SECOND EDITION

SPC SIMPLIFIED

Practical Steps to Quality

ROBERT T. AMSDEN
HOWARD E. BUTLER
DAVIDA M. AMSDEN

CRC Press
Taylor & Francis Group
A PRODUCTIVITY PRESS BOOK

SPC SIMPLIFIED: *Practical Steps to Quality, 2nd Edition*

Robert T. Amsden, Howard E. Butler, and Davida M. Amsden

This classic, practical book teaches statistical process control to everyone who needs to understand how to perform SPC. Revised to reflect the changing role of operators and line workers—and to cover even more problem-solving tools—the text maintains its best-selling "simplified" approach. No mathematical background is needed. Using clear, straightforward language, it simplifies the essentials for monitoring, analyzing, and improving quality, so that everyone can understand and apply them.

In an easy-to-follow, modular approach, the authors guide you step-by-step. You'll learn how to develop and analyze **frequency histograms, variable control charts**, and **attribute control charts**. Likewise, **machine and process capability, problem-solving tools**, and the **elements of a total quality management system** are explained. Each module contains numerous practice problems, with solutions given at the end of the book. Abundant real-life examples and sample charts show you how to evaluate the quality of your product or service and improve job performance.

In addition, this unique text:

- shows you how to use important basic quality tools: **Pareto analysis, brainstorming**, and **cause-and-effect diagrams**, and now also includes **checksheets, flowcharts**, and **scatter diagrams**.
- emphasizes problem-solving, and teaches when and where to apply the techniques learned.
- covers how SPC and problem-solving tools are used in organizations committed to continuous improvement.

SPC Simplified makes quality methodology understandable to the people who actually work on the processes to be analyzed. It is the cornerstone for a successful and profitable quality process for your entire organization.

ABOUT THE AUTHORS

Robert T. Amsden is Associate Professor of Decision Sciences at the School of Business Administration, University of Dayton, and provides training in SPC, TQM and just-in-time methodologies. He has served at the national level for the American Society for Quality (ASQ) and the Association for Quality and Participation (AQP).

Howard E. Butler is an ASQ Certified Quality Engineer and senior member of ASQ. He has been a consultant for 16 years and previously worked at General Motors Corporation developing and managing quality management systems. He has conducted SPC training seminars for companies throughout North America and for George Washington University.

Davida M. Amsden is a private consultant/educator in the areas of SPC, total quality systems, just-in-time manufacturing, and participative management. She has taught classes in SPC for the ASQ and for George Washington University.

ISBN 978-1-138-46415-5

9 781138 464155

CRC Press
Taylor & Francis Group
an informa business
www.crcpress.com

AMSDEN
BUTLER
AMSDEN

SPC SIMPLIFIED: *Practical Steps to Quality*

CRC

SPC SIMPLIFIED

Practical Steps to Quality

SECOND EDITION

ROBERT T. AMSDEN
HOWARD E. BUTLER
DAVIDA M. AMSDEN

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
A PRODUCTIVITY PRESS BOOK

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

First issued in hardback 2017

ISBN-13: 978-0-527-76340-4 (pbk)
ISBN-13: 978-1-138-46415-5 (hbk)

Library of Congress Cataloging-in-Publication Data

Amsden, Robert T.
SPC Simplified : practical steps to quality / Robert T. Amsden, Howard E. Butler, Davida M. Amsden—2nd ed.
p. cm.
Includes index
ISBN 0-527-76340-3 (alk. paper)
1. Quality control—Statistical methods. I. Butler, Howard E. II. Amsden, Davida M. III. Title
TS156.A47 1998
658.5'62—dc21

97-47363
CIP

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

SPC SIMPLIFIED

Practical Steps to Quality

SECOND EDITION

Preface

Statistical process control, a set of procedures using statistical techniques, has been used in industry for decades. However, widespread use of statistical process control declined throughout the 1950s, 1960s, and 1970s. The emphasis of most manufacturing organizations during this period was typically on the quantity of production and not on the quality of the products or services being produced. In many cases, the demand for products was greater than the ability to produce. Few managers felt the need to use any techniques designed to improve quality or even maintain a high level of quality in the products they manufactured. Statistical process control techniques were used mainly to help solve severe production problems. Quality engineers were ready with statistical problem-solving techniques, but by and large, production managers neither wanted nor needed the techniques.

Then, in the late 1970s a serious problem entered the American industrial scene. Markets were becoming global. Companies encountered competition from manufacturers located all over the world. This globalization created a drive for increased efficiency in the manufacture of products. The United States had long been the world's largest producer of manufactured goods. Previously, there was very little competition from other countries. It became apparent however, that other countries had now acquired the ability to produce many products at a lower cost and at better quality than similar products being produced in the United States.

Many manufacturing operations were studied in various companies around the world. Visitors to manufacturing plants in Japan reported that the competition outperformed the United States by working harder for less money. Others reported that the Japanese used something they called quality circles to get the people who worked in the same area on the production floor to work more effectively and produce better quality products. Neither of these answered the problem.

One thing learned was that in Japan many people on the production floor were making decisions concerning their operations as a normal part of their daily tasks. By contrast, workers in the United States had very little control and were seldom allowed to make decisions concerning their operations. In theory, management took all responsibility for the quality of the product. On rare occasions operators or line supervisors were asked to collect information or data and record it on a chart, but a quality engineer held the "secrets" of statistical process control. Even in such a situation, when the product did not meet standards, managers generally blamed the poor quality on lack of care on the part of the production operators.

Starting in the 1970s and especially during the 1980s, the production of goods and services has undergone drastic changes in the United States. In light of the global competition, international standards have been established stressing the importance of the customer. These standards are organizational guidelines for companies who expect to compete not only in their traditional marketing areas but in world markets. Market areas sometimes are very local, but more and more companies are expanding their area of business interests. Companies are finding that they are required to be certified as meeting the international standard. These standards are known as the ISO 9000 series of guidelines. They require, among other activities, the use of statistical process control in the manufacturing processes. Certification to the standard is a legal requirement to do business in many countries around the world. It is rapidly becoming a requirement of original equipment manufacturers in the United States. In fact, the three large automotive manufacturers in the United States have published their own standard, QS-9000, which adds specific requirements to the ISO 9001 standard. Certification of conformance to QS-9000 will be mandatory in the near future if a company wants to be a supplier to any of the three large manufacturers.

Good managers have learned over the years that everyone is responsible for maintaining quality. Associates on the production floor are encouraged to monitor their operations and take corrective action when necessary. Managers have realized that if so much is expected of the production floor workers, they must be provided with the training, tools, and environment to do their jobs well. Companies have learned that the best way to become efficient and competitive is to prevent defects. In turn, production associates are expected to take responsibility for their operations. If the people who "make it happen" on the production floor are to be successful, they must be supplied with the necessary tools and know-how to do their job.

After many years of working to solve quality problems in all kinds of processes and in companies of every size, we were convinced that a book was needed for everyone who has a responsibility to produce a product or service that meets the customer's wants, needs, and expectations. We have written this book mainly for production associates, set-up people, inspectors, and first line supervisors. Manufacturing managers and newcomers to quality engineering and quality improvement will also find it useful.

In this book you will learn how to develop and use the statistical techniques that are used most often to improve quality. These tools of quality are based on a number of mathematical principles. You don't need to know or understand the principles to use the techniques any more than you need to know how a television set works to enjoy your favorite program. The techniques you will use most often, whether it be in group problem solving activities or in monitoring and improving the quality of a production operation, are very simple and require only a little arithmetic. You can usually find the numbers you need in a specially prepared table, or you can make simple calculations with pencil and paper or a pocket calculator.

SPC Simplified has grown out of the experiences we have shared with many people over the years. The insights we gained working with production associates, inspectors, supervisors, engineers, managers, and customers made this book possible. We developed the book from a practical point of view, using examples based on real situations and working with people who have had the same problems that you face every day on the production floor. We thank all those people for their contributions.

We also wish to acknowledge the following: in Module 2 the bucket of plastic-coated chips is based on the work of the late Dr. Walter Shewhart; in Module 3 the late Harold Dodge told the story of the munitions factory; the late Dr. W. Edwards Deming gave the account of the paper coating process. Thanks to Mr. Stewart Schofe for the data for the individual and range chart in Module 3. We thank the American Society for Quality for allowing us to use the forms for the charts discussed in Module 3. Our thanks also go to Sid Rubinstein for allowing us to use the shaft movement data in Module 2.

The following people read portions of the manuscript: Joan and Garth Borton, Phyllis Cole, Bob Coon, Rick Eggers, Craig Kottke, Janice Losiert, Dave Loudner, Bob Morrison, Stephanie and Bill Paris, Drifty Miller, Stew Schofe, and Bernie Williams. Our thanks to them for their helpful suggestions and encouragement.

We give grateful acknowledgement to my wife, Jean, for her useful comments and suggestions.

Finally, we thank the editor, Karen Feinberg, who so skillfully shaped the ideas of three technical-minded authors into a very readable book.

H.E.B.
R.T.A.
D.M.A.

Introduction

This is a "how-to" book. In it you will learn how to use statistical techniques to monitor the quality of parts produced in manufacturing operations. These techniques can also be used in other ways, but in this book we will concentrate on manufacturing operations.

If you are involved in a manufacturing operation, you are trying constantly to make parts that meet the customer's requirements. You are also trying to make each part as much like the others as possible. To do these things you must gain and keep control of your operation.

To control the conditions of your operation you must be able to measure them. Over 100 years ago Lord Kelvin, an English scientist, said:

> "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is . . . unsatisfactory."

You can use calipers, gauges, or thermometers to measure a dimension, but statistical process control techniques will give you the tools to measure the performance of an operation and express it in numbers. By looking at the numbers you will know whether your operation is running smoothly or whether it needs to be adjusted. More important, you will learn to predict how well the operation will run in the future.

With the use of the simple statistical techniques discussed in this book, you will be able to measure the performance of operations both before and after corrective actions have been taken. This is true whether you are trying to bring an operation into control or to break through to a new, improved level of performance.

This book is divided into seven modules. At the beginning of each module you will find a list of the new terms used in that module. These terms will be explained as you read. For your convenience, all the new terms are listed and explained again in a glossary at the end of the book.

Module 1 gives the basic ideas or principles behind statistical control techniques. These principles are based on mathematics, but we will not ask you to get involved in mathematics. All you need to do is accept the basic principles and learn how to apply them in your job.

Module 2 deals with frequency histograms and checksheets. These are the simplest of the statistical techniques you will use. In fact, you may already be familiar with them. Histograms are a popular, easy way of picturing the variations you find when you measure a dimension of a part. You will find that many quality problems can be solved by using frequency histograms. Checksheets are useful in analyzing data that can not be measured.

Variables charts are covered in Module 3. These charts use the same type of measurements that are used in frequency histograms, but in a different way. The statistical techniques used to monitor and control these measurements are the most powerful and useful techniques you will learn here. They can tell you the most about the variation in a product with the smallest sample.

Module 4 deals with attributes, a different kind of quality measurement. In the language of quality control, an attribute is a measure of quality that can be stated as "good" or "bad." A part is defective or it is not. It is accepted or rejected by a "go/no-go" gauge. This type of inspection result is not usually regarded as a dimension, but the statistical techniques discussed in Module 4 will show you how to assign numbers to the results of attribute inspections. Once you can assign a number to your information, you can use control charts to maintain control of the quality.

Module 5 discusses capability analysis. If you intend to control the quality of your products, you should know the capability of your processes and operations—that is, how well they can meet the customer's requirements. Some of the same techniques you use to control your operations can also be used to measure capability.

The "tools of quality" are useful not only to improve the quality of products and processes, but also to identify the causes of problems in your work area and solve them. Module 6 shows some problem-solving techniques. Even though they may not fall under the heading of statistical quality control, these techniques are becoming more and more important in modern quality control systems.

Module 7 explains the concepts of total quality management and continuous improvement, and discusses how the SPC and problem-solving tools may be used to help a TQM program.

At the end of Modules 2, 3, 4, 5, and 6 you will find practice problems. These problems are typical applications of the "tools of quality" and will give you a chance to use your statistical techniques. The solutions to the problems will be found in a separate section at the end of the book. We suggest that you pay special attention to the solutions—they will confirm what you learned in the modules and explain the ideas behind the problems.

Contents

MODULE 1 Basic Principles

NEW TERMS IN MODULE 1
(in order of appearance)

frequency distribution	*average and range chart*
normal distribution curve	*average*
fishbone diagram	$\overline{X}$
chance causes or system causes	*range*
assignable causes or special causes	*R*
stable process	*upper control limit*
histogram	*lower control limit*
process spread	*out of control*
standard deviation	*in control*
sigma (σ)	*percent defective chart*
control limits	*management team solvable problem*
variables chart	*floor solvable problem*
attribute chart	

Have you ever been sick enough to be confined to a hospital bed, with a nurse coming around and taking your temperature, your pulse, and your blood pressure? If you have, you already know something about statistical process control. The readings that the nurse records on a chart are like the readings you will record on charts on your job. When you're sick, the doctor wants to know what is normal about you and what is not. With this information he will take the right steps to make you well.

Jobs can get sick, just like people. Like the doctor, you need a picture of how the job is performing. You need a running record of what is happening on your job to tell when it is sick and when you must take action to make it well.

Just as the doctor uses temperature and pulse charts to keep track of your condition, you will use control charts to monitor the condition of your job. When properly used, control charts will tell you three things:

1. When you're doing something you shouldn't.
2. When you're not doing something you should.
3. When you're doing things right.

In short, control charts will indicate how "well" your job is. They'll show you:

1. When the job is running satisfactorily.

or

2. When something has gone wrong which needs correcting.

Control charts will provide you with "stop" and "go" signals. They'll enable you to "point with pride" or "view with alarm" (and look for the cause of the trouble!).

To use these statistical tools effectively and profitably, you must understand some of the basic principles underlying statistical process control techniques. You may be one of the many people who feel uncomfortable when the word "statistics" is mentioned, but in using statistical process control techniques, you don't need to get deeply involved in mathematics. All you need to do is learn a few basic principles. An understanding of these principles will make it easier for you to understand and use the control chart techniques presented in this book.

All the ideas and techniques in this book are based on six principles. The first principle is:

1. No two things are exactly alike.

Experience has shown that things are never exactly alike. When two things seem to be alike, we often say that they're "like two peas in a pod." But when we open a pea pod and take a close look at the peas, we see slight differences. The peas are different in size, shape, or freedom from blemish. If you're concerned with manufacturing parts, you know that no two manufactured parts are exactly alike either. In one way or another, the parts will be slightly different in size, shape, or finish.

We often want to make parts interchangeable. To do this, we want to make them identical, but no two things are exactly alike. Therefore, we want to keep the variation between parts as small as possible. To help ourselves do this, we use a second basic principle:

2. Variation in a product or process can be measured.

Some variation is normal to your job, and this variation tends to increase. If you make no effort to measure or monitor the variation normally expected in your job, you could find yourself in a lot of trouble. That is, all processes that are not monitored "go downhill." Therefore, it's necessary to measure the output of any process or operation to know when trouble is brewing.

When you check the output of a process or operation, you will quickly notice one feature. This feature provides a basis for the third principle:

3. Things vary according to a definite pattern.

If you want to see this pattern take shape, all you need to do is record the measurements of a dimension on parts from one of your operations on