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# **The Nalco Guide to Boiler Failure Analysis**

**Nalco Chemical Company**

*Authored by*

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*Dedicated to Dr. William K. Baer, a Motivator*

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# Preface

This book is a comprehensive, authoritative field guide to boiler failures. Contained is information gathered during forty years of failure analysis at Nalco Chemical Company involving over 10,000 case histories. Failures in boilers of virtually all pressures and construction are represented. Failures in nearly all boiler locations, as well as some preboiler and afterboiler regions, are discussed. Many photographs of actual failures illustrate the text.

Critical, unprejudiced observation, bolstered by experience and common sense, are the most important factors in the correct identification of a boiler failure. This book alone cannot substitute for the trained, experienced analyst. Failure analysis is a learned skill. This book will help the novice and more experienced observer select the most likely failure modes quickly and simply. By direct comparison with the many illustrations and photos of real failures, the user will learn to identify many problems and pinpoint likely failure locations. Explanation of failures will be easier, and the interpretation and discussion of failure-analysis reports will be facilitated.

The book is not intended to be a substitute for rigorous failure analysis. Rather, the information should serve as an aid to in-plant investigation and as a readily accessible reference source in the field. Although the skilled observer can detect and correctly diagnose many failures based solely upon visual inspection, often there is no substitute for laboratory investigations.

Topics include overheating, chemical corrosion on both the fire side and water side, cracking, deposition, erosion, and manufacturing defects. Most failure modes or topics are discussed in seven sections including:

*Locations:* Failure locations are pinpointed.

*General description:* Failure mechanisms are described. The causes and sources of attack are discussed.

*Critical factors:* The most important or especially critical factors influencing failure are listed. Attack morphology and identification are stressed.

*Identification:* Visual inspection procedures are emphasized. The methods by which detailed metallographic procedures might elucidate failure mechanisms are also discussed.

*Elimination:* Necessary preventive and/or corrective steps to eliminate or reduce damage are listed and explained.

*Cautions:* Comparisons are drawn between failure mechanisms that produce damage with a similar appearance.

*Related problems:* Related problems and damages are described.

Case histories illustrate each chapter. Examples are chosen to illustrate both similarities and differences between actual and "classical" failures. These histories provide diverse perspectives on how failures actually occur.

Nalco Chemical Company is currently preparing a failure-analysis reference book dealing with cooling-water failures, which will follow the same format as this text. This second book should be available in 1991.

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## **About the Authors**

**ROBERT D. PORT** is a metallurgical engineer with more than twenty years' experience in failure analysis, at both Nalco Chemical Company and at independent metallurgical laboratories. Mr. Port is the author of numerous papers on failure analysis, and frequently speaks to technical societies and industrial groups. He is a member of the National Association of Corrosion Engineers (NACE) and is active on its committee for Failure Analysis in Steam Generating Systems and its committee on Corrosion in Steam Generating Systems. He is currently president of the Nalco chapter of Sigma Xi, an international organization for research scientists. Mr. Port attended the University of Illinois where he received his B.S. in Metallurgical Engineering.

**HARVEY M. HERRO** obtained a B.S. in Physics from Marquette University and a Ph.D. in metallurgical engineering from Iowa State University. Dr. Herro, who has been with Nalco since 1982, holds patents for corrosion monitoring using chemical techniques, is the author of numerous papers on corrosion and failure analysis, and is a frequent lecturer. He is an active member in NACE and the American Society of Metals (ASM).

Mr. Port and Dr. Herro both have made presentations at professional societies such as the Electric Power Research Institute (EPRI), NACE, and ASM. Dr. Herro has also presented at the American Boiler Manufacturer's Association (ABMA). Together, the authors have completed more than 4,300 failure analyses.

Nalco Chemical Company, headquartered in Naperville, Illinois, has worldwide sales of over one billion dollars.