# **Contents**

List of Tables	•
List of Figures	x
Notes on Contributors	X
Abbreviations	xi
Preface	XXI
Treate	XX

#### Part One POLICY AND ORGANIZATION

### 1 The Quality Concept and Objectives

3

Frank Price

Quality: the latest buzzword? — Quality: Is it important? — Quality: leadership through commitment.

### 2 Quality Organization and Programmes

13

Don Harrison

Organizing for design quality — Formal organization for conformance quality — Vendor assurance — Informal organization for conformance quality — Establishing a quality programme.

## 3 Training for Quality

33

Darek Celinski

Improving the general quality of products and services — Improving specific aspects of quality — Training to use quality control and quality improvement systems — Conclusion.

#### Part Two QUALITY-RELATED BUDGETS AND COSTS

### 4 Quality-related Costs

57

John Edge and David J. Smith

Types of quality-related costs — Life cycle costs — Introducing a quality cost system — Further reading and references.

#### **Budgeting for Quality** 5

71

John Hunt

The historical and organizational background - Quality function: parametric or global estimates - Quality audits, assessments and reviews — Developing global estimates through synthesis — Further reading and references.

# Part Three QUALITY IN ENGINEERING AND DESIGN

#### 6 Design Objectives

103

Robin Plummer

Motivation - Get market intelligence - Clarify the express requirements - Evaluate the implied requirements - Clarify the express and implied requirements of related legislation — Choice of market sector – Design parameters – Quality assured design – Failure mode effect and criticality analysis - Feedback from production — The role of the Design Council — Design objectives.

#### National and International Engineering Design Standards 7

117

Trevor C. Ashton

Aims and principles of standardization — International standardization - National standards - Company standards - The value of standards - Further reading.

#### Statutory Provisions and Obligations 8

135

David J. Smith

The Health and Safety Executive — The Health and Safety at Work Act 1974 - Industrial hazards - Product liability - The role of quality management - Further reading.

#### **Quality Control of Design** 9

147

161

Robin Plummer

Definitions — Design teams — design interfaces — Design architecture Design methodology — Design review — Documentation change and configuration control — Conclusion.

#### Control of Engineering Changes and Design Modifications 10 Dennis Lock

The framework of control - Origins and timings of engineering changes and modifications — Class B changes — Emergency changes - Concessions and related procedures - Documents and records.

187

	Peter Foyer and Eric Wallbank Reliability: the crucial 'hygiene factor' — Methodologies for achieve reliability — Availability calculations — The prototype phase — service activities — Total life economics — Some conclusions References and further reading.	In
Pa	rt Four SOFTWARE QUALITY	
12	The Traditional Approach to Software Quality  David J. Smith  Software failures — Standards and guidelines — Traditional meth  Typical checklists — Further reading.	<b>21</b> 3
13	Quality Software through Formal Methods  David J. Smith  The software design cycle — Formal requirements methods — Stanlysis — Dynamic test tools — Metrics — Accreditation — Furt reading.	
Par	t Five — STATISTICAL METHODS FOR QUALITY CONTROL IN MANUFACTURING	1
14	An Introduction to Statistics for Quality Applications  David Newton  Data — Probability — Probability plotting — Further reading.	243
15	Process Capability David Newton Assignable and unassignable causes — Capability analysis.	87
16	Control Charts: 1. Shewhart Charts  David Newton  To interfere or to ignore? — Control chart for sample averages	05

Control of variation: the ranges chart — The average and range  $(\bar{x}, R)$  chart — Control charts for attributes — Software for statistical process

Basic cusum procedure — Cusum charts for variables — Summary and

## Part Six PARTICIPATIVE QUALITY IMPROVEMENT

recommendations for further reading.

control (SPC) — Further reading.

Control Charts: 2. Cusum Charts

# 18 Common and Special Problems

351

333

John Edge

David Newton

17

11 Product Reliability

Management-controllable variation — Worker-controllable variation — Managing organizations and people: when quality participation does not work — The need for statistical control techniques — Further reading.
--

# 19 Quality Improvement: Lessons for Management

375

John Edge

The approach to quality in the late 1980s - Quality management -Further reading.

# 20 Quality Improvement Activities and Techniques

405

John Edge

Involving people: quality and project improvement teams — Involving people: quality circles — The factory as a people-driven system — Statistical techniques — Participation: summary and conclusion — Further reading.

# Part Seven QUALITY PLANNING FOR MANUFACTURE

# 21 Just-in-time and Supplier Development

451

D. M. Lascelles and B. G. Dale

The JIT concept — The customer-supplier relationship — Starting supplier development — References and further reading.

# 22 Essential Quality Procedures David J. Smith and John Edge

469

The need for procedures — Hierarchy of procedures — Appendix 1: Example of a typical quality manual — Appendix 2: Example of a quality procedure — Appendix 3: A typical work instruction document

# 23 Quality Audits and Reviews

495

Gordon Staples

Reasons for audits — Types of audits — Internal audits — External audits — Audit reports and records — Follow up activities — Conclusion.

# Part Eight QUALITY FUNCTIONS IN MANUFACTURING

# 24 Quality of Bought-out Materials

537

R. Plummer

Auditing and assessing, techniques, theory and practice — Purchase specifications — Purchase orders — Goods inwards — Stores procedures — Vendor rating — Inspection.

### 25 Quality of Bought-out Services

547

R. Plummer

An understanding of the problem — The building blocks — Statistical process control — Incident reporting — Specifying the objectives to be obtained by the service — Auditing and assessing — Quality management of services such as maintenance contracts — Consultancy — Product and design support — Conclusion.

## 26 Inspection

559

R. Plummer

Definition of inspection — Reasons for inspection — Planning inspection — Fitness for purpose — How much to inspect — Seriousness classification — Inspection stamps — Errors in inspection — Cost of inspection.

### 27 Metrology

571

Jim Bell, National Physical Laboratory

Some definitions — The role of measurement in achieving quality — The role of Government — Measurement traceability and measurement assurance — The operation of NAMAS — Future measurement needs — International cooperation.

#### 28 Functional Testing

589

Geoffrey Leaver

Fitness for purpose — Measurement — Testing — Automation of testing — Test procedures — Further reading.

### 29 Managing Non-conformances

607

Ray H. Spencer

The pitfalls and the opportunities — Definitions — Specifications and standards — Subjectivity — Precedent — Attitude — Objectivity — Process — Costing — Controls — Improvements — Future designs — Further reading.

Index

631

# **Tables**

5.1	Total effort needed to meet IS09001 system requirements.	
5.2	Ratio of effort according to IS09001 system level.	82
5.3	Estimated costs for third-party certification to IS09001.	82
5.4	Typical effort needed for audits, assessments and reviews.	85
5.5	Estimating guidelines for quality activities.	88
5.6	and desired for quality activities	92
5.7	The effect of certification on increase.	95
7.1	The effect of certification on inspection and repair estimates.  The value of standards about 19 and	s. 98
	The value of standards, showing methods which may be adopted.	
14.1	Normal distribution table.	133
15.1	Measurement of process and the state of the	263
15.2		s.290
15.3	The state of Diviens variation affor a director a	291
15.4	variation values of feldlive precision index	297
16.1	Process capability data for 26 samples.	301
16.2	Date for 15 samples taken from a stable, "in control" process.	306
16.3	- sold of control life idelities for charte ton commit-	313
16.4	- able of control milli factors for charte for the day of a line in the charter of the charter o	314
16.5		316
17.1	Table of control limits for attribute charts.	325
17.2	The cusums of 10 process observations.	334
17.3	Cusum tabulation for sample averages.	335
17.4	Mask parameters for cusum range charts.	342
17.5	Cusum range chart data.	342
17.6	Data of Figure 16.6 expressed as cusums.	344
19.1	Table of flidsk parameters for custome for the	346
	Quality management maturity grid (from Crosby; Quality is Free, 1979).	010
28.1		391
	Samples size needed for the same level of testing for different total batch sizes	
	different total batch sizes.	594
		J/ <del>1</del>

# **Figures**

A quality control loop.	21
An informal quality control loop.	23
Example of a company training policy statement for a	
system using departmental trainers.	38
Example of a company training policy statement for	
project-based supervisory development.	44
Operating quality cost subtypes.	60
Availability and cost in manufacturing.	64
Availability and cost for the user.	65
Quality economics: curves illustrating contrast between	
costs to the supplier and to the customer.	72
Fitness for purpose in relation to various costs.	111
The BSI kitemark.	125
The BSI safety mark.	125
Engineering change request form.	165
	173
Form for production permit or concession.	175
Inspection Report form (with provision for the granting	
of a manufacturing concession).	177
A document index sheet.	181
A master record index or build schedule form.	184
Typical failure pattern.	190
A typical failure mode analysis worksheet.	194
Consequence analysis for a road vehicle stub axle.	196
Car cost over three years.	206
Total life cost model.	208
The bathtub curve.	214
Fault/error/failure.	216
Traditional software quality methods.	220
	An informal quality control loop. Example of a company training policy statement for a system using departmental trainers. Example of a company training policy statement for project-based supervisory development. Operating quality cost subtypes. Availability and cost in manufacturing. Availability and cost for the user. Quality economics: curves illustrating contrast between costs to the supplier and to the customer. Fitness for purpose in relation to various costs. The BSI kitemark. The BSI safety mark. Engineering change request form. Engineering query note. Form for production permit or concession. Inspection Report form (with provision for the granting of a manufacturing concession). A document index sheet. A master record index or build schedule form. Typical failure pattern. A typical failure mode analysis worksheet. Consequence analysis for a road vehicle stub axle. Car cost over three years. Total life cost model. The bathtub curve. Fault/error/failure.

12.4 Documentation hierarchy.	
12.5 Safety system configurations	221
13.1 Software Design Cycle	227
13.2 Distribution of time and costs in software production.	230
(a) Common approach (b) Full Live and costs in software production.	
(a) Common approach (b) Enlightened approach.  13.3 The three quality problems.	231
13.4 Amounted design.	233
	236
14.1 Table of breaking loads (kg) of 20 test specimens of aluminium wire.	
14.2 Number of breakdowns in a state	244
	211
	244
	245
- 110 Bata table.	247
14.7 Skewness. (a) Symmetrical (coefficient = 0);	250
(*) - obitively skewed (coefficient > 0), (-) >	
14.8 Kurtosis. (a) Leptokurtic (coofficient > 0)	255
14.9 CONTINUOUS probability distant.	256
	260
14.11 Standardized normal district	261
13.14 INUITIBLE distribution over 1	262
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	264
14.14 Sampling distribution of sample averages.  14.15 Sampling distribution of sample averages.	265
14.15 Sampling distribution of any averages.	266
	267
14.1/ Exponential diguitaria	268
14.10 Ine Welbull probability dans to a	269
14.18 The Weibull probability density function, $f(x)$ , for different values of the shape parameter $g(x)$ .	
14.19 Normal probability alar (1)	271
14.20 Discrete probability distribution.	275
14.21 Binomial distribution.	277
14.21 Binomial distribution with $n = 20$ , $p = 0.08$ . 14.22 Binomial distributions. (a) $n = 10$ , $p = 0.2$ ; (b) $n = 10$ , $p = 0.8$ ; (c) $n = 10$ , $p = 0.5$ ; (d) $n = 50$ , $n = 0.2$	279
p = 0.8: (c) $n = 10$ (a) $n = 10$ , $p = 0.2$ ; (b) $n = 10$	2/ )
p = 0.8; (c) $n = 10$ , $p = 0.5$ ; (d) $n = 10$ , $p = 0.2$ ; (b) $n = 10$ , 14.23 Example: normal approximation	280
14.23 Example: normal approximation to the binomial.  15.1 Relationship of process and specific responses.	283
15.1 Relationship of process and specification tolerance.  15.2 Relative precision.	292
15.3 Effects of non-new all	292 293
	493
skewed; (b) peaked (leptokurtic); (c) 'flat' (platykurtic).	290
i y marticy,	2 <del>4</del> 74

15.4	The meant (a) Stable process	
	average; (b) Average subject to random variation.	300
16.1	The effect of correcting the mean.	307
16.2	Averages control chart.	309
16.3	Averages chart with action and warning lines.	310
16.4	Examples of runs of consecutive points (a) run of points	510
	above target (samples 3 – 11); (b) run of consistently	
	reducing points.	311
16.5	A typical charting form as used in industry, containing	511
	data from Table 16.4.	318
16.6	Attributes chart (np chart for numbers nonconforming).	323
16.7	PRE control.	327
17.1	Cumulative sum chart (using data in Table 17.2).	336
17.2	A Shewhart chart (using the same data as Figure 17.1)	337
17.3	Effect of scale ratio on cusum plots for similar	337
	data. (a) compressed vertical scale (a large); (b)	
	expanded vertical scale (a small).	338
17.4	General form of decision mask.	339
17.5	Use of decision mask. (a) no decision; (b) upward	007
	change; (c) downward change.	340
17.6	Half mask for cusum ranges chart.	341
17.7	A cusum range chart (using data in Table 17.4).	343
17.8	Cusum chart for number non-conforming (data from	040
	Figure 16.6).	345
18.1	Organization for management by results.	352
19.1	Statement of quality policy.	388
19.2	The Deming circle.	394
19.3	The chain reaction.	397
19.4	Deming's 14 points for the transformation of industrial	577
	quanty.	398
19.5	The Deming philosophy.	399
19.6	Deming's seven deadly diseases of Western management.	400
20.1	Advantages and disadvantages of Taylorism and	100
	craftmanship (Hutchins, 1986).	410
20.2	Typical manufacturing company.	414
20.3	Checks and balances in manufacturing a product.	415
20.4	The new view of organizations.	424
20.5	Hardware design checklist.	427
20.6	Graphical representation of the Pareto principle.	429
20.7	Error classification of system interfaces	432
20.8	Ishikawa 4Ms fishbone diagram.	434

20.9 A worked Ishikawa diagram.	
20.10 Process analysis.	436
20.11 A worked process/cause analysis dia	437
20.12 of Callutracitional quality control	437
20.13 Innovation improves process manter	440
TOTAL THE PUBLIC MANUE ombodies the Distriction	443
22.1 Hierarchy of quality procedures.	445
23.1 Document hierarchy.	470
23.2 Internal audit schedule. Suggested content for	500
examining customer – supplier links.	
23.3 Internal audit schedule. Traditional audit schedule.	503
23.3 Internal audit schedule. Traditional style, department by department.	
23.4 Typical external audit programme.	503
23.5 An agenda for a closing meeting.	509
	527
27.1 Some organizations requiring measurement. 27.2 Traceability chain for length measurements. 27.3 How National Physics 12.	575
27.3 How National Physical Laboratory	576
27.3 How National Physical Laboratory measurements serve	
27.4 Factors affecting credibility.	577
27.5 Benefits of accreditation.	578
27.6 NAMAS fields of calibration and testing.	580
27.7 The prototype Tetraform.	581
27.8 The NPC-designed seems	584
27.8 The NPC-designed scanning optical interferometer. 28.1 System documentation.	585
29.1 The stages of non-conformation.	604
29.1 The stages of non-conformance management. 29.2 A typical non-conforming material report. 29.3 Documents were before the conformance management.	614
29.3 Documents used dependent	615
29.3 Documents used, dependent upon disposition. 29.4 A typical corrective action request form.	617
29.5 Example of an outling new form.	622
29.5 Example of an outline non-conformance management procedure.	_
	624