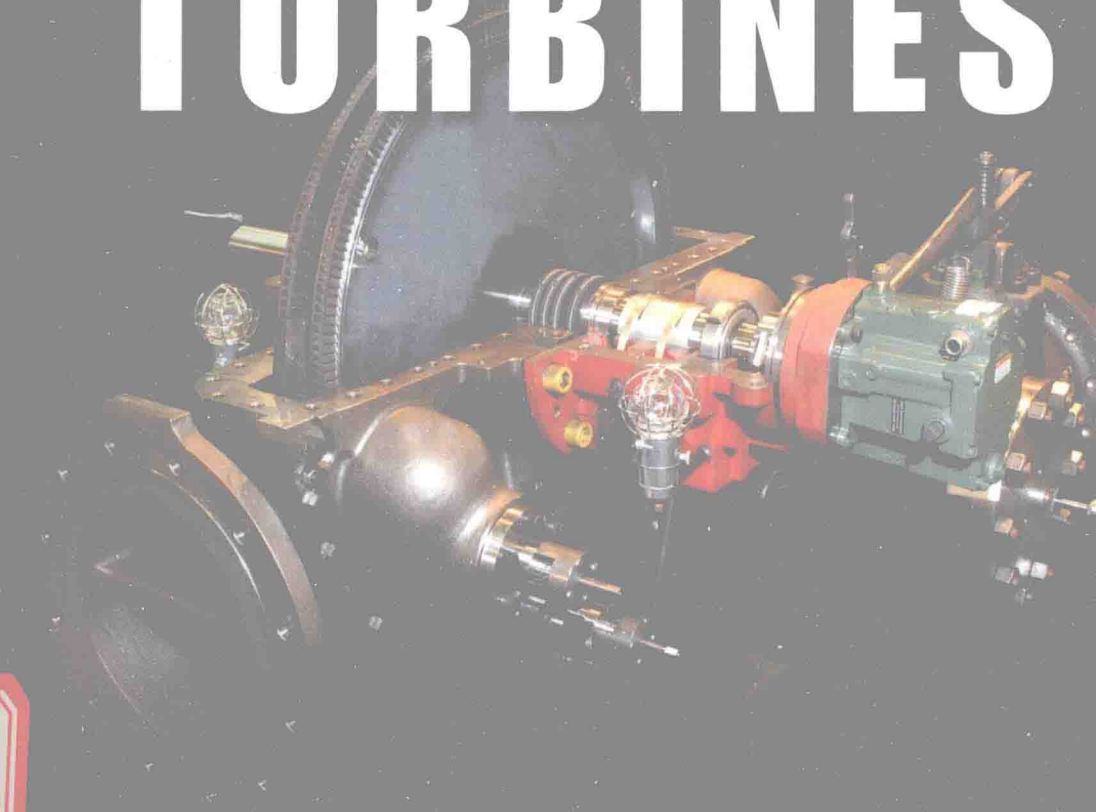
OPERATOR'S GUIDE TO

GENERAL PURPOSE STEAM TURBINES



ROBERT X. PEREZ and DAVID W. LAWHON

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Operator's Guide to General Purpose Steam Turbines

An Overview of Operating Principles, Construction, Best Practices, and Troubleshooting

Robert X. Perez and David W. Lawhon

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Scrivener Publishing
100 Cummings Center, Suite 541J
Beverly, MA 01915-6106

Publishers at Scrivener
Martin Scrivener (martin@scrivenerpublishing.com)
Phillip Carmical (pcarmical@scrivenerpublishing.com)

We dedicate this book to our families for their constant support and encouragement.

Preface

"We are what we repeatedly do.
Excellence, then, is not an act, but a habit."

—*Aristotle*

If you operate steam turbines in your plant you are probably asking: Why do I need a whole book devoted to steam turbine operations? The short answer is because we all want our steam turbines to operate reliably and safely during their lifetimes and to avoid nasty surprises, such as massive failures, unexpected outages or injuries. Owners of steam turbines should continuously strive to protect life, limb and property and minimize the life cycle costs through the use of proven operating practices like those contained in this book. The best practices presented in this book can be used as a basis for your plant's steam turbine reliability program and operating procedures.

The life cycle cost (LCC) of a machine is the total of the purchase, installation, repair, and operating costs incurred throughout its lifetime. As an operator the only way to affect a steam turbine LCC is by minimizing maintenance cost. This is accomplished by employing proven start-up procedures that will

minimize undue stresses and erosion and by monitoring them in order to detect minor issues before they lead to costly repairs. General purpose (GP) steam turbine drivers present operators with special challenges because they tend to have a minimum of automation and instrumentation which makes their reliability dependent on the skill and knowledge of their caretakers. In other words, their reliability is dependent on the quality of human implemented procedures and human-based monitoring methods.

When installed and operated properly, GP steam turbines are reliable and tend to be forgotten, "out of sight, out of mind". But these sleeping giants can create major headaches if ignored. Three real steam turbine undesirable consequences that immediately come to mind are:

- *Injury and secondary damage due to an overspeed failure.* An overspeed failure on a large steam or gas turbine is one of the most frightening of industrial accidents. A huge amount of thermal, chemical, and mechanical energy is contained within a large steam turbine when it is in service. If the rotational speed of the steam turbine ever exceeds its safe operating limits, the main shaft and impeller wheels can be pulled apart by centrifugal force, releasing a tremendous amount of energy. In the worst case, the disintegrating parts can

break through the turbine housing and fling hot, fast-moving shards of metal in all directions. The results of such a failure are always very costly due to the peripheral equipment damage and can sometimes be fatal to personnel in the area.

- *The high cost of an extensive overhaul due to an undetected component failure.* The cost of a major steam turbine repair can run ten or more times that of a garden variety centrifugal pump repair. If an early failure is not detected, it will usually result in a more costly failure. For example, a simple packing leak can result in oil contamination, which can lead to a bearing failure, which can lead to major rotor damage. Repair cost can rapidly escalate if the chain of failure events is not stopped early, i.e., in the primary stage.
- *Costly production losses due an extended outage if the driven pump or compressor train is unspared.* The value of lost production can quickly exceed repair costs. Extending the mean time between repairs though the implementation of best practices will in turn reduce production downtime and dramatically increase overall profits.

A major goal of this book is to provide readers with detailed operating procedure aimed at reducing these

risks to minimal levels. Start-ups are complicated by the fact that operators must deal with numerous scenarios, such as:

1. Overspeed trip testing
2. Starting up a proven steam turbine driver after an outage
3. Shutting down a steam turbine driving a centrifugal pump or centrifugal compressor
4. Commissioning a newly installed steam turbine
5. Starting up after a major steam turbine repair

It is not enough to simply have a set of procedures in the control room for reference. To be effective, operating procedures must be clearly written down, taught, and practiced—until they become habit. Operators must be fully committed to following the prescribed steam turbine operating procedure every time and carefully monitoring them in the field in order to detect signs of early failures before serious damage is done. To support this commitment this book will:

- Provide operators with a broad exposure to the principles of steam turbine design and operations
- Explain common failure modes and how they can be prevented or mitigated and

- Provide proven operating procedures that can protect your steam turbines from costly and dangerous failures.

The authors hope the reader will find the contents of this book to be useful and applicable in their present assignment. We also hope the ideas and suggestions provided here compel you to commit yourself to operational excellence.

Robert X. Perez and David W. Lawhon

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