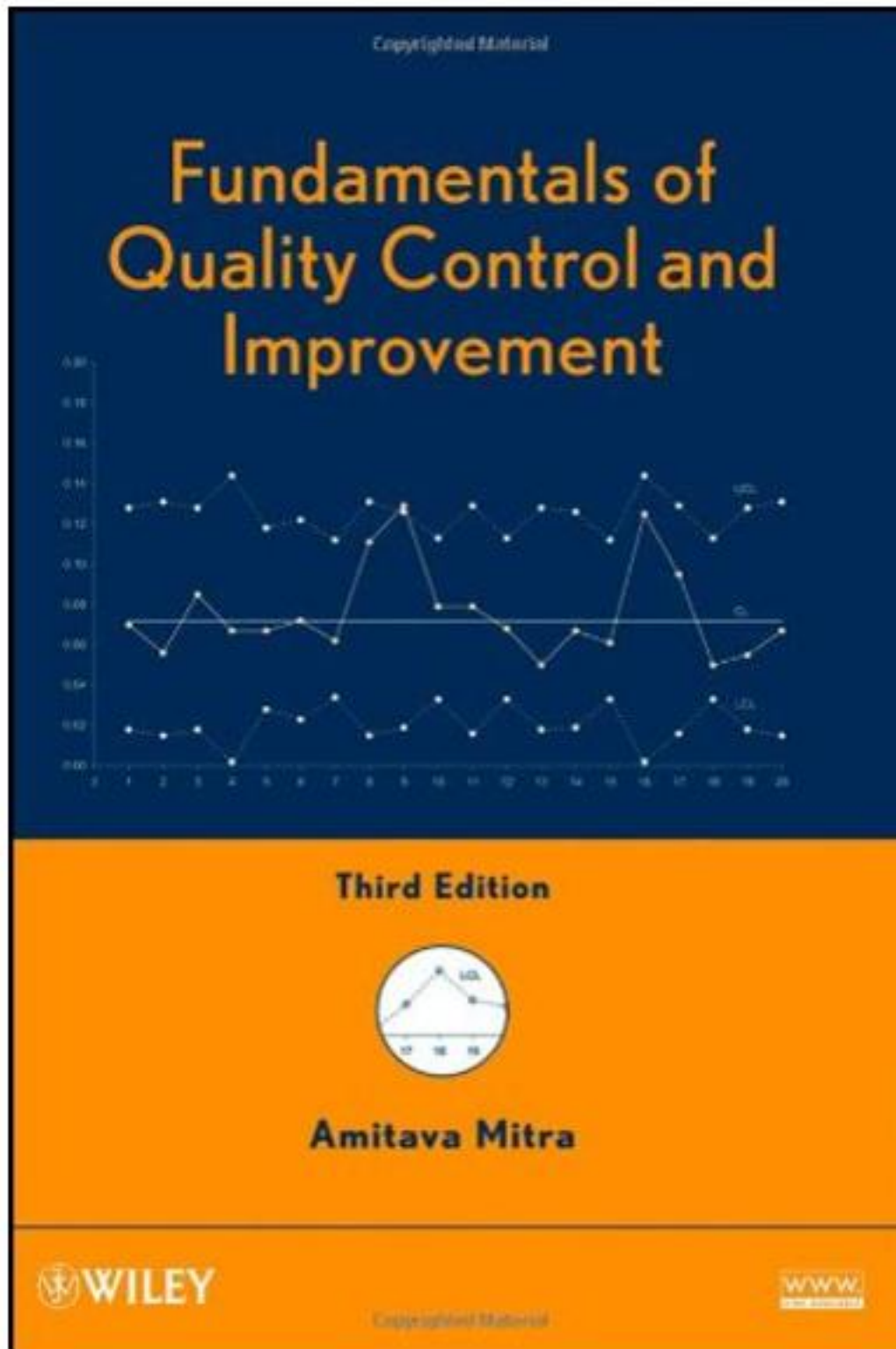


Solutions Manual

# Fundamentals of Quality Control and Improvement

3rd Edition

**Amitava Mitra**



*Solutions Manual to Accompany*

**Fundamentals of Quality Control  
and Improvement**

*Solutions Manual to Accompany*

# **Fundamentals of Quality Control and Improvement**

Third Edition

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# CONTENTS

PREFACE	vii
CHAPTER 1: INTRODUCTION TO QUALITY CONTROL AND THE TOTAL QUALITY SYSTEM	1
CHAPTER 2: SOME PHILOSOPHIES AND THEIR IMPACT ON QUALITY	15
CHAPTER 3: QUALITY MANAGEMENT: PRACTICES, TOOLS, AND STANDARDS	27
CHAPTER 4: FUNDAMENTALS OF STATISTICAL CONCEPTS AND TECHNIQUES IN QUALITY CONTROL AND IMPROVEMENT	45
CHAPTER 5: DATA ANALYSES AND SAMPLING	73
CHAPTER 6: STATISTICAL PROCESS CONTROL USING CONTROL CHARTS	85
CHAPTER 7: CONTROL CHARTS FOR VARIABLES	97
CHAPTER 8: CONTROL CHARTS FOR ATTRIBUTES	125
CHAPTER 9: PROCESS CAPABILITY ANALYSIS	151
CHAPTER 10: ACCEPTANCE SAMPLING PLANS FOR ATTRIBUTES AND VARIABLES	177
CHAPTER 11: RELIABILITY	197
CHAPTER 12: EXPERIMENTAL DESIGN AND THE TAGUCHI METHOD	203

## PREFACE

This solutions manual is designed to accompany the text, “Fundamentals of Quality Control and Improvement.” To assist the student and the instructor in the teaching of the material, this manual includes solutions to the end-of-the chapter problems. The answers to the discussions questions are included too. Detailed explanation on the discussion questions may be found in the text and references. Associated figures and graphs on solutions to the problems are kept to a minimal. Most of the computations may be conducted using the Minitab software.

## **CHAPTER 1**

# **INTRODUCTION TO QUALITY CONTROL AND THE TOTAL QUALITY SYSTEM**

- 1-1. a) Call center that sells computers – possible definitions of quality that involve different variables/attributes could be as follows:
- i) Time to process customer order for computers – Time measured in hours.
  - ii) Total turn over time (starting with customer placement of order to customer receipt of computer) – Time measured in hours.
  - iii) Proportion of delivered orders that do not match customer requirements exactly.
  - iv) Proportion of orders that are fulfilled later than promised date.

Integration of the various measures to one measure is not easily attainable. Individual measures, as proposed, should not be difficult to measure.

- b) Emergency services for a city or municipality:

- i) Time to respond to an emergency – Time measured in minutes.
- ii) Time to process an emergency call – Measured in minutes and seconds.

Proposed measures readily obtainable.

- c) Company making semiconductor chips:

- i) Total manufacturing costs/10,000 chips.
- ii) Parts per million of defective chips.
- iii) Equipment and overhead costs/10,000 chips.

Measure iii) can be integrated into measure i). Measure ii) will influence manufacturing costs per conforming product. All of the measures should be easily obtainable.

- d) A hospital: Variety of measures exist based on patient satisfaction, effectiveness of services, efficiency of operations, rate of return to investors, and employee/staff/nurse/physician satisfaction.
- i) Proportion of in-patients satisfied with services.
  - ii) Length of stay of patients, by specified diagnosis related groups – Measured in days.
  - iii) Turn around time for laboratory tests, by type of test – Measured in hours/minutes.
  - iv) Annual or quarterly rate of return.

Most of the measures can be readily obtained. It may be difficult to integrate all such measures. However, some of these measures, such as annual rate of return, may serve as an integrated measure.

- e) Deliver mail/packages on a rapid basis:



$$Z_1 = \frac{21-17.50}{2} = 1.75; Z_2 = \frac{9-17.50}{2} = -4.25.$$

Using the standard normal distribution, the area above the UCL is 0.0401, while the area below the LCL is 0.0000. The area between the control limits is 0.9599, which is the probability of non-detection of the shift on a given sample.

The probability of detecting the shift by the second sample  
 $= 0.0401 + (0.9599)(0.0401) = 0.0401 + 0.0385 = 0.0786.$

d)  $ARL = 1/0.0401 = 24.94.$

acceptance and rejection lines are found based on a chosen level of producer's risk and acceptable mean life, and a chosen level of consumer's risk and a minimum mean life.

11-5. Reliability =  $\exp(-0.00006)(4000) = 0.7866$ . MTTF =  $1/\lambda = 1/0.00006 = 16666.667$  hrs.

$$\begin{aligned}\text{Availability} &= \frac{\mu}{\lambda + \mu} \\ &= \frac{0.004}{0.00406} = 0.985.\end{aligned}$$

11-6.  $R(t) = \exp(-\lambda(6000)) = 0.92$ . This yields  $\lambda = 0.13896 \times 10^{-4}/\text{hour}$ , or MTTF =  $1/\lambda = 71958.314$ .

11-7. It is given that  $\alpha = 300$  and  $\beta = 0.5$ .  $R(t) = \exp[-(500/300)^{0.5}] = 0.275$ . MTTF =  $300 \times \Gamma(1/0.5 + 1) = 600$ .

11-8. Reliability of the remote control unit =  $(0.9994)^{40} = 0.9763$ . Reliability of redesigned unit =  $(0.9994)^{25} = 0.9851$ .

11-9. We have,  $0.996 = \exp[-\lambda_s(3000)]$ , which yields  $\lambda_s = 0.1336 \times 10^{-5}/\text{hour}$ . The failure rate for each component is  $\lambda = \lambda_s/25 = 0.1336 \times 10^{-5}/25 = 0.53 \times 10^{-7}/\text{hour}$  or  $5.3/10^8$  hours. MTTF for each component is  $1/\lambda = 18.7125 \times 10^6$  hours.

11-10. System reliability is  $R_s = 1 - (1 - 0.93)(1 - 0.88)(1 - 0.95)(1 - 0.92) = 0.9999664$ .

11-11. For each component, MTTF = 3000 hours, yielding an individual failure rate  $\lambda = 1/3000 = 3.333 \times 10^{-4}/\text{hour}$ . Reliability of the subassembly is  $R_s = 1 - [1 - \exp(-(1/3000)2500)]^4 = 0.8978$ . For the subassembly, MTTF =  $3000 [1 + 1/2 + 1/3 + 1/4] = 6250$  hours. If the MTTF of the subassembly were to be 6600, we have  $6600 = (1/\lambda)[1 + 1/2 + 1/3 + 1/4]$ , yielding  $\lambda = 3.156 \times 10^{-4}/\text{hour}$ . So, for each component, MTTF = 3168 hours.

11-12. The reliability of the subsystem with components A and B is  $R_1 = 1 - (1 - 0.96)(1 - 0.92) = 0.9968$ . The reliability of the subsystem with components E, F, and G is  $R_2 = 1 - (1 - (0.95)(0.88))(1 - 0.90) = 0.9836$ . So, the system reliability is  $R_s = (0.9968)(0.94)(0.89)(0.9836) = 0.8202$ . To improve system reliability, try to improve the reliabilities of C and D.

11-13. For the subsystem with components A and B, MTTF =  $(1/0.0005)(1 + 1/2) = 3000$ . For the subsystem with components E, F, and G, MTTF =  $(1/0.0064)(1 + 1/2) = 234.375$ . Note that the failure rate of the subsystem with components E and F in series is  $0.0004 + 0.006 = 0.0064$ . Now, the system failure rate is:

$$\lambda_s = 1/3000 + 0.0003 + 0.0008 + 1/234.375 = 0.0057/\text{hour},$$

**TABLE 12-18. Experimental Layout and Calculations**

Outer array ( $L_8$ )		E	1	1	1	1	2	2	2	2				
		F	1	1	2	2	1	1	2	2				
		ExF	1	1	2	2	2	2	1	1				
		G	1	2	1	2	1	2	1	2				
		ExG	1	2	1	2	2	1	2	1				
Inner array ( $L_9$ )														
Run	A	B	C	D	Response Variable								$\bar{y}$	S/N
1	1	1	1	1	19.3	20.2	19.1	18.4	21.1	20.6	19.5	18.7	19.612	26.372
2	1	2	2	2	20.6	18.5	20.2	19.4	20.1	16.3	17.2	19.4	18.962	21.887
3	1	3	3	3	18.3	20.7	19.4	17.6	20.4	17.3	18.2	19.2	18.887	23.589
4	2	1	2	3	20.8	21.2	20.2	19.9	21.7	22.2	20.4	20.6	20.875	28.554
5	2	2	3	1	18.7	19.8	19.4	17.2	18.5	19.7	18.8	18.4	18.812	26.960
6	2	3	1	2	21.1	20.2	22.4	20.5	18.7	21.4	21.8	20.6	20.837	25.335
7	3	1	3	2	17.5	18.3	20.0	18.8	20.2	17.7	17.9	18.2	18.575	25.187
8	3	2	1	3	20.4	21.2	22.4	21.9	21.5	20.8	22.5	21.7	21.550	29.345
9	3	3	2	1	18.0	20.2	17.6	22.4	17.2	21.6	18.5	19.2	19.337	20.141

**Factor A – Average S/N**

Level 1:  $(26.372 + 21.887 + 23.589)/3 = 23.949$

Level 2:  $(28.554 + 26.960 + 25.335)/3 = 26.950$

Level 3:  $(25.187 + 29.345 + 20.141)/3 = 24.891$

**Factor A – Average response**

Level 1:  $(19.612 + 18.962 + 18.887)/3 = 19.154$

Level 2:  $(20.875 + 18.812 + 20.837)/3 = 20.175$

Level 3:  $(18.575 + 21.550 + 19.337)/3 = 19.821$

**Factor B – Average S/N**

Level 1:  $(26.372 + 28.554 + 25.187)/3 = 26.704$

Level 2:  $(21.887 + 26.960 + 29.345)/3 = 26.064$

Level 3:  $(23.589 + 25.335 + 20.141)/3 = 23.088$

**Factor B – Average response**

Level 1:  $(19.612 + 20.875 + 18.575)/3 = 19.687$