



Amitava Mitra

**Fundamentals of**  
Quality Control  
and Improvement

# Fundamentals of Quality Control and Improvement

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# Fundamentals of Quality Control and Improvement



*To my parents,  
who instilled the importance of  
an incessant inquiry for knowledge*

# P R E F A C E

This book covers the foundations of modern methods of quality control and improvement that may be applied to manufacturing and service industries. Quality is one of the key elements in surviving tough competition. Consequently, there is a need for technically competent people who are well-versed in the area of statistical quality control and improvement. This book should serve the needs of students in business, management, engineering, technology, and other related disciplines. It should also provide a valuable reference for professionals in the field.

The methods of this book may be applied to real-world situations but are based on statistical foundations. This book is an outgrowth of many years of teaching, research, and consulting in the field of quality assurance and statistical process control. Mathematical derivations and proofs have been kept to a minimum to allow a better flow of material. Although an introductory course in statistics would be useful to a reader of this text, the foundations of statistical tools and techniques are discussed in Chapter 3 in an effort to make the book as complete as possible.

A prominent feature of this book is the multitude of examples. For each major concept there is at least one example demonstrating its application. Furthermore, case studies are included at the end of almost every chapter. These case studies present realistic applications of quality control principles, and aid in the mastery of the material. The use of a particular quality control software package is also demonstrated in Chapter 15.

The book is divided into six parts. Part I, which deals with the philosophy and fundamentals of quality control, consists of two chapters. Chapter 1 is an introduction to quality control and the total quality system. In addition to introducing the reader to the nomenclature associated with quality control and improvement, it provides a framework for the systems approach to quality. Discussions of quality costs and their measurement as well as the management of the quality function are presented. Chapter 2 presents some philosophies of leading experts such as Deming, Crosby, and Juran and discusses their impact on quality. Deming's 14 points for management are analyzed, and the three philosophies are compared. The chapter also discusses the criteria for the Malcolm Baldrige National Quality Award in the United States and the International Standards Organization (ISO) 9000 standards used internationally.

Part II deals with the statistical foundations of quality control and consists of two chapters. Chapter 3 offers a detailed coverage of statistical concepts and techniques in quality control and improvement. It presents a thorough treatment of inferential statistics. Depending on the students' background, only selected sections of this chapter may need to be covered. Chapter 4 deals with graphical methods of data presentation and quality improvement. Modern tools such as cause-and-effect diagrams, box plots, quantile-quantile plots, and multivariable charts are covered in this chapter.

In general, the field of statistical quality control may be thought of as comprising two areas: statistical process control and acceptance sampling. Part III deals with statistical process control and consists of four chapters. Chapter 5 provides an overview of the principles and use of control charts. A variety of control charts for variables are discussed in detail in Chapter 6. In addition to charts for the mean and range, those for the mean and standard deviation, individual units, cumulative sum, moving average, geometric moving average, trends, and others are presented. Control charts for attributes are discussed in Chapter 7. Charts such as the  $p$ -chart,  $np$ -chart,  $c$ -chart,  $u$ -chart, and  $U$ -chart are presented. The topic of process capability analysis is discussed in Chapter 8. The ability of a process to meet customer specifications is a keen area of interest. Process capability analysis procedures and process capability indices are treated in depth. The chapter also discusses proper approaches to setting tolerances on assemblies and components. Part III should form a core of material to be covered in most courses.

Part IV deals with acceptance sampling procedures and consists of two chapters. Each chapter describes methods for acceptance of a product based on information from a sample. Chapter 9 presents acceptance sampling plans for attributes. In addition to lot-by-lot attribute sampling plans, those for continuous production are also included. Standardized plans such as *ANSI/ASQC Z1.4-1981* are covered as well. Chapter 10 discusses acceptance sampling plans for variables. Standardized plans such as *ANSI/ASQC Z1.9* are presented. With the emphasis on process control and improvement, sampling plans do not occupy the forefront. Nevertheless, they are included to make the discussion complete.

Part V deals with product and process design and consists of three chapters. With the understanding that quality improvement efforts are generally being moved further upstream, these chapters constitute the backbone of the available methodology. Chapter 11 deals with reliability and explores the effects of time on the proper functioning of a product. Design principles by which the reliability of a system may be improved are discussed. Chapter 12 provides the fundamentals of experimental design. Different designs, such as the completely randomized design, randomized block design, and Latin square design are presented. Estimation of treatment effects using factorial experiments is included. Chapter 13 provides a treatment of the Taguchi method for design and quality improvement; the philosophy and fundamentals of this method are discussed. Various sections of Part V could also be included in the core material for a quality control course.

Finally, Part VI deals with applications of quality control and improvement in the service sector and appropriate computer software. There are two chapters in this part. Chapter 14 describes applications of quality control and improvement methods to a variety of service industries such as banking, education, food, government, health care services, public utilities, and transportation. Chapter 15 discusses features of some available computer software in quality control. The application of one particular software package (*SAS/QC*) is demonstrated.

This book may serve as a text for an undergraduate or a graduate course for students in business,

management, engineering, technology, and other related disciplines. For a one-semester or one-quarter course, Part I, selected portions of Part II (usually parts of Chapter 3 and all of Chapter 4), Part III, and selected portions of Part V and Part VI could be covered. For a two-semester or two-quarter course, all of Part V and Part VI, along with portions from Part IV could be covered as well.

Many individuals have contributed either directly or indirectly to the development of this book, and thanks are due to them. Modern trends in product/process quality through design and improvement, as well as discussions and questions from undergraduate and graduate classes over the years have shaped this book. Applications encountered in a consulting environment provided a scenario for examples and exercises. Constructive comments from the reviewers have been quite helpful. The manuscript preparation center of the College of Business at Auburn University under the able guidance of Bess Whitten did a remarkable job. Thanks are due to Bess and also to Loraine Hyde, Linda Mathis, and Margie Wright for their dexterity and proficiency. My editor, Charles E. Stewart, Jr., is to be commended for his patience and understanding. I have found that writing a book causes an enormous drain on one's time. For that reason, my wife, Sujata, and son, Arnab, were deprived of my time—my appreciation to them.

A. M.

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