

# Contents

<i>List of Figures</i>	<i>xi</i>
<i>List of Charts</i>	<i>xv</i>
<i>List of Case Studies and Examples</i>	<i>xx</i>
<i>Reference of Charts</i>	<i>xxii</i>
<i>Preface</i>	<i>xxv</i>
<i>Acknowledgements</i>	<i>xxvii</i>
<i>Introduction</i>	<i>xxix</i>
The aim of the book	xxix
The structure of the book	xxx
How to use this book	xxxiii
<b>Part 1 An Introduction to the Theory of SPC</b>	<b>1</b>
1 Statistical process control	3
A word on processes ...	3
... And a word on variation	4
Some statistical measures	5
Why is understanding variation important to management?	7
Summary of the implications of process variation	10
Tampering (over-control) and its effect on performance	11
Control charts: the tool for understanding process performance	14
Dispelling some myths of SPC	16
Are there situations where SPC is not appropriate?	19
The relationship between SPC and Six Sigma	19
Summary	20
<b>Part 2 Exploding Data Analysis Myths</b>	<b>21</b>
2 Problems with monthly report tables, goals and quartiles	23
Introduction	23
Comparing pairs of numbers: a trap for the unwary	23
Death by numbers: the Saga of the monthly report	25
Who wins the prize? How not to compare regional performance statistics	27
Falsifying the data (and how to spot it): one result of setting targets	29
Querying the top quartile: Does it mean anything?	32
Summary	36

3	Exploring the mis-information in moving average charts	37
	<i>How they fail to respond to process changes, out-of-control points, trends and seasonality</i>	37
	Introduction	37
	Analysis	38
	Coping with seasonality and trends	43
	What moving averages actually monitor	44
	Summary	46
4	The problems with year-to-date figures	47
	Introduction	47
	Analysing YTD against plan	47
	Analysing this year's YTD against last year's YTD	50
	Why YTD charts do not work?	52
	Analysing the YTD average	53
	Comparing YTD and YTD average charts with control charts	54
	Summary	57

<b>Part 3</b>	<b>Putting SPC into Practice – The Cases</b>	<b>59</b>
	The sources of the case studies	59
	Control charts in the real worlds are not always so clear	60
	A word on chart formats	60
	Layout of and information in the case studies	61
	How to use the case studies?	62
5	Investigating variation in chemical concentration	63
	<i>How control charts were used to identify, investigate and prove the cause of fluctuations in results</i>	63
6	Improving examination results by analysing past performance and changing teaching methods	69
7	Demonstration that moving averages are poor indicators of true process performance	75
	<i>Monitoring the frequency of incidents</i>	75
8	Monitoring rare events	85
	<i>How a sudden but uncertain change in safety record was shown to be significant</i>	85
9	Comparing surgical complication rates between hospitals	91
10	Comparing the frequency of rare medical errors between centres	103
11	Metrics proposal for a training administration process	119
12	Reducing problems during borehole drilling	133
	<i>An example of monitoring two metrics on one chart</i>	133
13	Applying control charts to benchmarking in the drilling industry	141
14	Comparing the results of using different charts to analyse a set of data	153
	<i>An application to a batch production process</i>	153

15	Using control charts to analyse data with a trend	165
	<i>An application to cost management</i>	165
16	Identifying a decrease in the use of hospitality suites	175
17	Increase in reject rate at manufacture due to inspectors' fear of losing their jobs	187
18	Comparison of test results of production process	195
	<i>From a batch production process to identify a key cause of variation and that the process is not capable of producing within specification</i>	195
19	Categorising, de-seasonalising and analysing incident data using multivariate charts	213
20	Comparison of time-spent training across different facilities of an organisation	233

#### **Part 4 Implementing and Using SPC** **251**

21	Understanding and interpreting a control chart	253
	Introduction	253
	The normal distribution and the standard deviation	253
	The importance of the standard deviation	255
	Definition of a process in a state of control	256
	Interpreting a control chart	257
	Possible causes of control chart signals	260
	A note on the British and American control chart limits	260
	Summary	260
22	Selecting the appropriate control chart	263
	Introduction	263
	Variables or attributes data?	263
	Defects or defectives data?	266
	Equal or variable size samples?	268
	Choosing between the p and np chart	268
	Choosing between the c and u chart	269
	Choosing between $\bar{X}$ and $\bar{\bar{X}}$ charts	270
	Monitoring the mean and variability	271
	Use of X/MR charts in place of c, u, np and p charts	272
	Median and mid-range charts	272
	Median moving range charts	273
	Difference charts	273
	Z charts	274
	R or s charts?	274
	Cumulative sum (cusum) charts	274
	Selecting the most powerful chart	275
	Summary	275
23	Procedures and formula for drawing control charts	277
	Introduction	277
	Frequency of measurements	278
	Setting up charts	278

<b>Part I Variables charts</b>	<b>279</b>
The $\bar{X}$ /R charts	279
The s (standard deviation) chart	286
The median/R chart	287
Difference charts	289
Z charts	289
X/MR charts	290
Comments	293
Moving mean/moving range charts	293
<b>Part 2 Attributes charts</b>	<b>294</b>
p charts	294
np charts	299
c charts	300
u charts	302
Multivariate charts	304
24 An introduction to cusum (cumulative sum) charts	307
Introduction	307
Basic cusum charts	307
Weighted cusum charts	317
Summary	320
25 Issues for the more advanced SPC users	321
Introduction	321
The number of observations required to identify a process change (average run length)	321
Identifying and dealing with non-normally distributed data	326
Identifying and dealing with auto-correlation	328
Dealing with rare events data	329
Analysing data in groups and subgroups	330
Summary	336
26 Data analysis tools	337
Introduction	337
Histograms	337
Run charts	343
Bar charts	344
Ranked bar charts and Pareto charts	347
Check sheets	348
Scatter diagrams	349
Summary	351
27 Setting up a processing monitoring system	353
Introduction	353
Deciding what to chart	354
Creating a framework for measurement	357
Collecting, charting, analysing and deciding on appropriate action	359
A word on process improvement	364
Summary	366

28	Potential process performance metrics	367
	Introduction	367
	The power of different chart types	367
	A word on normalisation	368
	Sample size/frequency of measurement	369
	Outcome vs. process measures	369
	Generic metrics applicable to a wide variety of organisations and sectors	370
	Activity-specific metrics	371
	Industry-specific metrics	371

## **Part 5 Developing SPC Skills: Organisational Review Questions, Workshops and Exercises**

**375**

29	The Rods Experiment	377
	<i>A practical case study that can be used for training</i>	377
	Introduction	377
	Data generation and collection	379
	Check sheet	380
	Histogram	380
	Creating a run chart	382
	Completing the X/MR control chart	383
	Introducing the process change. Monitoring and analysing in real time	384
	Drawing and interpreting an $\bar{X}$ /range chart	387
	Drawing and interpreting a cusum chart	389
	The difference chart	391
	The Z chart	392
	Comments	394
30	Organisational review questions, workshops and exercises	395
	Reviewing what is happening in your organisation today	395
	Selecting performance indicators	396
	Selecting the correct control chart	397
	Data workshops and case studies	399
	Discussions	404
31	Answers to exercises in Chapter 30	405
	Selecting the right control chart	405
	Control chart interpretation	407
	Downtime workshop	407
	Repairs workshop	407
	Days taken to raise invoices workshop	410
	Blending workshop – Part 1	410
	Rejected tenders	414
	Surgical complications	415



<b>Part 6</b>	<b>An Introduction to Six Sigma</b>	<b>421</b>
	<b>Luis Miguel Giménez</b>	
32	An Introduction to Six Sigma	423
	Introduction	423
	What is Six Sigma?	423
	The basis of Six Sigma	424
	The three key roles in Six Sigma: Management, Specialists and Staff	424
	The meaning of quality in Six Sigma	424
	The two key measures in Six Sigma	425
	Selecting improvement projects	425
	The Six Sigma improvement methodology	425
	<i>Bibliography, references and other resources</i>	<b>439</b>
	<i>Experimental Resources</i>	<b>441</b>
	<i>Appendix A</i>	<b>443</b>
	<i>Glossary of terms and symbols</i>	<b>445</b>
	<i>Index</i>	<b>455</b>