TROUBLESHOOTING

ROTATING MACHINERY

ROBERT X. PEREZ and ANDREW P. CONKEY

Scrivener Publishing

WILEY

Troubleshooting Rotating Machinery

Including Centrifugal Pumps and Compressors, Reciprocating Pumps and Compressors, Fans, Steam Turbines, Electric Motors, and More

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Co-published by John Wiley & Sons, Inc. Hoboken, New Jersey, and Scrivener Publishing LLC, Salem, Massachusetts.
Published simultaneously in Canada.

Cover design by Kris Hackerott

Library of Congress Cataloging-in-Publication Data:

ISBN 978-1-119-29413-9

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Troubleshooting Rotating Machinery

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Beverly, MA 01915-6106

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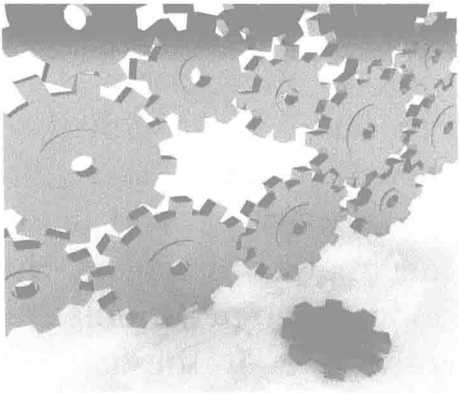
The authors would like to dedicate this book to their wives, Elaine Perez and April Conkey, for all their help and encouragement.

Preface



Troubleshooting is part science and part art. Simple troubleshooting tables or decision trees are rarely effective in solving complex, real-world machine problems. For this reason, the authors wanted to offer a novel way to attack machinery issues that can adversely affect the reliability and efficiency of your plant processes. The methodology presented in this book is not a rigid "cookbook" approach but rather a flexible and dynamic process aimed at exploring process plant machines holistically in order to understand and narrow down the true nature of the problem. Throughout this book, the term *process machinery* will be used to refer to rotating machinery commonly encountered in processing plants, such as centrifugal pumps and compressors, reciprocating pumps and compressors, fans, steam turbines, and electric motors.

Our first book in this series, *Is My Machine OK?* deals, in large part, with assessing process machinery in the field. This guide takes the assessment process to the next level by helping operators, mechanics, managers, and machinery professionals better troubleshoot process machinery *in-situ*, i.e., in the field. To cover the topic of troubleshooting, the authors will cover the following topics in this book:

- What field troubleshooting means and entails
- How to use this guide as a complement to *Is My Machine OK?*
- Using the "who, what, when, where, why" troubleshooting methodology
- How to use cause maps to investigate possible causes
- Real-world case studies
- How to use machine-specific troubleshooting tables

To be successful, the troubleshooter must be persistent, open-minded and disciplined. Once field data is collected, an unbiased, logical approach to the finding is required to hone in on the most probable source of an observed symptom (or symptoms). Without a comprehensive and logical analysis of the findings, the investigator is only guessing, which wastes valuable time and resources. We hope those reading and using this guide will fully utilize the ideas and concepts presented to minimize maintenance cost and risk levels associated with machinery ownership.

Robert X. Perez and Andy P. Conkey

Acknowledgements

The authors would like to thank the following individuals for their help in reviewing this book and improving its contents with many useful suggestions. This book would not have been possible without their contributions, inspiration and support:

Ken Atkins, Engineering Dynamics
David Lawhon, Shell Oil
Julian LeBleu, Machinery Consultant
Carol Conkey, Copy Editor

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Troubleshooting for Fun and Profit

Process machines are critical to the profitability of processes. Safe, efficient and reliable machines are required to maintain dependable manufacturing processes that can create saleable, on-spec product on time, and at the desired production rate. As the wards of process machinery, we wish to keep our equipment in serviceable condition.

One of the most challenging aspects of a machinery professional or operator's job is deciding whether an operating machine should be shut down due to a perceived problem or be allowed to keep operating and at what level of operation. If he or she wrongly recommends a repair be conducted, the remaining useful machine life is wasted, but if he or she is right, they can save the organization from severe consequences, such as product releases, fires, costly secondary machine damage, etc. This economic balancing act is at the heart of all machinery assessments.

The primary purpose of this guide is to help operators and machinery professionals troubleshoot machines that are in a process service and operating at design process conditions. The reader may ask: What is the difference between field troubleshooting and other analysis methods such as a root cause analysis, failure analysis, and a root cause failure analysis?

Consider the following definitions:

Field troubleshooting is a process of determining the cause of an apparent machine problem, i.e., symptom, while it is still operating at actual process conditions. Troubleshooting efforts tend to focus on a specific machine or subsystem, using a proven body of historical knowledge. The body of knowledge may be in the form of troubleshooting tables and matrices or manufacturer's information. Keep in mind that process machinery can only truly be tested and evaluated in service and under full load, i.e., *in-situ*. Very few testing facilities are available that can test a pump or compressor at full process loads and with actual process fluids. Field troubleshooting evaluates the mechanical integrity of a machine in process service in order to determine if symptoms are the result of an actual machine fault or a process-related problem.

Here are examples of troubleshooting opportunities:

Example #1: Pump flow has fallen well below its rated level.

Example #2: Compressor thrust bearing is running 20 °F hotter than it was last month.

Root cause analysis (RCA) is a broad analysis of a system made up of multiple components or subsystems or an organization made up of multiple processes. These complex systems may not have any historical failure information to reference and are not well understood. The overall complexity may require that the overall system be broken down and analyzed separately. Here are two examples of RCA opportunities:

Example #1: The finished product from a process unit went out of spec.

Example #2: Plant XYZ safety incidents for the month of May have doubled when compared to last year's total.

One distinction between RCA approaches and troubleshooting is that RCAs tend to address larger problems that often require a team approach, while troubleshooting can normally be conducted by a single individual. As a general rule, maintenance and operations personnel normally participate more in troubleshooting activities than in root cause analysis activities due to the very nature of their jobs.

Failure analysis is the process of collecting and analyzing physical data to determine the cause of a failure. Physical causes of failure include corrosion, bearing fatigue, shaft fatigue, etc. Failure analyses can only be conducted after a component failure. A failure is defined as a condition when a component's operating state falls outside its intended design range and is no longer able to safely, or efficiently, perform its intended duty.