DESIGN RELIABILITY

Fundamentals and Applications

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Dedication

This book is affectionately dedicate to my mother
Udham Kaur.

Preface

Today at the dawn of the twenty-first century, we are designing and building new complex and sophisticated engineering systems for use not only on Earth but to explore other heavenly bodies. Time is not that far off when humankind will permanently reside on other planets and explore stars outside our solar system. Needless to say, the reliability of systems being used for space explorations and for use on Earth is becoming increasingly important because of factors such as cost, competition, public demand, and usage of untried new technology. The only effective way to ensure reliability of engineering systems is to consider the reliability factor seriously during their design.

Over the years as engineering systems have become more complex and sophisticated, the knowledge in reliability engineering has also increased tremendously and it has specialized into areas such as human reliability, software reliability, mechanical reliability, robot reliability, medical device reliability, and reliability and maintainability management.

Even though there are a large number of texts already directly or indirectly related to reliability engineering, there is still a need for an up-to-date book emphasizing design reliability with respect to specialized, application, and related areas. Thus, the main objective of writing this book is to include new findings as well as tailor the text in such a manner so that it effectively satisfies the needs of modern design reliability. Therefore, this book is written to meet this challenge and its emphasis is on the structure of concepts rather than on mathematical rigor and minute details. However, the topics are treated in such a manner that the reader needs no previous knowledge to understand them. Also, the source of most of the material presented in the book is given in references if the reader wishes to delve deeper into particular topics. The book contains a large number of examples along with their solutions, and at the end of each chapter there are numerous problems to test reader comprehension.

The book is composed of 17 chapters. Chapter 1 presents the historical aspect of reliability engineering, the need of reliability in engineering design, reliability in the product design process, and important terms and definitions, and information sources. Chapter 2 reviews mathematics essential to understanding subsequent chapters. Fundamental aspects of engineering design and reliability management are presented in Chapter 3. As the failure data collection and analysis are considered the backbone of reliability engineering, Chapter 4 presents many associated aspects. Chapter 5 presents many basic reliability evaluation and allocation methods. However, the emphasis of the chapter is on the basic reliability evaluation methods. Chapters 6 and 7 describe in detail two most widely used methods (i.e., failure modes and effect analysis and fault tree analysis, respectively) to evaluate engineering design with respect to reliability. Chapter 8 presents two important topics of

reliability engineering: common-cause failures and three state devices. Two specialized areas of reliability, mechanical reliability and human reliability, are discussed in Chapters 9 and 10, respectively.

Chapter 11 presents the topics of reliability testing and growth essential in the design phase of an engineering system. Chapters 12 through 14 present three application areas of reliability, i.e., reliability in computer systems, robot reliability, and medical device reliability, respectively. In particular, the emphasis of Chapter 12 is on computer software reliability. Chapter 15 presents important aspects of design maintainability and reliability centered maintenance. Chapters 16 and 17 describe three topics directly or indirectly related to design reliability: total quality management, risk assessment, and life cycle costing.

The book is intended primarily for senior level undergraduate and graduate students, professional engineers, college and university level teachers, short reliability course instructors and students, researchers, and engineering system design managers.

The author is deeply indebted to many individuals including colleagues, students, friends, and reliability and maintainability professionals for their invisible inputs and encouragement at the moment of need. 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 boss, friend, and wife, Rosy, for typing various portions of this book and other related materials, and for her timely help in proofreading.

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The Author

B.S. Dhillon, Ph.D., is a professor of Mechanical Engineering at the University of Ottawa. He has served as a Chairman/Director of Mechanical Engineering Department/Engineering Management Program for 11 years at the same institution. He has published over 260 articles on Reliability and Maintainability Engineering and on related areas. In addition, he has written 20 books on various aspects of system reliability, safety, human factors, design, and engineering management published by Wiley (1981), Van Nostrand (1982), Butterworth (1983), Marcel Dekker (1984), and Pergamon (1986) among others. His books on Reliability have been translated into several languages including Russian, Chinese, and German. He has served as General Chairman of two international conferences on reliability and quality control held in Los Angeles and Paris in 1987. Also, he is or has been on the editorial board of five international journals.

Dr. Dhillon is a recipient of the American Society of Quality Control Austin J. Bonis Reliability Award, the Society of Reliability Engineers' Merit Award, the Gold Medal of Honor (American Biographical Institute), and Faculty of Engineering Glinski Award for excellence in Reliability Engineering Research. He is a registered Professional Engineer in Ontario and is listed in the *American Men and Women of Science*, *Men of Achievements*, *International Dictionary of Biography*, *Who's Who in International Intellectuals*, and *Who's Who in Technology.*

At the University of Ottawa, he has been teaching reliability and maintainability for over 18 years. Dr. Dhillon attended the University of Wales where he received a B.S. in electrical and electronic engineering and an M.S. in mechanical engineering. He received a Ph.D. in industrial engineering from the University of Windsor.

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