

Contents

Preface	iii
Forethoughts	xi
1 Hazard identification and assessment	1
1.1 Introduction	1
1.2 A note on nomenclature	5
1.3 Legal requirements	7
2 Hazard and operability studies (Hazop)	9
2.1 What is a Hazop?	9
2.2 Who carries out a Hazop, and what should be recorded?	20
2.3 When is a Hazop carried out and how long does it take?	26
2.4 Some points to watch during Hazop	27
2.5 An example of a Hazop	34
2.6 Could a computer carry out a Hazop?	37
2.7 The limitations of Hazop	41
2.8 'Do we need to Hazop this plant?' 'It is only a simple project' or 'It is similar to the last one'	47
2.9 The use of quantitative methods during Hazop	50
2.10 The use of Hazop in other industries	51
2.11 Other methods of identification	54
2.12 Auditing Hazop	56
2.13 Conclusion	56
Appendix to Chapter 2 – Some accidents that could have been prevented by Hazops	61
A2.1 Reverse flow	61
A2.2 Bhopal	62
A2.3 A fire in a water sump	63
A2.4 A protective device that did not work	63
A2.5 Services and modifications – two neglected areas	64
A2.6 A computer-controlled batch reaction	65

A2.7 Abbeystead – an explosion in a water pumping station	67
A2.8 The Sellafield leak	67
A2.9 Formation of separate layers	71
A2.10 The need for different sorts of knowledge	72
A2.11 An incident from another industry	75
3 Hazard analysis (Hazan)	77
3.1 Objective	77
3.2 Why do we want to apply numerical methods to safety problems?	78
3.3 The stages of Hazan	80
3.4 Choosing targets or criteria	83
3.5 Estimating how often an incident will occur	105
3.6 Pitfalls in Hazan	120
3.7 The man or woman in the middle	130
3.8 Examples of Hazan	133
3.9 A summary of the main sources of error in Hazan	143
3.10 A final note	143
Appendix to Chapter 3 – Belt and braces	148
4 A manager's guide to hazard analysis	152
4.1 Introduction	152
4.2 Arithmetic, algebra and units	153
4.3 The model	154
4.4 The unforeseen hazards	158
4.5 The assumptions	159
4.6 Data	160
4.7 Human reliability	162
4.8 The recommendations	163
4.9 Comparison with experience	164
4.10 Closed shop or open shop?	165
5 Objections to Hazop and Hazan	168
5.1 Objections to Hazop	168
5.2 Technical objections to Hazan	169
5.3 Popular objections to Hazan	181
5.4 The regulator's view	187
Appendix to Chapter 5 – Limitations on the application of quantitative methods to railway travel	193
6 Sources of data and confidence limits	195
6.1 Data banks and data books	195

6.2	If failure has never occurred	196
6.3	Confidence limits	196
6.4	Data on mechanical equipment may be data on people	197
6.5	Chaos	198
6.6	Pitfalls in extrapolating data	199
7	The history of Hazop and Hazan	203
7.1	Hazop	203
7.2	Hazan	207
Conclusions		213
Addendum 1 – An atlas of safety thinking		214
Addendum 2 – Myths of Hazop and Hazan		218
Index		224