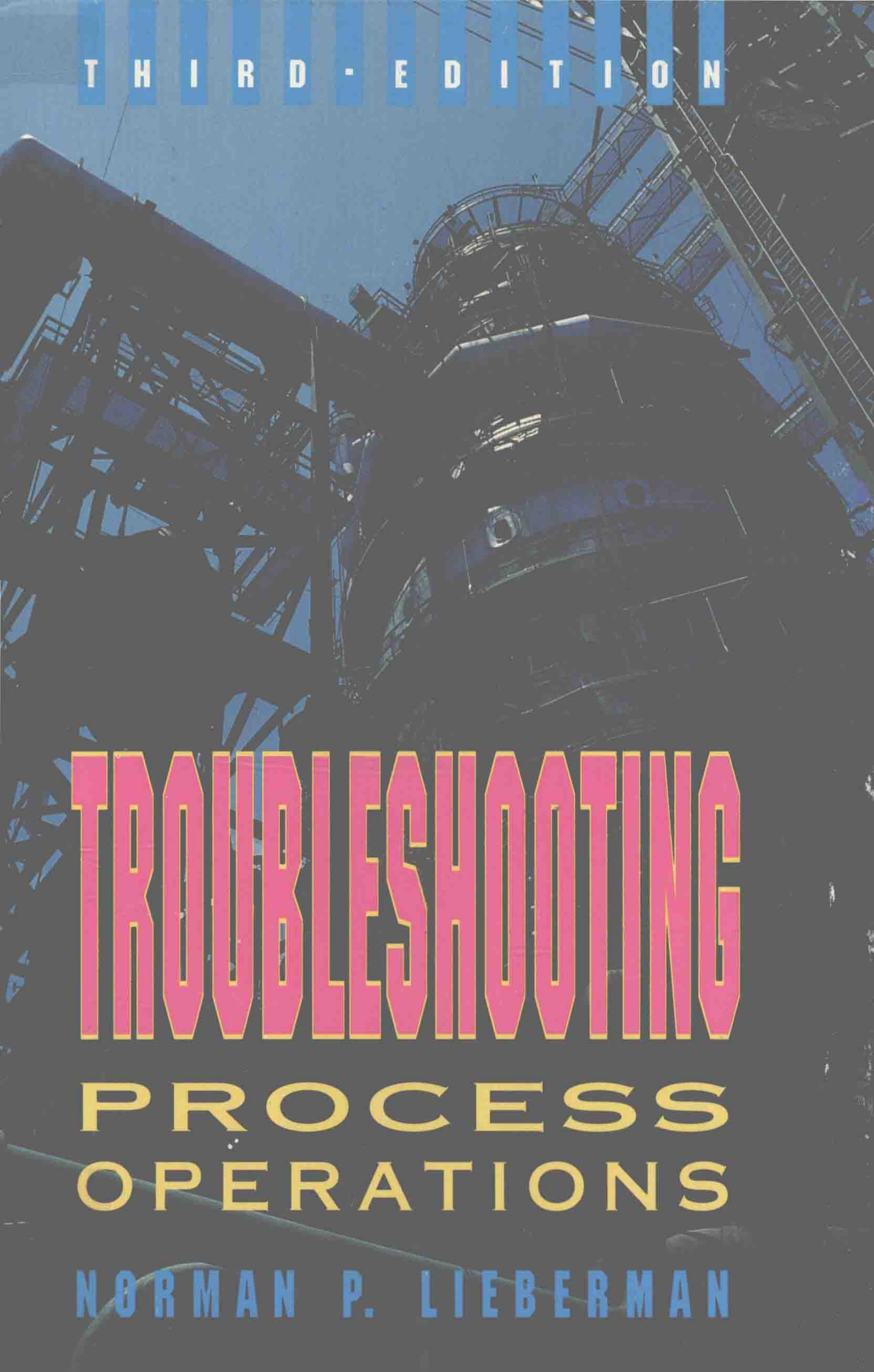
THIRD · EDITION
TROUBLESHOOTING
PROCESS
OPERATIONS
NORMAN P. LIEBERMAN

Troubleshooting Process Operations

THIRD EDITION

Norman P. Lieberman

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TROUBLESHOOTING PROCESS OPERATIONS

Third Edition

Dedication

To my parents—Mary and Lou. Wisdom comes with experience in life.

Acknowledgments

The author wishes to thank his friends and colleagues in the major U.S. refineries who have supported his efforts to disseminate process technology at their plants:

- ARCO—Doug Arnold
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Preface to third edition

Ten years ago, I wrote the first edition to this book. For the past seven years, I have operated my refinery troubleshooting business. During this period I have worked through enough process operating problems and equipment design errors to fill a dozen volumes. Much of my business continues to be conducted with the 15 or so major refiners in the United States and Canada. The tech service engineers employed by my clients, who work with me on these jobs, always ask what special techniques I employ to solve these problems. The procedure I use is the same one I used 10 years ago:

1. Discuss the problem with the shift operators.
2. Personally collect field data and carefully observe the operation of the unit.
3. Develop a theory as to the cause of the malfunction.

The error my clients often make is that they develop a theory, usually with process computer simulations, as to the cause of the malfunction. The theory is then reviewed with management and other technical personnel at a large meeting. If no one objects to the theory, it is accepted as the solution to the problem.

Typically, no one at the meeting has discussed the problem or the solution with the shift operators, nor has anyone personally observed the process deficiency in the field. Finally, the intended solution is not put to a plant test to see if it is consistent with the problem. This approach to solving refinery process problems by the major oil companies often results in wasting capital resources and engineering man-hours.

I would be pleased to discuss any problems or comments relating to the information imparted in this text as they may apply to specific operating or design problems.

Norman P. Lieberman
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Preface to second edition

A process plant is more man than machine, and the process engineer's trade is closer to the practice of medicine than to mechanical engineering. As a process plant troubleshooter, I find more in common with my family doctor than with my neighbor, a computer programmer.

A process unit resembles man also in that, to function, it must be able to respond properly to a variety of circumstances that the designer never quite anticipated. I like to think that our creator built into mankind the same degree of flexibility that we find in a tried-and-true Cat Cracker.

Process plant engineering, especially troubleshooting, is different from most other branches of technology in another respect: It is not advancing very quickly. The principles of distillation, hydraulics, phase separation, and heat transfer, as they apply to process applications, have been well known for quite some time. The challenge in troubleshooting consists of untangling the influence that human error, mechanical failure, and corrosion have on these well-known principles. The aspect of the job that makes it so difficult is that most process problems are initiated by human error—a never-ending source of surprise.

This book is written for the practicing refinery operator or process engineer. It is based on my 20 years of trials and tribulations as a process plant operator, troubleshooter, and designer, as well as those of my friends and colleagues in the process industry. Recently, an acquaintance of mine, a young fellow pursuing a graduate degree in chemical engineering, read the manuscript for this book. He inquired as to what percentage of process troubleshooting technology he had mastered as a result.

"Not much," I responded, "but I hope my book will give you a proper respect for the magnitude and complexity of process plants in general and troubleshooting assignments in particular."

Norman P. Lieberman

Preface to first edition

Rummaging through the attic, I happened upon my old college textbooks. Much to my dismay, these treasured volumes, elucidating the principles of mass transfer, fluid flow, and differential calculus, seemed slightly incomprehensible and rather irrelevant. After 15 years of applying the fundamentals of chemical engineering in a dozen refineries, I still did not feel ready for that final exam in advanced thermodynamics.

I can, however, diagnose and repair any and all basement sump pump problems. The operation and maintenance of my home air conditioner is no mystery. I can even adjust the air registers on my furnace and remove the accumulated deposits from the water heater.

The years dedicated to operating, designing, and troubleshooting petroleum processes have taught me these skills. Long, humid nights spent listening to the roar of giant steam turbines under a South Texas sky have schooled me in the challenges facing refinery shift workers.

Such are the experiences I wish to relate in this book. It is not only the facts, but the feelings of working in a petroleum refinery that I hope to pass along.

Norman P. Lieberman

Introduction

One warm spring day, the telephone rang in my Chicago home. Once again, one of our refineries had a problem. Thus began a typical troubleshooting assignment.

This refinery depended on twin plants to recover sulfur removed from the crude oil. The Environmental Protection Agency regulates emissions in refineries, and the ability to recover sulfur can and has limited refinery throughput.

On this day the refinery was in trouble. Due to a boiler-tube failure, brought on by a combination of bad luck and poor judgment, one of the two sulfur recovery plants had suddenly shut down. With only one plant operable, refinery crude run had been reduced by 25%. Possibly as a political gesture to corporate headquarters—more likely for lack of anything better to do in a desperate situation—I was called upon to help.

To help! But to help do what? Was I supposed to advise on repair and start-up of the plant that was out of service? Was I supposed to investigate the cause of the boiler failure? Maybe they wanted me to devise a method to squeeze more capacity out of the plant that was still operating. The novice troubleshooter should realize at the start of his career that the man asking for assistance usually has only the vaguest idea what he wants done. More often than not, he needs help in diagnosing the problems and not with implementing the solution.

By Saturday afternoon I had arrived at the plant site. Needless to say, most refinery failures occur on weekends. As I had suspected, based on prior experience, no data had been assembled for my review, no meetings had been set up to solicit my advice, and no instructions had been left to define my task. Actually, the professional staff had all forgotten I was coming and had gone home.

This was just as well. The troubleshooter should begin by talking to the unit shift operators. These people run the plant 24 hours a day and, although they don't always know why something happened, they can often tell you what really transpired.

After a ritual exchange of pleasantries, I sat down with the shift foreman. We discussed the situation; rather, he talked and I concentrated on suppressing my impatience. There is something about being in a refinery on a Saturday afternoon that makes one want to get on with the job and get home.

It soon became apparent that the refinery really was in a difficult spot. The remaining sulfur recovery plant was limited to 100 tons/day (T/D) of sulfur. The refinery normally made 130 T/D. Consequently, crude run had been cut by 40,000 barrels per day (B/D) to avoid emitting sulfur pollutants to the atmosphere. The daily penalty was huge, several times my total annual salary.

Limited! As soon as any operator uses the word limited, the troubleshooter should respond, "Which piece of process equipment is limiting plant capacity?" After some evasion, the foreman referred me to the chief operator, who would be able "to answer my question in more detail." (The psychology of dealing with chief operators is a subject unto itself, as mentioned in Chapter 30. Suffice it to say that utmost diplomacy is always warranted.) The chief came right to the point. The sulfur recovery plant was limited by front-end pressure. The hydrogen-sulfide feed gas (H_2S) would spill to the flare whenever the pressure in the feed drum exceeded 10 pounds per square inch gauge (psig).

Figure I–1 illustrates the setup. The control valve, upstream of the feed drum, was used to hold the pressure in the drum below 10 psig. As the flow through the plant was raised by opening this valve, the pressure drop in the plant increased. As a result, pressure in the feed drum also rose.

The plant superintendent had left instructions to avoid spilling hydrogen sulfide to the flare. The operators were merely conforming to these instructions. Raising feed gas charge above the 100-T/D rate would cause the feed drum to exceed 10 psig.

But why was the pressure control valve, which allowed feed gas to spill to the flare, set at 10 psig? The feed drum was designed to withstand much higher pressures. The chief operator informed me that they held to the 10-psig limit because "We always do it this way." For a recital of the historical circumstances supporting this limit, I was referred to the senior shift operator—Mr. Leroy Jackson. (This name is fictional, but the story is true.)

Demonstrating the cooperativeness that refinery workers display when they really know what they are talking about, he explained the problem. "When we raise gas flow to the feed drum, its pressure goes up," said Jackson. "This doesn't hurt anything. Except at about 10 psig, the feed flow recorder reaches the end of the chart. Then we don't know the plant

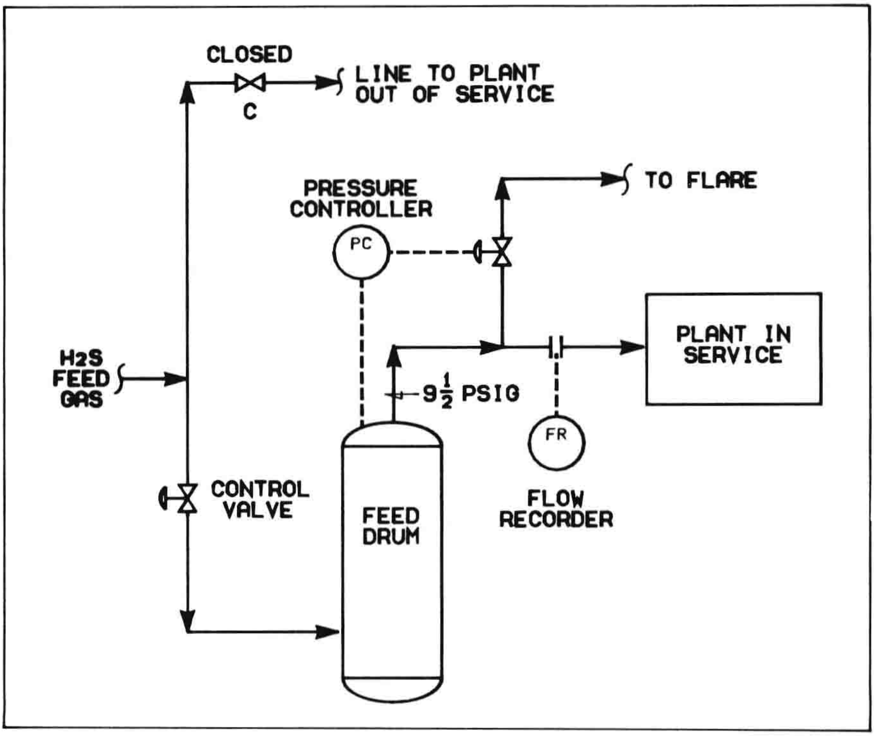


FIGURE I–1 ▪ Pressure in the feed drum limited the plant's capacity.

feed rate. Of course, this doesn't really matter, but it's sort of convenient to be able to read this flow."

He was referring to the flow recorder shown in Figure I–1. When I explained how important it was in terms of dollars per day to increase sulfur plant feed, Mr. Jackson registered surprise. "Why, if someone had told me what was up, I'm sure we could have done something to get that extra sulfur through the plant."

Well, we did do something; we installed a new range tube on the flow recorder. A range tube is part of an orifice plate flow recorder transmitter. The longer the range tube, the greater the flow that can be measured by a flow recorder. We doubled the length of the range tube. This increased the maximum feed gas flow that could be recorded by 44% (i.e., the square root of two). Changing a range tube takes about 30 minutes and about as many dollars.

The next step was to increase the setting on the pressure control valve, which spilled feed gas to the flare. Mr. Jackson increased this setting from 10 psig to 15 psig. The task involved climbing several ladders and turning a dial inside the local pressure controller box.

The hardest part in any troubleshooting job always involves the human element. In this case, I had to convince the foreman to try something new. It does very little good to say, "There is now no rational reason for you not to increase the feed gas rate." The trick is to allow the man making the critical decisions to think it is his idea to increase the charge rate.

With some apprehension the foreman issued instructions to the chief operator to increase feed ever so slightly while making sure that the plant did not slide into oblivion as a consequence. By the end of the next day, the refinery had reestablished normal crude runs; sulfur production had risen to 125 T/D.

In retrospect, it may seem ludicrous to have cut back production because of a limited range on an unimportant flow recorder. Both the problem and solution seem to be the sort of thing local supervision should have handled. Perhaps troubleshooting of this type is too trivial for the trained chemical engineer.

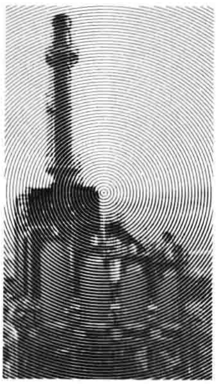
Most refinery difficulties have a simple origin. However, this simple origin is clouded by false data, misconceptions, superficial observations, and third-hand reports. If the answer was obvious, you would not have been called upon. Your technical training is one tool you take into the field to reveal the underlying problem, but confining your investigation to technical areas will severely limit your chances of success.

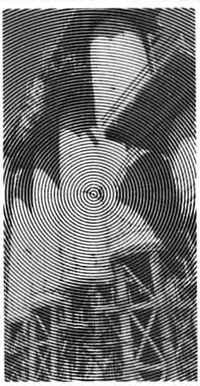
The capacity limit of this sulfur plant was, in a sense, not due to the small range of the flow recorder. A communications breakdown between the unit operators and first-line supervision had resulted in an artificial limitation. The troubleshooting engineer is most effective when he overcomes this failure to communicate. This is best done by personally gathering data, making direct field observations, and most importantly, soliciting the opinions of the shift operators. This type of activity, when joined with sound technical training, makes a powerful combination with which to tackle refinery problems.

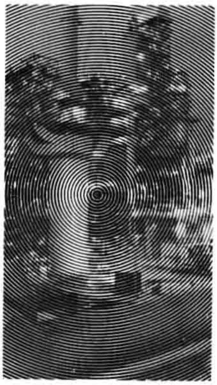
Even the most competent and experienced operating superintendent can become ineffective when given an incomplete account of a problem. He is often too involved in administrative matters to find the time to go out into the field and get the straight story. This is a weakness common to all large organizations.

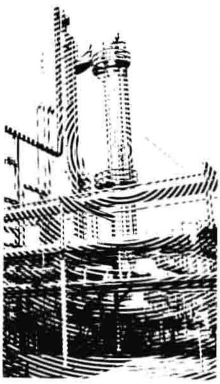
In the tale just recited, my contribution was to go to the most important source of data available: the shift operator. One should cut through all the layers of supervision and ask the people who turn the valves. To summarize, the answers are in the field—not in the office.

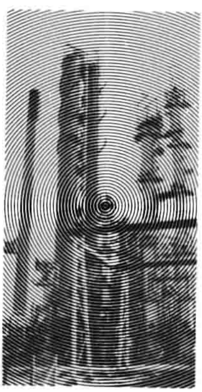
Contents











SECTION 1

Specific Processes

I search for something once well known but long since forgotten.