

## PREFACE

Engineering maintenance is an important sector of the economy. Each year US industry spends well over \$300 billion on plant maintenance and operation, and in 1997 the US Department of Defense's budget request alone included \$79 billion for operation and maintenance. Furthermore, it is estimated that approximately 80% of the industry dollars is spent to correct chronic failures of machines, systems, and people. The elimination of many of these chronic failures through effective maintenance can reduce the cost between 40 and 60%. This century will usher in a broader need for equipment management—a cradle-to-grave strategy to preserve equipment functions, avoid the consequences of failure, and ensure the productive capacity of equipment. **This** cannot be achieved by simply following the traditional approach to maintenance effectively—human error in maintenance, quality and safety in maintenance, software maintenance, reliability-centered maintenance, maintenance costing, reliability, and maintainability also must be considered. Today, a large number of books are available on maintenance, but to the best of my knowledge, **none** covers all the areas listed above. Material on **such topics** is available either in technical articles or in specialized books, but not in a single volume. In order to perform the maintenance function effectively, knowledge of these topics is essential, but maintenance professionals find it difficult to obtain such information in a single maintenance text. The main objective of this book is to cover all the above and other related current topics in a single volume in addition to the traditional topics of engineering maintenance. The book focuses on the structure of concepts rather than the minute details. The sources of most of the material are given in references, **which** will be useful to readers who desire to delve deeper into specific areas.

Chapter 1 presents various introductory aspects concerning engineering maintenance including engineering objectives, engineering maintenance in the 21st century, and maintenance-related facts and figures. Chapter 2 reviews the basic probability theory and other pertinent mathematical topics that will help the reader understand subsequent chapters of the book. Chapter 3 discusses various aspects related to maintenance management and control, including department functions and organizations, elements of effective management, management control indices, and project control methods. Chapter 4 is devoted to preventive maintenance (PM) and covers topics such as preventive maintenance elements; steps for establishing a PM program; and PM measures, models, and advantages and disadvantages. Chapter 5 presents various aspects of corrective maintenance (CM) ranging from CM types and measures to CM mathematical models. Chapter 6 is devoted to the important subject of reliability centered maintenance (RCM) and covers topics such as RCM goals and principles, RCM process, RCM components, and RCM program effectiveness indicators. Inventory control in maintenance is presented in Chapter 7. This chapter covers topics such as inventory types and purposes, inventory control models, safety stock, and estimation of spare part quantity. Chapter 8 and 9 are devoted to human error in maintenance and quality and

safety in maintenance, respectively. Some of the topics covered in Chapter 8 are facts and figures on human error in maintenance, maintenance error in system life cycle, guidelines for reducing human error, and techniques for predicting the occurrence of human error. Chapter 9 includes topics such as the need for quality maintenance processes, maintenance work quality, quality control charts for use in maintenance, post maintenance testing, safety and maintenance tasks, guidelines for equipment designers to improve safety in maintenance, and maintenance personnel safety. Chapter 10 presents various aspects concerning maintenance costing, including reasons for maintenance costing, factors influencing cost, labor and material cost estimation, cost estimation models, and cost data collection. Chapter 11 presents an important area of modern maintenance, i.e., software maintenance. Some of the topics relating to software maintenance are types of software maintenance, software maintenance problems, software maintenance tools and techniques, and software maintenance costing. Chapters 12 and 13 are devoted to two areas closely related to maintenance, i.e. reliability and maintainability. Chapter 12 covers reliability measures, reliability networks, and reliability analysis methods. Chapter 13 includes maintainability management in system life cycle, maintainability design characteristics, maintainability measures and functions, and common errors related to maintainability design.

This book will be useful to senior level undergraduate and graduate students in mechanical and industrial engineering; maintenance and operations, engineers; college and university level teachers; students and instructors of short courses in engineering maintenance; and equipment designers, managers, manufacturers, and users. The author is deeply indebted to many friends, colleagues, and students for their interest and encouragement throughout this project. I thank my children, Jasmine and Mark, for their patience and intermittent disturbances leading to desirable coffee and other breaks. And last, but not least, I thank my wife, Rosy, for typing various portions of this book, editorial input, proofreading, and tolerance.

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