Guide to Quality Control

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Asian Productivity Organization

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Preface to the second revised English edition

The Asian Productivity Organization published an English translation of the Japanese book *Gemba no QC Shuho* in April 1971. Written and edited by Dr. Kaoru Ishikawa and published by the Japan Union of Scientists and Engineers, the book was written to introduce quality control practices in Japan which contributed tremendously to the country's economic and industrial development. This book soon came to be regarded as the best book on the subject as practised in Japan.

The revised translated editions which followed were designed to meet the need for a unique book with Asian characteristics applicable and adaptable to other countries. The subtleties of the Japanese language and the practical difficulties in faithfully translating one language to another necessitated several translations and revisions of the original volume. The collective effort of a team of translators, the Asian Productivity Organization, and the guidance and technical advice of Prof. Norio Shibata of the Graduate School of Business Administration of the Keio University, Tokyo, resulted in a much-improved version of *Guide to Quality Control.* In addition, on the basis of feedback from actual application of the techniques, Dr. Kaoru Ishikawa has made further improvements, mainly involving Pareto diagrams and practice problems. These changes have increased the effectiveness of the quality control methodology.

Many large companies have used the book as an indispensible part of their in-house training kit. The book is intended as a guide rather than a detailed handbook. Those interested in studying the subject further should refer to other publications, some of which are listed in the bibliography at the end of this book. The appendices also contain some new material and some footnotes have been added. These should give readers a better grasp of the contents, especially those topics which are unique Japanese innovations such as binomial probability papers. The present book should be

suitable for both self-study and classroom training.

As the Quality Control Circle, where workers study and analyze the quality control process on their own initiative, is a unique feature in Japan, the original Japanese book is still serving the needs of QC Circle members in their quest for improvement through group study and discussions. If national productivity organizations in APO member countries could encourage use of this book in a similar manner for the benefit of foremen and workers, even greater achievements may be realized.

The Asian Productivity Organization thanks Dr. Kaoru Ishikawa and the Japan Union of Scientists and Engineers for their cooperation. It also wishes to thank Prof. N. Shibata, Interlingua Language Services, Ltd., and all those who contributed to the translated and revised versions.

Asian Productivity Organization

Tokyo, November 1985

Preface to the original edition

Japan's industrial workers are, qualitatively, among the world's finest. But further polishing is necessary for them to display their true brilliance and strength. Therefore, one of our aims in publishing *Quality Control for the Foreman* magazine and in starting the QC Circle activities was to enable workers to study together. Since then the QC Circle movement has become a world-wide phenomenon.

Throughout Japan it is apparent that factory workers have the desire to study. Workers as well as foremen have begun reading about quality control and other subjects related to their work. The circulation of *Quality Control for the Foreman* has grown rapidly, and many books of the "factory QC reader" type are being published. We are pleased to see this trend.

To promote the desire to study, in 1968 we adopted the slogan: "QC Circle members—Let's study!" But in order to study, a proper textbook is necessary. It was apparent that those already published on QC were somewhat too sophisticated to serve millions of factory workers. Foremen also found these books inappropriate for training new employees. The result was a growing demand for an easier book.

This book builds upon the articles and exercises concerning QC which the editorial committee of *Quality Control for the Foreman* originally wrote for the magazine.

The techniques in this book are those we feel should be known by all QC Circle leaders and, if possible, all Circle members as well. This book can be used for self-study, training of employees by foremen, or in QC reading Circles. However, this book contains only the techniques and is not concerned with the concept of QC or the reasons behind it. Other books are available concerning those matters, and some of them are presented at the end of this book.* But we believe it was very useful to bring this kind of information together in one volume. Reading the book should be helpful,

*List of books in Japanese not included in this translated version.

though study alone is not enough. Techniques must be practised on the job!

I wish to thank Mr. Koichi Ohba for his help in publishing this book, and also the editorial staff of the JUSE Publishing Company.

April 1968

KAORU ISHIKAWA
Editorial Committee Chairman

How to use this book

Study Method

The explanations of QC techniques and the practice problems which appeared in the magazine *Quality Control at the Factory* during 1967 have been brought together in this book. To compile these chapters, which cover a year's publication of the magazine, studies on the fundamental techniques of quality control were made at the factories by the editing committee of the QC magazine. The contents are something each factory foreman, group leader, and circle leader can effectively master.

Because of its origins, this book is not like an ordinary textbook, but it is highly suitable for self-study. Careful reading from cover to cover should provide a good understanding of the subject. In addition, the following study method will demonstrate how quality control can be of practical help.

Self-study method

Chapters 1 to 12 explain the techniques of quality control. Chapter 13 embodies practice problems 1 to 12 along with the answers. This final chapter also gives additional explanations to help understand the answers to the practice problems. The numbers given to each chapter in the table of contents correspond to the numbers given to the practice problems in chapter 13. For example, chapter 5 deals with Pareto diagrams and practice problem 13.5 in the last chapter also deals with them.

When embarking on self-study, the following steps and tips will be helpful.

1. To study the explanations of QC techniques
   - First, go over the whole chapter once. Even if you come across some parts that are not clear, keep on reading until the end of the chapter. In many cases, the difficult parts will be cleared up further on.
   - Once you have finished going over the whole chapter, go back to the beginning again, and read through leaving more time. Parts that are unclear should be read again until understood.
   - When going through the chapter for the second time, write down the

words and formulas you think are important as well as anything you did not understand.
   - After the second reading, review the words and formulas you have written to see whether you really understand them. If you come across any you are not certain of, read that part of the book again.
   - When you have more or less understood the contents proceed to the next step.
2. Find the practice problems corresponding to the chapters and try to solve them.
   - If you have trouble solving the problems, go back to the chapter and read the contents again. Try to come up with some sort of solution before referring to the answers.
   - Check your answer against the correct answer provided in the book.
   - Find out where the difference lies between your answer and the one in the book. Read the chapter once again trying to discover the cause of the mistake, and try re-answering the problem.
   - If your answer corresponds to that in the book, congratualtions! Carry on!
3. Read the explanations that follow the answers to the practice problems. Here you will come across new things that were not mentioned in the earlier chapters. So read this section carefully.
4. Once you've learned how to solve the practice problems, think about which of the techniques can be applied to your situation. You are bound to find such data if you look carefully enough. You may also come up with ideas on new types of data you want to collect.
5. If you can find data concerning matters you are already familiar with, try applying these techniques.
6. Show the results to the factory staff and your colleagues and seek their criticism as well as advice.

There will be cases where an example used in a given practice problem is not related to your kind of work. Whether it relates to your field or not, you should be able to answer the problem if you have gone through the steps. Of course, self-study is hard and painstaking; the most important thing is to keep at it. If possible, it is advisable to form a study group with some of your colleagues.

Group-study method

Group-study also involves a certain degree of self-study, since participants are assigned problems to prepare, review, and practise. Here are some points that should be considered in group-study.

1. The first 12 chapters (explanations of the quality control techniques).
   - Participants at first study on their own (self study).
   - Participants take turns lecturing (rotating lecturers).
   - Those not appointed to lecture on a given topic should do the associated preparatory study work.
   - Have someone from outside the group—for example, a member of the factory staff who may be engaged in quality control activities—come and give lectures. The group members should prepare the lessons and have questions ready.
   - Group members should exchange opinions and try to find similar problems to which techniques can be applied and discuss whether the applications are suitable or not.
2. Practice problems. Following the study of the techniques, try solving the problems given for each technique (the practice problems in chapter 13 with the corresponding number).
   - Let each member of the group present his answer orally; answers should also be written and distributed among the members for discussion purposes.
   - All answers, whether right or wrong, will provide a locus of study material. The presentation of various viewpoints will allow for the most comprehensive analysis.
   - The group should not only point out possible errors, but examine how to make improvements.
   - If conclusions cannot be reached after discussion within the group, the group should reread pertinent sections of the book together. If the problem is not solved at this stage, seek the cooperation of the staff members in the factory.
   - Remember that practice problems are limited. Similar data should be sought to apply the quality control techniques to actual data. The results of these applications should also be discussed by the group.

Contents

Chapter 1

How to collect data

1.1 The purpose of collecting data

A great deal of data can be collected in factory situations. First consider the purpose of collecting these data.

When we introduce a particular method of doing a job, it is natural to consider whether the method is appropriate or not. The decision is usually based on past results and experience, or perhaps on conventional methods. However, in the case of factory work, where data are collected through the actual manufacturing process, the procedural methods are introduced on the basis of the information obtained. The manufacturing procedure will be most effective if a proper evaluation is made, and on-the-job data are essential for making a proper evaluation.

Data and subsequent evaluation will form the basis for actions and decisions. As factory operations will vary with the manufacturing procedure involved, data should be classified in terms of the various purposes.

(1) Data to assist in understanding the actual situation

These data are collected to check the extent of the dispersion in part sizes coming from a machining process, or to examine the percentage of defective parts contained in lots received. As the number of data increase, they can be arranged statistically for easier understanding, as will be explained further on. Estimates and comparisons can then be made concerning the condition of lots received as well as the manufacturing process, utilizing specified figures, standard figures, target figures, etc.

(2) Data for analysis

Analytical data may be used, for example, in examining the relationship between a defect and its cause. Data are collected by examining past results and making new tests. In thise case, various statistical methods are used to obtain correct information.

(3) Data for process control

After investigating product quality, this kind of data can be used to

determine whether or not the manufacturing process is normal. Control charts are used in this evaluation and action is taken on the basis of these data.

(4) Regulating data

This is the type of data used, for example, as the basis for raising or lowering the temperature of an electric furnace so that a standardized temperature level may be maintained. Actions can be prescribed for each datum and measures taken accordingly.

(5) Acceptance or rejection data

This form of data is used for approving or rejecting parts and products after inspection. There are two methods: total inspection and sampling. On the basis of the information obtained, it can be decided what to do with the parts or products.

1.2 Correct data

Data serve as the basis for action. After evaluating actual conditions as revealed by the data, proper action can be taken. The first critical step is to determine whether or not the data represent typical conditions. The situation can be stated as follows:

1) Is the data gathered likely to reveal the facts?

2) Are the data collected, analyzed, and compared in such a way as to reveal the facts?

The former is a problem of sampling methods, and the latter is a problem of statistical processing.

The important point in sampling is to know just what the data are to be used for; in other words, be certain of the purpose. For example, if the problem with a given product is impurity dispersion it is hardly sufficient to take only one sample per day to find out the daily dispersion rate. Or, in comparing defects produced by workers A and B, it is essential to take at least two separate samples from both workers' products. Full consideration should be given to the reason for collecting data, proper sampling techniques, and stratification. One should not take a disproportionate share of a certain kind of data simply because they can be collected easily. Also, partial data which happen to be convenient to collect are not necessarily effective and sufficient.

But even the use of proper sampling techniques is not enough. It is necessary that the data represent the facts and that the statistical method applied leads to an objective evaluation.

For example, if you have 100 data representing the hardness of material X, it is generally impossible to draw any conclusions from the numerical value alone. The basis for a decision can only be realized after comparing them with the overall situation, as represented in a histogram or check sheet. And, in comparing the hardness of material Y with that of material X, it is still necessary to use statistical techniques, after measuring the dispersion in the samples of each.

1.3 Kind of data

Even assuming that the need for having data is understood, on many jobs it is often hard to obtain data in neat numerical values. It is impossible to measure the softness of fabrics, plating lustre, or the whiteness of paper, in discrete numerical figures such as one encounters for size and weight.

For example, relative comparisons may be used to determine the softness of three kinds of fabric. Exact measurement may not be possible, but the arrangement of fabrics in order of softness can provide excellent data. The vibration of an automobile, or flickering during the projection of an 8 mm motion picture, would be difficult to measure with simple instruments alone. But five persons could test drive the car or watch the movies and then report their observations.

As previously stated, the purpose of collecting data is not to categorize everything into neat figures but to provide a basis for action. The data itself can be in any form.

Generally, data can be divided into these groups:

1) Measurement data: continuous data
   Length, weight, time, etc.
2) Countable data: enumerate data
   Number of defectives, number of defects, percentage defective, etc.

In addition, there are also data on relative merits, data on sequences, and data on grade points, which are somewhat more complicated but useful to those with the experience to draw appropriate conclusions from them.

1.4 Analysis of data

After data are collected, they are analyzed, and information is extracted through the use of statistical methods. Therefore, data should be collected and organized in such a way as to simplify later analysis.

First of all, clearly record the nature of the data. Time may elapse between the collection and the analysis of the data. Moreover data sheets may be useful at other times for other uses. If is necessary to record not