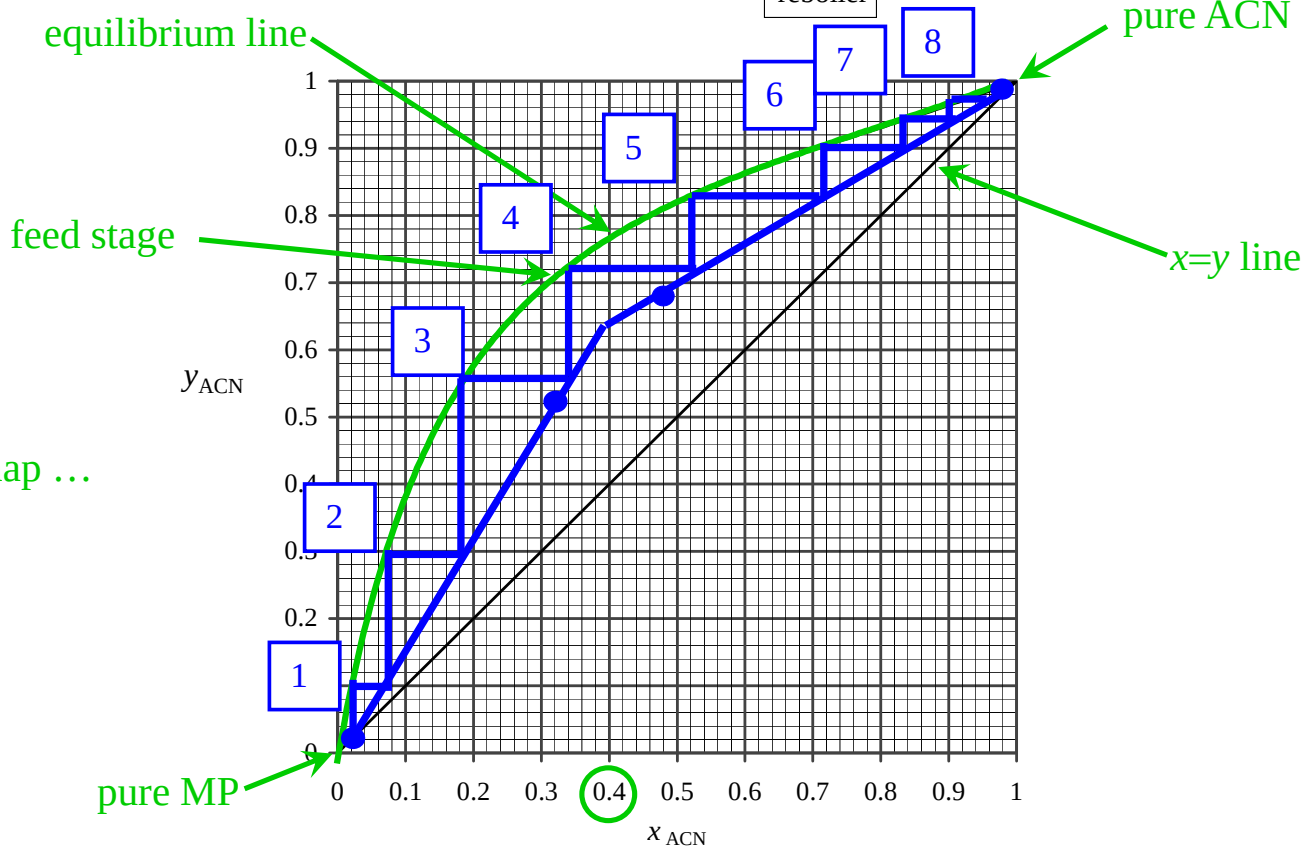
y: $0.98 - 0.30 = 0.68$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{5}{3} \times \frac{0.10}{0.10} = \frac{0.50}{0.30}$$

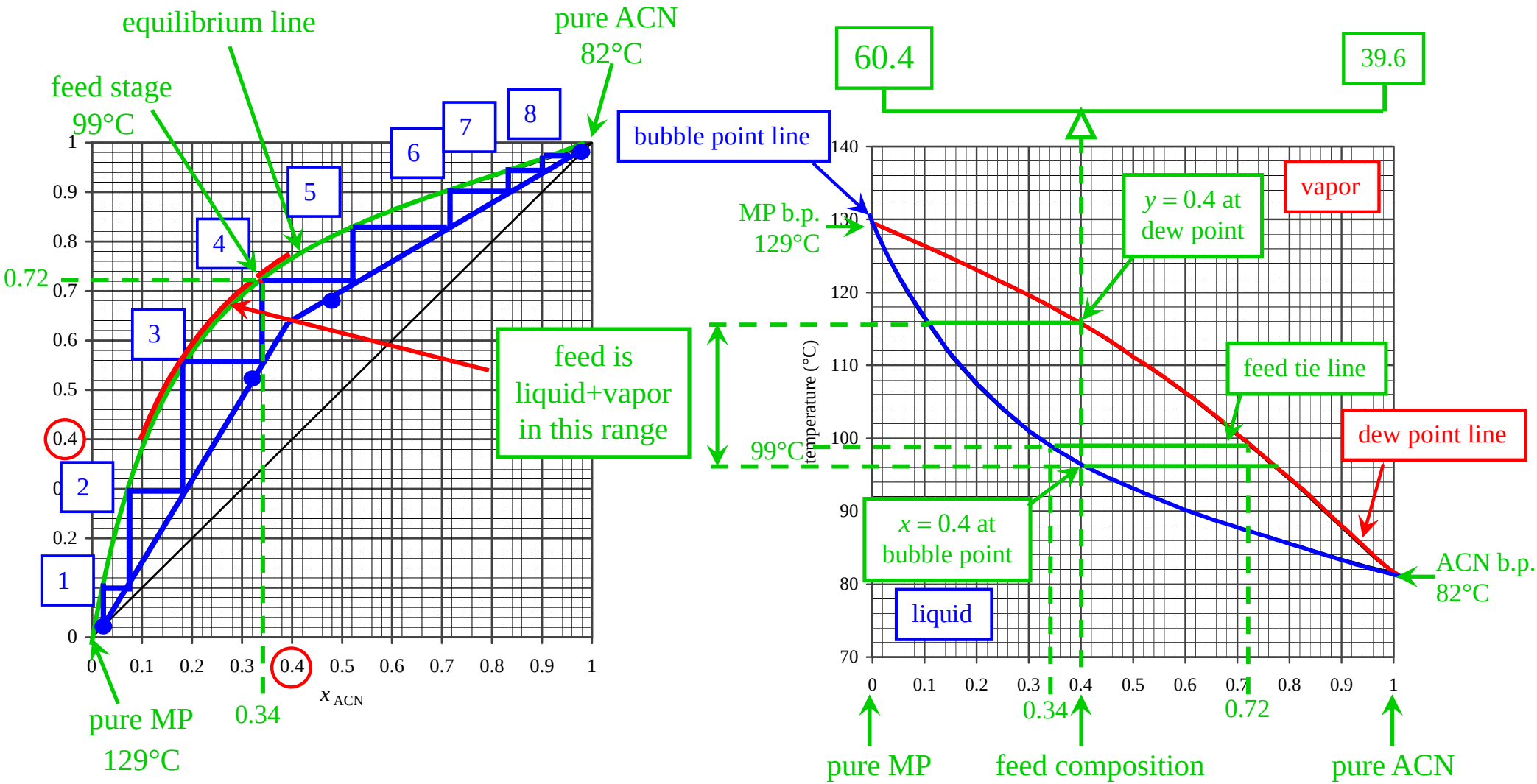
x: $0.02 + 0.30 = 0.32$

y: $0.02 + 0.50 = 0.52$

x-y pair on operating line and on *x*=*y* line: $x = y = 0.02$



Distillation Example 2, continued.



liquid+vapor everywhere

Equilibrium on one line only

Need two streams to plot a point

Use operating lines

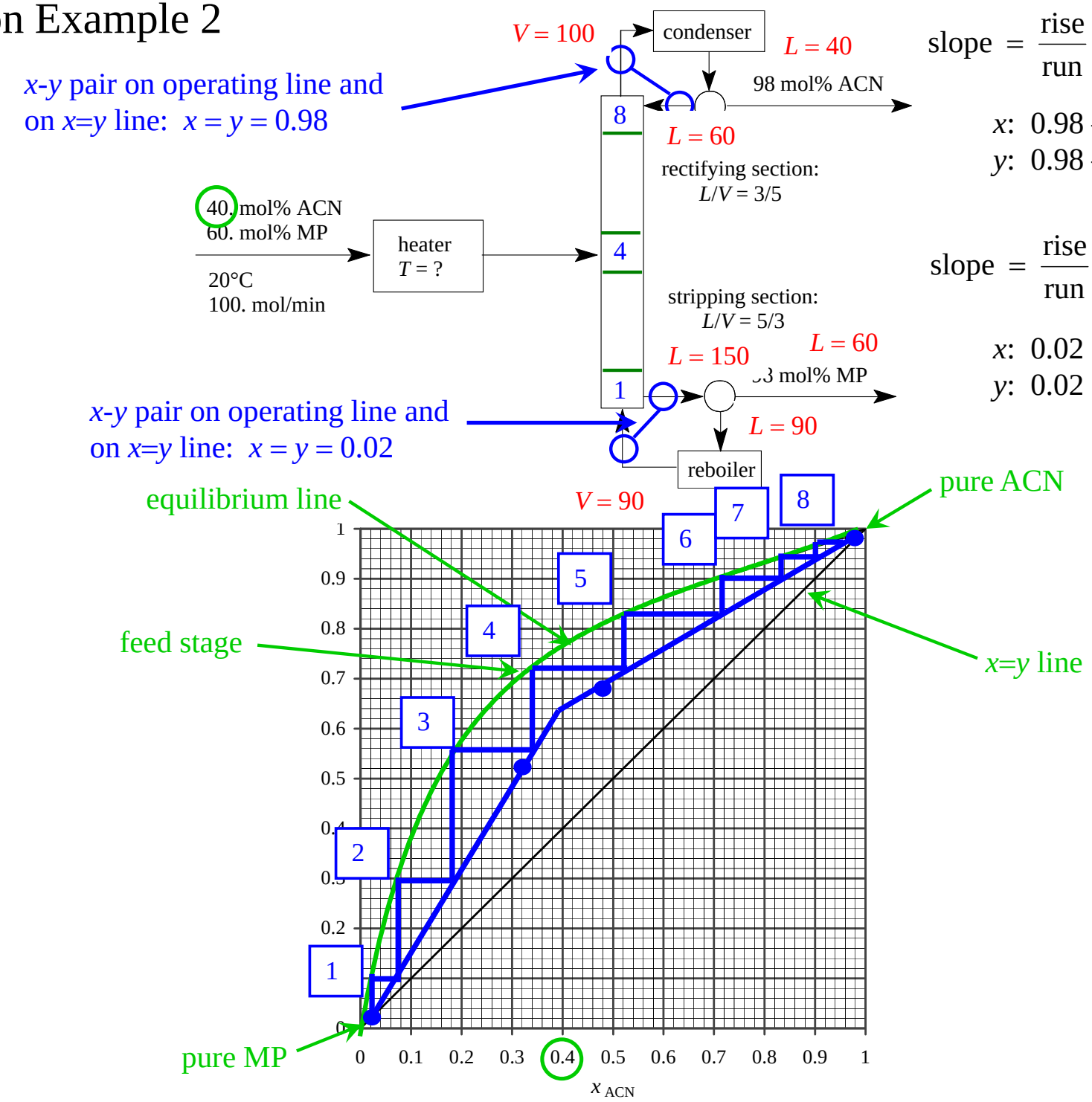
liquid+vapor in one region only

Equilibrium everywhere

One stream defines a point

Use tie lines

Distillation Example 2



$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{3}{5} \times \frac{0.10}{0.10} = \frac{0.30}{0.50}$$

x: $0.98 - 0.50 = 0.48$

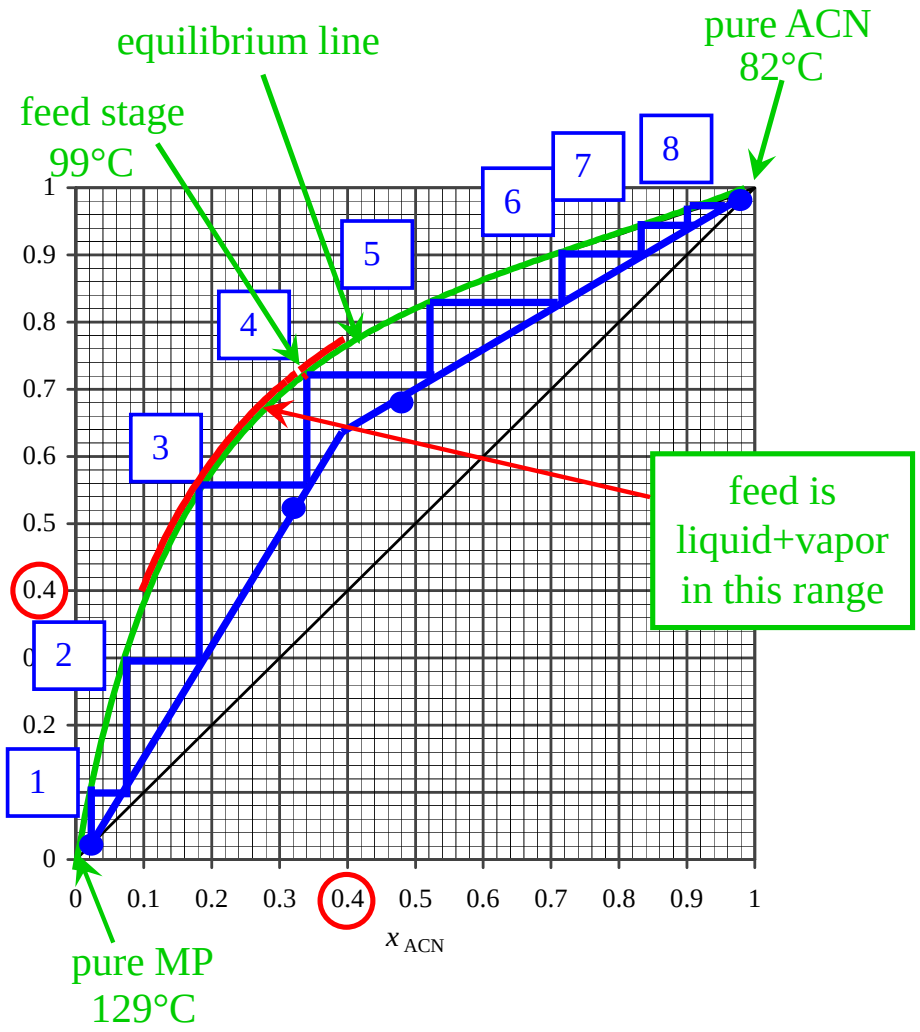
y: $0.98 - 0.30 = 0.68$

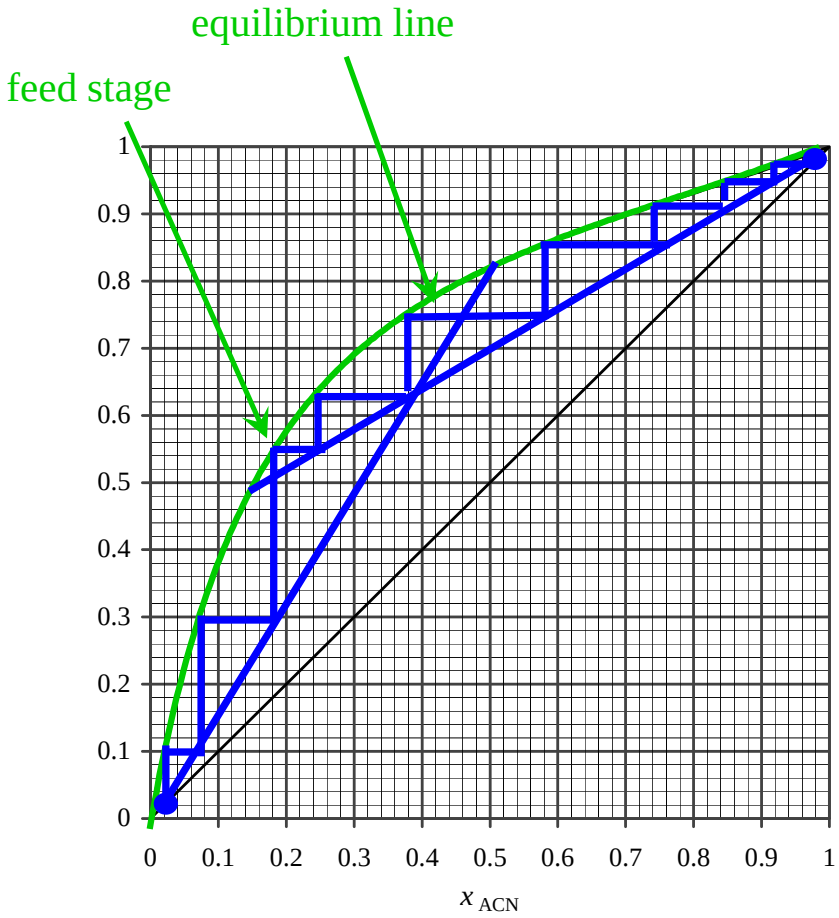
$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{5}{3} \times \frac{0.10}{0.10} = \frac{0.50}{0.30}$$

x: $0.02 + 0.30 = 0.32$

y: $0.02 + 0.50 = 0.52$

Distillation Example 2, continued.



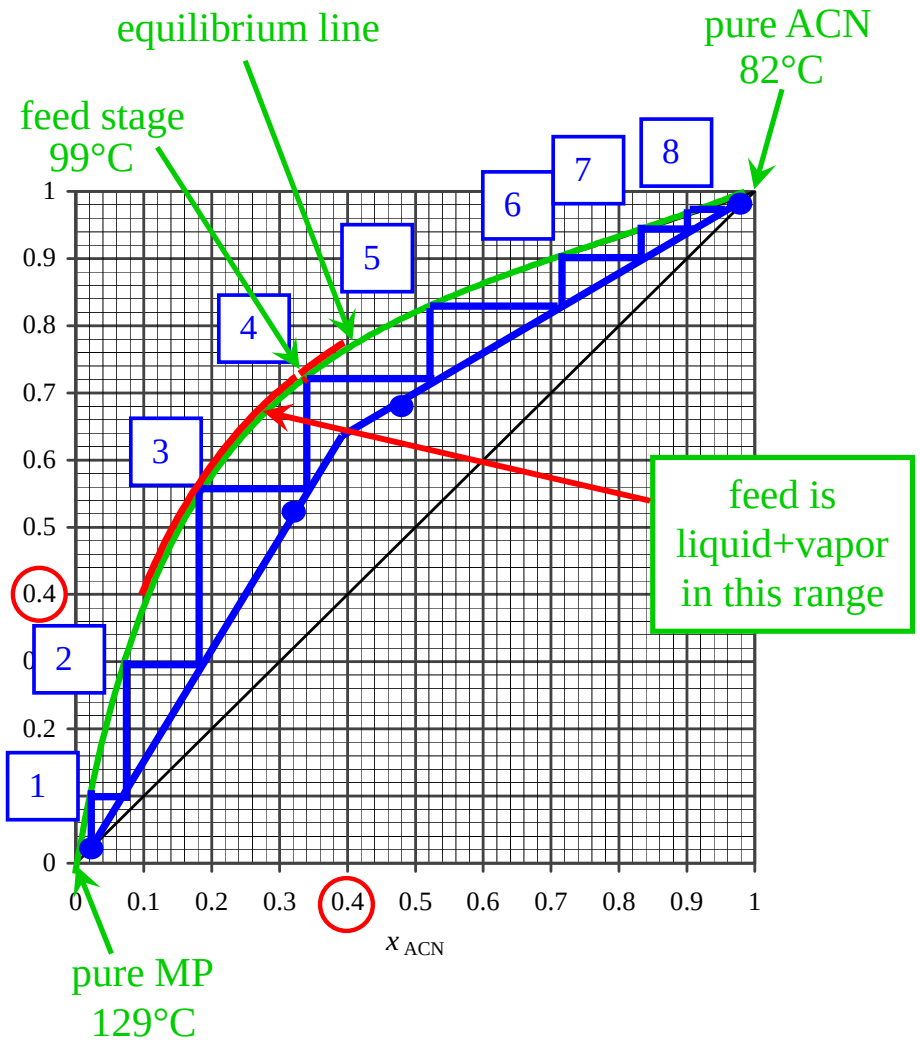


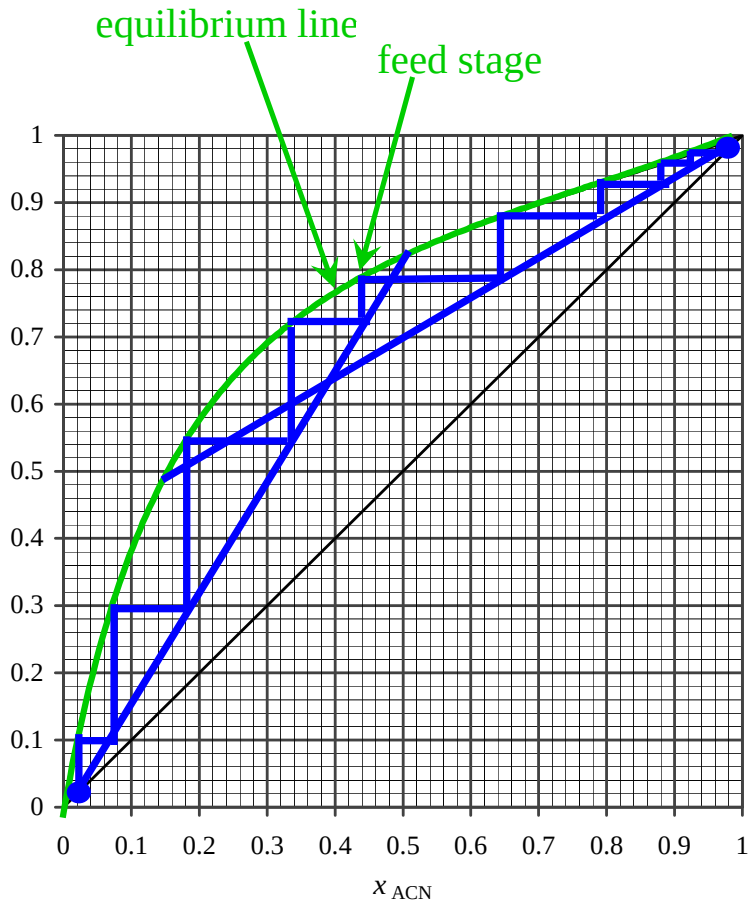
Same operating lines

Valid construction? Valid operation?

Valid!

Distillation Example 2, continued.





Same operating lines

Valid construction? Valid operation?

Not Valid!

Prelim 2 2025 Statistics

Mean: 90 / 120 (75%)
Std. Deviation: 20

A - K: Kong (Front of room)
L - Z: Angel (Back of room)

Solution is posted.

Problem 1: 22 ± 8 / 35 (62%)
Problem 2: 18 ± 3 / 20 (90%)
Problem 3: 13 ± 6 / 20 (69%)
Problem 4: 15 ± 5 / 20 (77%)
Problem 5: 20 ± 7 / 25 (78%)