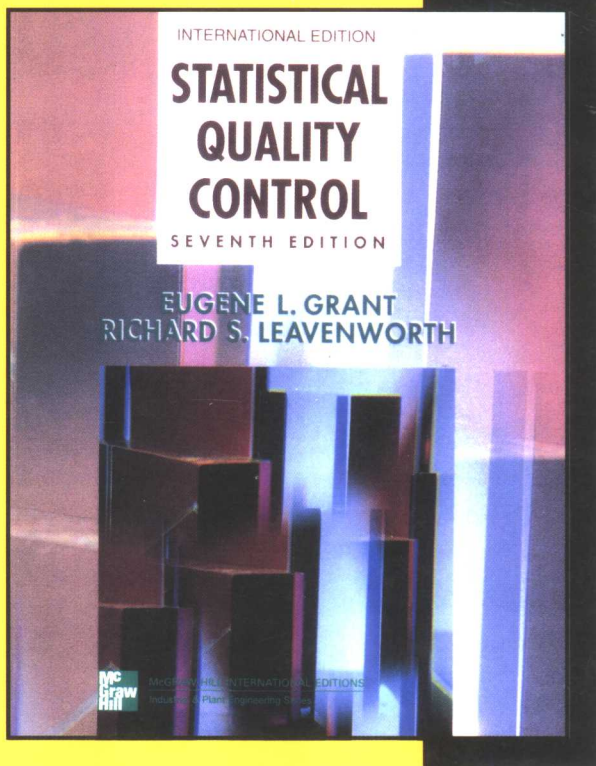


国外大学优秀教材 —— 工业工程系列 (影印版)

Eugene L. Grant and Richard S. Leavenworth

统计质量控制

(第7版)



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国外大学优秀教材——工业工程系列（影印版）

STATISTICAL QUALITY CONTROL

SEVENTH EDITION

统计质量控制

（第7版）

Eugene L. Grant

Professor of Economics of Engineering, Emeritus
Stanford University

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Professor of Industrial and Systems Engineering, Emeritus
University of Florida



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STATISTICAL QUALITY CONTROL, seventh edition.

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Forward

This textbook series is published at a very opportunity time when the discipline of industrial engineering is experiencing a phenomenal growth in China academia and with its increased interests in the utilization of the concepts, methods and tools of industrial engineering in the workplace. Effective utilization of these industrial engineering approaches in the workplace should result in increased productivity, quality of work, satisfaction and profitability to the cooperation.

The books in this series should be most suitable to junior and senior undergraduate students and first year graduate students, and to those in industry who need to solve problems on the design, operation and management of industrial systems.


Gavriel Salvendy

Department of Industrial Engineering, Tsinghua University

School of Industrial Engineering, Purdue University

April, 2002

前 言

本教材系列的出版正值中国学术界工业工程学科经历巨大发展、实际工作中对工业工程的概念、方法和工具的使用兴趣日渐浓厚之时。在实际工作中有效地应用工业工程的手段将无疑会提高生产率、工作质量、合作的满意度和效果。

该系列中的书籍对工业工程的本科生、研究生和工业界中需要解决工程系统设计、运作和管理诸方面问题的人士最为适用。

加弗瑞尔·沙尔文迪
清华大学工业工程系
普渡大学工业工程学院（美国）
2002年4月

ABOUT THE AUTHORS

EUGENE L. GRANT is Professor of Economics of Engineering, Emeritus, at Stanford University. He holds B.S. and C.E. degrees from the University of Wisconsin, an M.A. in Economics from Columbia, and an honorary Doctorate of Engineering from Montana State University. After serving in the U.S. Navy in World War I and with the U.S. Geological Survey thereafter, he joined the faculty of Montana State University in 1920 and left there with the rank of Professor in 1930 to become Associate Professor of Civil Engineering at Stanford. Prior to becoming emeritus in 1962, he served as Executive Head of the Civil Engineering Department (1947–1956) and Chairman of the Industrial Engineering Committee (1946–1952).

From 1941 through 1944, he directed the Engineering, Science, and Management War Training (ESMWT) program at Stanford where, in conjunction with Holbrook Working, he helped develop an intensive short course in Quality Control by Statistical Methods for key personnel of war industries. This became the model for a nationwide program of similar courses sponsored jointly by the War Production Board and the United States Office of Education; alumni of these courses formed the American Society for Quality Control in 1946.

He received the 1952 Shewhart Medal from ASQC and was awarded honorary membership in 1968. In 1966 ASQC established an annual E. L. Grant Award for distinguished contributions to quality control education. He is one of three honorary academicians of the International Academy for Quality. In 1965, the Engineering Economy Division of the American Society for Engineering Education established an annual E. L. Grant Award for the best paper in each volume of *The Engineering Economist*. Professor Grant received the Founders Award from the American Institute of Industrial Engineers in 1965 and the Wellington Award in 1979. He received a Distinguished Service Citation from the University of Wisconsin College of Engineering in 1964. In 1987 he was elected to the National Academy of Engineering.

In addition to "Statistical Quality Control," his books are "Principles of Engineering Economy," now in its eighth edition (1990), published by John Wiley & Sons and now coauthored with W. G. Ireson and R. S. Leavenworth; "Depreciation," published by The Ronald Press Company (1949), coauthored with P. T. Norton, Jr.; and "Basic Accounting and Cost Accounting," published by McGraw-Hill

Book Company (1956 and 1964), the second edition coauthored with L. F. Bell. He was coeditor with W. G. Ireson of "Handbook of Industrial Engineering and Management," published by Prentice-Hall (1955 and 1971).

RICHARD S. LEAVENWORTH received his Ph.D. degree in Industrial Engineering from Stanford University in 1964. After two years at Virginia Polytechnic Institute and State University, he joined the faculty of the University of Florida, where he is now Professor Emeritus of Industrial and Systems Engineering. Over the years, he has won teaching awards and has served the University as Acting Chairman of the Department, and as Assistant Dean for Planning and Analysis.

Dr. Leavenworth's research, sponsored in part by the Office of Naval Research, has resulted in numerous technical reports and publications in the *Journal of Quality Technology*, *Naval Research Logistics Quarterly*, and *Transactions of the Institute of Industrial Engineers*. He has developed a number of courses for in-plant training and presented seminars and short courses nationally and internationally. His consulting and training activities have included such organizations as the U.S. Department of Commerce, General Electric Company, Manhattan Industries, Florida Department of Transportation, U.S.D.A. Food Safety Inspection Service, Harris Corporation, the Tennessee Valley Authority, the Naval Aviation Depot, Jacksonville, Florida, Blue Cross/Blue Shield of Florida, George Washington University, and Technology Training, Inc.

He is coauthor with E. L. Grant and W. G. Ireson of "Principles of Engineering Economy" (8th ed., 1990) published by John Wiley & Sons, New York, and with E. L. Grant of "Statistical Quality Control" published by McGraw-Hill, New York, since its fourth edition (1972). Both texts have been translated into Spanish and are widely distributed through International Students Editions.

He has served the Institute of Industrial Engineers (IIE) nationally as Region Vice President and Vice President for International Operations, has held numerous offices in local chapters, and has served as editor, *The Engineering Economist*. In 1984 he was presented the IIE Quality Control and Reliability Engineering Division Award of Excellence. He is a Fellow of IIE and a Senior Member of the American Society for Quality Control and a member of the American Society for Engineering Education and the American Statistical Association and is a Registered Professional Engineer in California and Florida. In 1991, he served on the Board of Examiners for the Malcolm Baldrige National Quality Award and, in 1993, on the Board of Examiners for the Florida Governor's Sterling Award for quality.

**TO THE MEMORY OF
John Charles Lounsbury Fish**

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PREFACE

This book is a practical working manual. It deals primarily with various types of control charts and acceptance sampling systems and procedures. These are simple but powerful techniques that have been widely used in many industries and in many countries throughout the world to improve product and service quality and to reduce costs. The most effective use of these techniques depends upon their being understood by production and inspection operators and their supervisors, by engineers, and by middle and upper level management.

The objective has been to write a book that might be immediately useful to all of these groups. No attempt has been made to write for the professional statistician or the mathematician. The aim has been to give just enough theory to supply practical working rules that will enable one to recognize the limitations of the methods as well as their many uses.

A special feature of this book is the liberal use of descriptions of actual cases from a number of economic sectors. Each example has been selected to bring out one or more important points. These examples reflect the general viewpoint of the book that the statistical techniques described should be studied primarily as a means to various ends desired by a cost-conscious management. A number of examples deal not only with the behavior of random variables but also with the behavior of people in various industrial and business situations.

The book retains its intuitive approach to probability and statistics. The authors believe that this approach is very important to engineering and business students who may have very little industrial experience but may have some responsibility for teaching SQC courses in-house to operators and inspectors. Just as in previous editions, the changes from the preceding edition have been made in part to improve the presentation of fundamental principles and in part to try to keep the treatment of various topics up-to-date. Some of the changes are as follows:

1. The book is now divided into four parts. Part One is a short introduction to the topics covered in the other three parts. Part Two treats topics concerning statistical process control (SPC), Part Three discusses scientific sampling, and Part Four deals with the economics of quality as well as some management and teaching aspects of quality control.

2. The treatment of simple \bar{X} and R charts (Chap. 2) begins Part Two. This change is intended to emphasize the idea that control needs to be achieved before histograms and estimates of process centering and dispersion (introduced in Chaps. 3 and 4) can be relied on to predict future results.
3. The material on rational subgrouping (Chap. 8) has been separated from that on process capability (Chap. 9) to emphasize the importance of establishing purpose when setting up sampling procedures and methods of recording data. The addition of error of measurement material and gage repeatability and reproducibility (R&R) studies at this point emphasizes the importance of purpose in determining rational subgrouping.
4. Process capability analysis and aspects of design and inspection specifications and design tolerances have been combined into Chap. 9 to emphasize their importance in process improvement.
5. Chapter 10 on special process control procedures now contains comments on the so-called precontrol technique (10.2.8), the use of box plots (10.3.4), exponentially weighted moving average (EWMA) charts (10.6.3), and the special problems introduced by extremely small production runs (10.9) and extremely high-quality production (10.10). The chapter concludes with CuSum charts for averages.
6. The scope of Part Three has been somewhat reduced without deleting material important to U.S. students. All standard measures of effectiveness of sampling procedures are now covered in Chap. 11. The emphasis has shifted to that of analyzing any sampling process, rather than simply sampling for product acceptance purposes, because nearly all quality inspection involves sampling, either from an unknown and possibly shifting universe, or from a lot. Standard plans therefore are used more as a vehicle for understanding the implications of various kinds of sampling.
7. Chapter 17 on economic aspects of quality control has been expanded to include the ASQC categories of quality costs (17.3.1) and Taguchi's loss function and its related index, C_{pm} (17.4).
8. A new chapter (Chap. 18) describes some of the history and evolution of statistical quality control and the dramatic impact that Walter Shewhart, Harold Dodge, and W. Edwards Deming have had on quality control in the twentieth century.
9. Another new chapter (Chap. 19) introduces and compares the two most influential quality management models that are evolving in this last quarter of the twentieth century: (a) the total quality model best exemplified by the criteria and guidelines for the U.S. Malcolm Baldrige National Quality Award and (b), the registration requirements of the ISO 9000 set of quality standards. The difficulty of integrating and implementing these management models in an operational setting, such as a factory floor or a service facility, is presented through the use of problem solving models, the "seven basic tools," and storyboard models.
10. A computer disk accompanies the book. It contains simple SPC software, some easily identifiable data tables for examples and problems in the book,

and some probability calculation programs written in BASIC. TXT files on that disk contain instructions for running the programs. Instructions are also included in the Instructor's Solutions Manual that accompanies this book and is available to instructors from the publisher.

This edition follows the general pattern of the six earlier editions, which were greatly influenced by the viewpoint and philosophy of Dr. W. Edwards Deming. The authors also wish to acknowledge their debt to Harold F. Dodge, whose extensive comments had a great influence on the writing of the second and third editions. Particular mention should be made of Ms. Bonnie Small for her review and suggestions for the fourth edition and of the staff of the University of Tennessee Center for Productivity through Quality for their review of the fifth edition. Our thanks are also extended to a number of users of the sixth edition for their suggestions for changes and improvements.

Reviewers of the manuscript of this edition provided much valuable input in its modification. These reviewers included Suraj Alexander, Roger Berger, Richard Buhman, Kenneth Case, who also is a Consulting Editor in the field for McGraw-Hill, Owen Miller, Joel Nachlas, Ahmad Seifoddini, Jill Swift, and Gary Wasserman. Their approaches to the subject, which ranged from strong management to strong statistics orientations, contributed many insights. Needless to say, not all of their suggestions could be incorporated while still maintaining the essential character of the book as previously described. Further acknowledgment should be made of the reviews by Professors Swift and Wasserman of the accompanying software developed by Mr. Mark Shewhart.

In addition, our thanks are offered to Mr. Seymour Selig for his assistance with material on military standards and to Dr. John F. Mahoney for his comments and help in the development of new tables of factors for control charts. Nevertheless, as in all technical books, the final responsibility for the selection and treatment of material must fall on the shoulders of the authors, and they should receive the blame for any deficiencies.

Eugene L. Grant

Richard S. Leavenworth

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