A Working Guide to Process Equipment

About the Authors

Norman P. Lieberman is a chemical engineer with 56 years of experience in process plant operation, design, and field trouble shooting. An independent consultant, he troubleshoots oil refinery and chemical plant process problems and prepares revamp designs. Mr. Lieberman teaches 20 seminars a year on "Troubleshooting Pro cess Plant Operations" and has written ten books on plant process operations and problems.

Elizabeth T. Lieberman is a chemical engineer with more than three decades of experience in the process industries. She works as a consultant troubleshooting oil refinery and chemical plant process problems. Ms. Lieberman also has experience in ceramic clay proeess ing, refractories processing, and the conveyance of slurry flow.

A Working Guide to Process Equipment

Norman P. Lieberman

Elizabeth T. Lieberman

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Sponsoring Editor
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To the union of two people
Weathering life's storms together
Watching the lightning
Waiting for the thunder
In friendship, In partnership
In love

To the Memory of
Our Friend and Colleague

Gilles de Saint Seine
Process Engineer
Total-Fina-Elf, France

It's more than losing a friend, it seems as if
Liz and I have lost part of ourselves, but we
will always remember his gentle determination
and insightful work, his love of family and
consideration for his colleagues, and not least
his marvelous wit.

This book is dedicated to our parents:

Elizabeth and Tom Holmes, innovative engineers,
courageous under fire at war and in peace.

Mary and Lou Lieberman whose enduring strength and
fortitude have been little noted, but long remembered.

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Preface to the Fifth Edition

- Try boiling water in a new, smooth teacup in your microwave oven. It won't boil at 100°C. Lack of nucleate boiling sites causes a Faux Limited situation.
- Blow across the top of a clear straw. Notice how the brown Coca Cola is drawn up half an inch inside the straw. It's the venturi effect that creates Draft.
- Watch an air lift pump circulate water in a fish tank filter. It's the same principle that creates circulation in a Thermosyphon reboiler.
- Which evaporates faster: whiskey or water? Well, alcohol has a larger Vapor Pressure than water, and will evaporate more rapidly.
- Even though our sun is six million miles distant from our little planet, the power of Radiant heat transfer still warms our earth.

We're immersed in examples of how process equipment works. It's the basis for the emergence of humankind from our primitive origins. It was the application of hydraulics, heat transfer, combustion, and the differential rates of evaporation (i.e., relative volatility) that has allowed us humans to achieve domination of our planet—mainly through exploitation of fossil fuels.

Lately, I've noticed that our ability to exploit coal and natural gas has gotten badly out of hand. I've calculated that in 100 years, our hydrocarbon-based civilization will collapse unless we, the technical segment of society, intervene. As you read our book, consider your social responsibility to the rest of creation that shares our planet with us. Time is not on our side.

Norm Lieberman

If you have any questions, you can contact us at:

norm@lieberman-eng.com
+1 504 887 7714
+1 504 456 1835 (fax)
+1 504 430 0757 Mobile

Preface to the Fourth Edition

Buried deep in our genetic heritage, hidden in an obscure string of DNA, is coding for Process Equipment Operations. An instinctive desire to apply energy to trans mute the properties of naturally occurring materials into other, more useful forms. Like cooking food; or fusing clay into ceramic pots; or reacting sulfur with air to produce sulfuric acid; or transmuting lead to gold.

Looking back on 50 years as a process engineer, the most satisfying period of my career was devoted to converting gas oil into viscous polypropylene via cracking reac tions and refrigeration.

The gene that codes for operation and design of process equipment, such as distil lation columns and fired heaters, is a recessive gene. Only one out of 40 individuals have inherited this genetic code for process equipment operations as a dominant trait.

Should you wish to determine if your child has inherited this genetic makeup for process equipment operations, observe if the child:

- Is fascinated by fire
- Tries to dam and divert little streams
- Is attracted by boiling water
- Asks what makes a windmill turn

Thus, only one out of 40 people have the potential to evolve into process engineers or operators. The rest will become Directors of Human Resources or Maintenance Superintendents.

My older sister often asks, “Norman. You’re over 72. When are you going to retire? You’re too old to be climbing distillation towers. You’ll fall off one of these days.”

“Arline,” I explain, “I can’t retire. It’s in my blood.”

“Norman, you’re crazy! Everyone else in our family retired in their 60s. It couldn’t be in your blood. Dad moved to a retirement village when he was only 62.”

“You don’t understand, Arline. It’s a recessive gene I inherited from our ancestors generations ago. I can’t retire. It’s part of my DNA. It’s instinctive behavior. Like a

beaver building a dam. Or squirrels gathering nuts in the fall. I can't retire. I'll just have to go on until the end."

Norm Lieberman

If you have questions, you can contact us at:

norm@lieberman-eng.com
1–504-887-7714
1–504-456-1835 (fax)

Introduction

We all come from different countries and different backgrounds, but we have something in common: the desire to figure out how the equipment works and improve operation. We two are the same and no different: one of us is born and raised in the USA and trained in oil and gas production and refining, the other started in the UK and trained at first in clay production for the ceramic industry, handling all things from the clay pit through to fine china, sanitary ware, and high temperature refractories, and then moved on to work in oil refining. But we are both chemical engineers, and together we troubleshoot process plants, with products as varied as artificial sugar sweetener, paper, synthetic rubber, oil, and gas, to name a few.

Since 1983, we estimate that some 21,000 men and women have attended our process industry technology seminars. If you think that this book is only about distilling hydrocarbons, oil refining and petrochemical production, you'd be wrong because this book is about the workings of the everyday equipment that makes up most large-scale process plants.

We have explained over 960 times the ways to operate, troubleshoot, and even design heat exchangers, distillation towers, vacuum ejectors, fired heaters, centrifugal pumps, and compressors, which are indeed found in oil refineries and petrochemical plants but also in all sorts of other process plants too. Throughout these lectures and seminars, a common thread has emerged.

The general knowledge about how process equipment functions is disappearing in the process industry. Process equipment is basically the same now as in the 1930s. Pumps, distillation trays, heaters, and reciprocating compressors have not changed. Modern methods of computer control cannot alter the basic performance of most process equipment we work with.

In this book, we have returned to the basic ideas of understanding how process equipment works, and how to perform basic engineering calculations. Several years ago, we started accumulating the most frequently asked questions at our seminars. We have tried to summarize these questions and our answers within the text of this fifth edition.

You do not need a technical degree to understand our text. Certainly, it is a book about process equipment technology. But our book is based on the science and maths discussed in high school. We have traded precision for simplicity in crafting this text.

In the next 30 to 40 years we humans will need to make some changes in our consumption of fossil fuels. There is already growing interest in the production and use of "bio-fuels" with the intention to keep the atmospheric CO_2 levels below 600 ppm. Bio-fuels are largely produced via the Fischer-Trops process, originally developed to convert coal and other hydrocarbons to gasoline and diesel. Currently, the Fischer-Trops process is used to convert animal waste, garbage, and wood chips to bio-diesel that is blended with diesel produced from refined crude oil in a 20/80 percent mixture (i.e., 20 percent derived from organic waste components).

But our review of the Fischer-Trops process flowsheet indicates that, as with so many other types of process plants, 90 percent of the equipment required still relies on the types of process technology we have described in this fifth edition of A Working Guide to Process Equipment. So, as we all continue to move forward, it is our hope that this text should still be applicable for many more decades to process operators and engineers.

We will be pleased to answer questions pertaining to our text:

Elizabeth and Norman Lieberman
P.M.B. 267, 5000 W Esplanade, Metairie, Louisiana 70006, USA
+1 504 887 7714 (phone)
+1 504 456 1835 (fax)
+1 504 430 0757 (mobile)
norm@lieberman-eng.com (email)

Acknowledgments

Fortunately for us there are those who benevolently accept that students, just like chil dren, are always with you.

The authors gratefully acknowledge the most kind and generous support of J. F. Richardson (JFR) in the production of the second edition, and also the timely assistance provided by R. P. Chhabra (Raj), J. Hearle (Jonathan), and J. R. Condor. The areas of this book dealing with fluid flow in pipes and hazardous pipe work would have been impoverished without their help and guidance.

My days at the University College Swansea (South Wales, UK), both during under graduate years and at times since then when I have had the need or opportunity to revisit, are very special to me, as are my days spent working with ECLP in Cornwall, UK. The college and its staff have provided a rock-steady foundation for everything that comes my way as an itinerant chemical engineer alongside my coauthor Norman.

I will never forget the experience of working (quite literally) in the field with JFR, Raj, and Jonathan: sometimes paddling through inches of china clay slurry in an isolated pump house, or tracking down vent valves for pressure readings on a cross-country pipeline that traversed several miles in the heart of Cornwall.

That hands-on training and field work, just as it should be, was very much part of the academic work of the thriving Chemical Engineering Department at the University College Swansea. We have to thank the late Prof. J. F. Richardson for that, and we hope that his concept will live on and grow as a model to us all in his absence.

But there are another group of people that we authors would also like to gratefully acknowledge, and that's you all, our readers. Pardon us if that seems a little trite, but it is very true. We always welcome comments or questions, and just occasionally someone will tell us that this book in one or other of its editions helped them figure something out, and that truly makes all the work worthwhile. We had an experience just like that quite recently whilst with a seminar group in Canada, which is why we're prompted to add this extra acknowledgement.

Thanks!