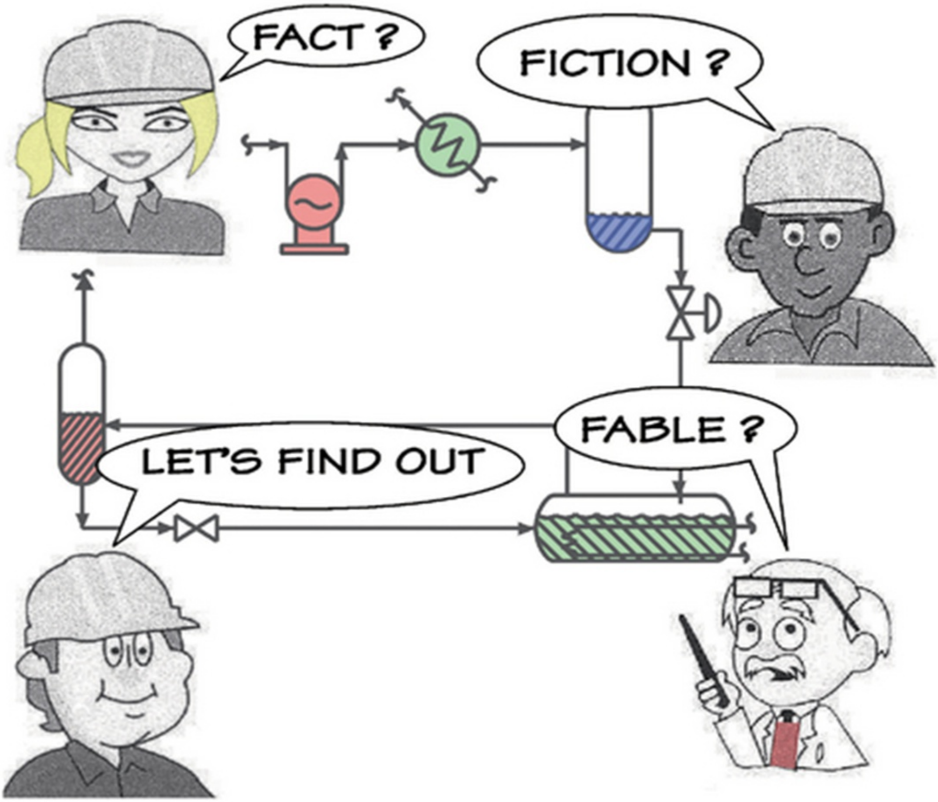
PROCESS ENGINEERING

FACTS, FICTION AND FABLES



Norman P. Lieberman

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100 Cummings Center, Suite 541J
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Publishers at Scrivener
Martin Scrivener (martin@scrivenerpublishing.com)
Phillip Carmical (pcarmical@scrivenerpublishing.com)

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To Allen and Irene Hebert, whose dedication and determination have been tirelessly applied to assemble this text. And who jointly originated the concept for assembling my cast of cartoon characters into book format.

Contents

Introduction

I started work as a process engineer for the American Oil Company in 1965. Now, after 52 years, I'm still a process engineer. Still working in the same way, on the same problems:

- Distillation Tray Efficiency
- Shell & Tube Heat Exchangers
- Thermosyphon Reboilers
- Draft in Fired Heaters
- Steam Turbine Operation
- Vacuum Steam Ejectors
- Centrifugal Pump Seals
- Surge in Centrifugal Compressors
- Reciprocating Compressor Failures
- Process Safety
- Fluid Flow

Most of what I need to know to do my job, I have still to learn. And I'm running out of time! So, with the help of my little friends in this book, I've recorded what I have learned so far. I hope this will help you in solving process problems.

The difficulty of being a process engineer is that our job is to solve problems. Not with people, but with equipment. Within minutes, or hours, or days, the validity of our efforts are apparent. More like plumbing, less like other branches of technology.

Most things I've tried as a process engineer haven't worked. But those that have been successful I remember, and use again. And it's insights from these successful plant trials and projects that I have shared with you in my book.

One thing's for certain. The money paid for this book is nonrefundable. But should you have process questions, I'll try to help.

Norm Lieberman
1-504-887-7714
norm@lieberman-eng.com

PART I

CHAPTER ONE

PROCESS OPERATIONS & DESIGN

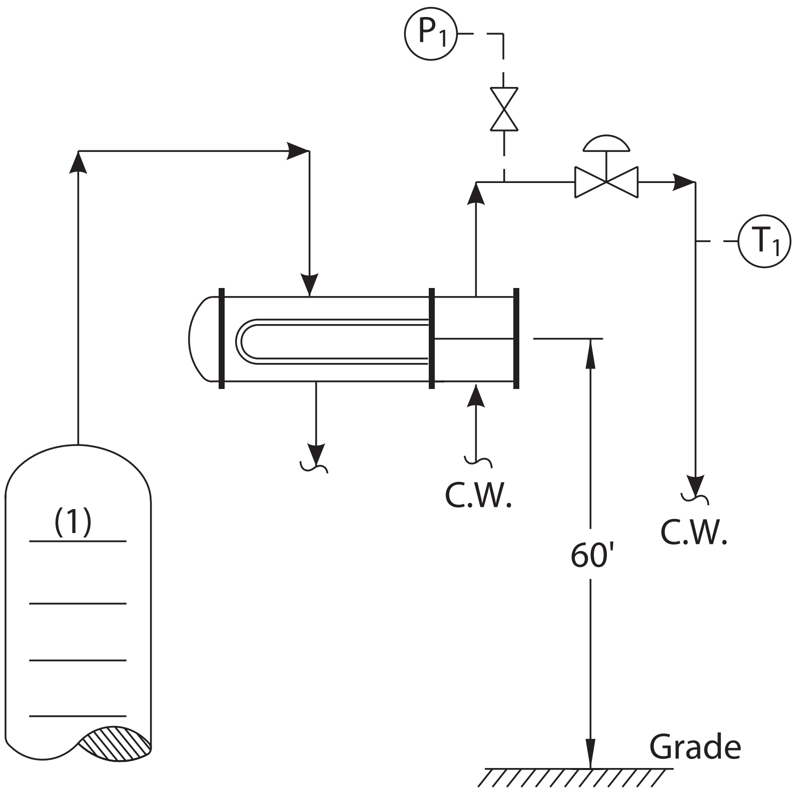
CARL & CLARE

Hello! I'm Clare! I work for Carl. We troubleshoot refinery process equipment! We're a team!

Hi! I'm Carl! I know everything, because I'm really, extremely, smart! Clare is my associate!

INCREASING COOLING WATER FLOW THRU AN ELEVATED CONDENSER OR COOLER

Clare! Let's open the cooling water outlet valve to get more water flow.



No, Carl! The Condenser is 60 feet above grade. The pressure at P_1, is under vacuum! Opening that valve will give us less cooling water flow!

NO! Opening a valve will always increase flow!

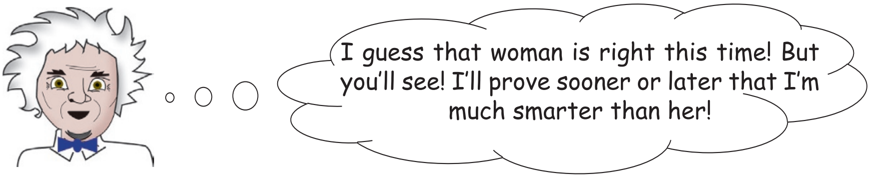
Sorry, Carl! Opening that valve reduces the pressure at P_1, further below the atmospheric pressure. This causes the air to flash-out of the cooling water, which chokes back water flow!

Clare! WRONG! I'm really smart! Anyway, where's the test to prove you're right?

OK. I'll close the valve and you'll see the temperature at T_1 will go down. But don't close it too much! Otherwise, you will throttle the water flow. Then, T_1 will get hotter!

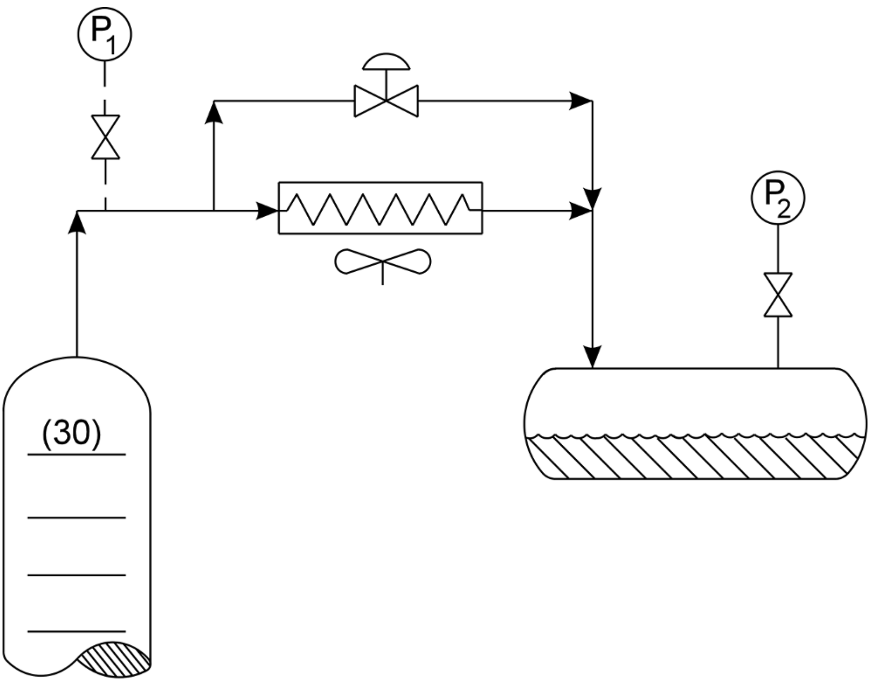
But Clare! How do I know how to adjust that stupid valve?

Carl, dear! Set the valve to hold a back-pressure of about 3" Hg. That's minus 0.10 atmosphere. At 100 °F, that will stop air evolution from the water, but not throttle the water flow too much!

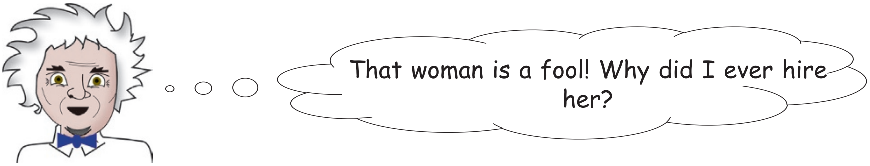

I guess that woman is right this time! But you'll see! I'll prove sooner or later that I'm much smarter than her!

HOT VAPOR BY-PASS PRESSURE CONTROL

Clare! Close the hot vapor by-pass valve! We need to lower the tower pressure. Do it now!



Sorry, Carl! When I closed the valve the tower pressure went up … not down!

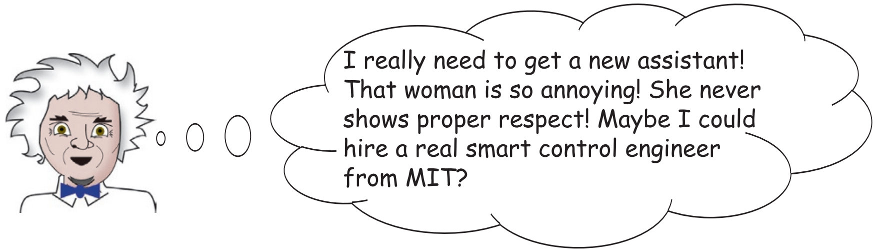


No, Clare! Closing the valve will cool off the reflux drum! The pressure at P2 will drop, and draw down the pressure at P1. Understand?

But Carl! How about the pressure drop across the air cooler? It increases as more flow is forced through it. True, the pressure at P2 will always fall! But the pressure at P1 may go up or down—depending on the air cooler DP!

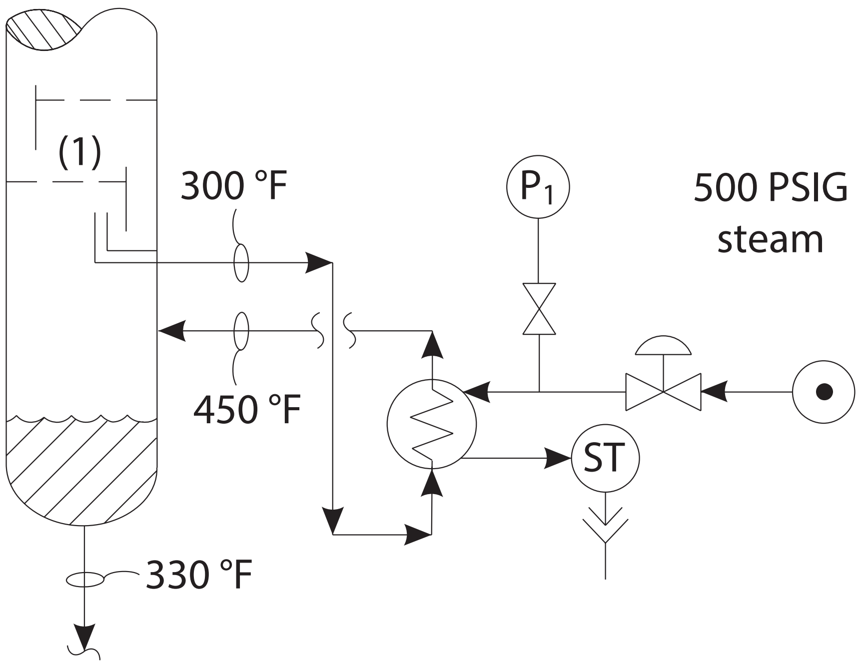
But, but...? Closing the hot vapor by-pass is supposed to lower the tower pressure, according to my design manual!

But suppose the tubes get full of salts and scale? Then what? Also, Carl, we now have a vacuum in the reflux drum, which can be quite dangerous! Air could be sucked into the drum and an explosive mixture could form! Don't forget there's pyrophoric iron sulfide deposits ($Fe(HS)_2$) in the drum! They'll auto-ignite at ambient temperatures!

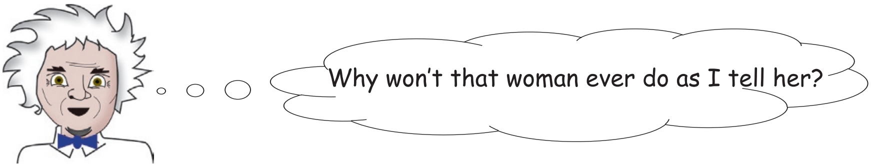

I really need to get a new assistant! That woman is so annoying! She never shows proper respect! Maybe I could hire a real smart control engineer from MIT?

STALLING A THERMOSYPHON REBOILER

Clare! Open the steam supply valve! Quick! We need more reboiler heat. The reflux drum is going empty!



Sorry, Boss! That won't help! The Once-Thru Thermosyphon Reboiler is STALLED OUT!



Clare! More steam flow will have to give us more heat to the reboiler! Open that valve!

Opening the steam valve will not increase steam flow when the reboiler is STALLED-OUT!

STALLED-OUT? What does that mean?

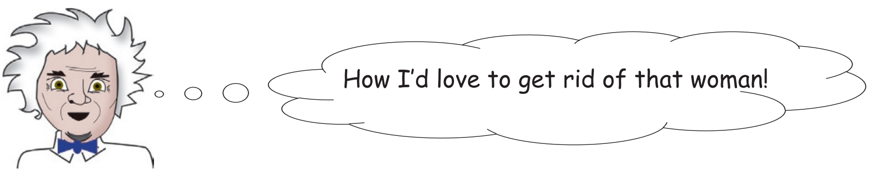
Stalled-out means heat duty is limited by the process flow to the tube-side of the reboiler! The process flow rate to the reboiler is real low now and limiting the steam condensation rate!

How do you know that, Clare? Do you have X-ray vision?

Carl! Look at the reboiler outlet. It's 450°F! The tower bottoms are only 330°F. Most of the 300°F liquid from tray #1 is leaking past the draw pan, and dumping into the bottoms' product!

OK, Clare, OK! But still, the steam inlet valve is only 50% open! Won't opening it 100% help some?

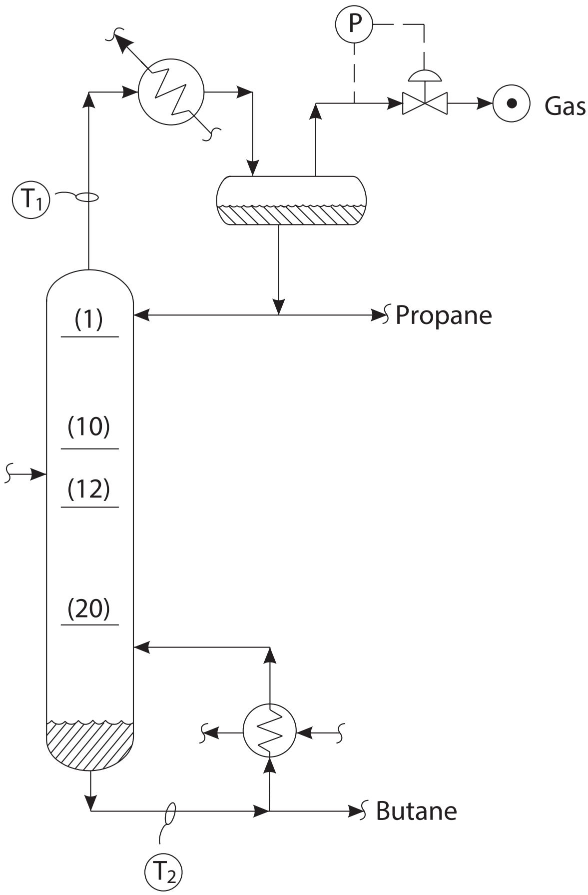
No, Sir! The pressure at P1 on the steam inlet line is 500 PSIG! The same as the steam supply pressure. There is zero DP across the steam supply valve. The valve position, with no DP, is IRRELEVANT!



I guess we should have used a total trap-out chimney tray for tray #1! I remember you suggested that last year, Clare. Perhaps you'd like a transfer to the Process Design Division? They would probably love to have you! I remember that in the old days we had bubble cap trays, which could never leak and cause this loss in thermosyphon circulation, or stalling-out.

OPTIMIZING FRACTIONATOR PRESSURE

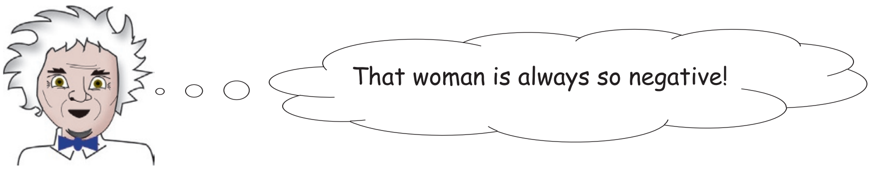
Clare! The best way to optimize tower pressure is to target for the lowest pressure!



Why is that, Carl?

Because, Clare, as we learned at university, the lower the pressure, the greater the RELATIVE VOLITILITY between propane and butane!

But Carl! Suppose the lower tower pressure causes entrainment? Then, a lower pressure will reduce tray separation efficiency and make fractionation worse!



Well! What do you suggest? It takes too long to wait for lab sample results.

Carl, I suggest:

1. At a constant reflux rate, start lowering the fractionator pressure.
2. Now, watch the delta T (T1 - T2).
3. That tower pressure, that maximizes delta T, will give the best split between butane and propane. But make the moves slowly!