

- Chapter 1 The production and distribution process p. 1
- 1.1 Process Efficiency p. 2
- 1.1.1 Criteria for assessing efficiency p. 2
- 1.1.2 Improving efficiency p. 2
- 1.1.3 Cost measurement and pitfalls p. 3
- 1.2 Work and Its Value p. 4
- 1.2.1 Mechanization and productivity p. 4
- 1.2.2 Value added and its measurement p. 4
- 1.3 Manufacturing and Service Industries p. 5
- 1.3.1 Conversion processes p. 5
- 1.3.2 Factor influencing the efficiency of industries p. 5
- 1.3.3 Factors affecting demand p. 6
- 1.4 The Systems Approach p. 6
- 1.5 Impact of Efficiency on Resources p. 8
- 1.5.1 Efficiency of utilization p. 8
- 1.5.2 Efficiency and non-renewable resources p. 9
- 1.6 Maintenance--The Questions to Address p. 8
- 1.7 Chapter Summary p. 9
- Chapter 2 Process functions p. 11
- 2.1 The Functional Approach p. 11
- 2.2 Functional Block Diagrams (FBD) p. 13
- 2.3 Failure Mode and Effect Analysis (FMEA) p. 17
- 2.4 Effective Planning p. 19
- 2.5 Prevention of Failures or Mitigation of Consequences? p. 19
- 2.6 Chapter Summary p. 20
- Chapter 3 Reliability engineering for the maintenance practitioner p. 23
- 3.1 Failure Histograms p. 23
- 3.2 Probability Density Function p. 25
- 3.3 Mortality p. 26
- 3.4 Hazard Rates and Failure Patterns p. 27
- 3.5 The Trouble with Averages p. 30
- 3.6 The Special Case of the Constant Hazard Rate p. 32
- 3.7 Availability p. 33
- 3.8 Mean Availability p. 34
- 3.9 The Weibull Distribution p. 41
- 3.10 Deterministic and Probabilistic Distributions p. 43
- 3.11 Age-Exploration p. 44
- 3.12 Chapter Summary p. 44
- Chapter 4 Failure, its nature and characteristics p. 57
- 4.1 Failure p. 57
- 4.1.1 Failure - a systems approach p. 57
- 4.1.2 Critical and degraded failures p. 58
- 4.1.3 Evident failures p. 58
- 4.1.4 Hidden failures p. 58
- 4.1.5 Incipient failures p. 59
- 4.2 The Operating Context p. 59

- 4.3 The Feedback Control Model p. 61
- 4.4 Life Without Failure p. 61
- 4.5 Capability and Expectation p. 62
- 4.6 Incipency p. 64
- 4.7 Limits to the Application of Condition Monitoring p. 69
- 4.8 Age Related Failure Distribution p. 69
- 4.9 System Level Failures p. 70
- 4.10 Human Failures p. 70
- 4.11 Chapter Summary p. 73
- Chapter 5 Life cycle aspects of risks in process plants p. 77
- 5.1 Design Quality p. 79
  - 5.1.1 Marketing inputs p. 80
  - 5.1.2 Operability p. 80
  - 5.1.3 Maintainability p. 81
  - 5.1.4 Reliability p. 84
- 5.2 Risks During Construction p. 88
- 5.3 The Pre-Commissioning and Commissioning Phases p. 88
- 5.4 Planning of Maintenance Work p. 89
- 5.5 The Operational Phase p. 89
  - 5.5.1 Steady state operations p. 89
  - 5.5.2 Competence and motivation p. 90
- 5.6 Modifications to Plant and Change Control p. 90
- 5.7 Maintenance Costs p. 92
  - 5.7.1 Failure rates and their impact p. 93
  - 5.7.2 Maintenance cost drivers p. 93
  - 5.7.3 Maintenance cost drivers--shutdowns (turnarounds) p. 95
  - 5.7.4 Breakdowns and Trips p. 97
- 5.8 End of Life Activities p. 97
- 5.9 Chapter Summary p. 97
- Chapter 6 Process plant shutdowns p. 99
- 6.1 Factors Affecting Operating Run Lengths p. 99
  - 6.1.1 Loss of integrity p. 99
  - 6.1.2 Loss of efficiency p. 100
  - 6.1.3 Incorporation of plant changes p. 101
- 6.2 Risks Related to Planned Shutdowns p. 101
- 6.3 Planning p. 102
- 6.4 Safety and Environmental Hazards p. 102
  - 6.4.1 Traffic safety p. 103
  - 6.4.2 Waste management p. 103
  - 6.4.3 Hazardous materials management p. 103
  - 6.4.4 Fire and evacuation drills p. 104
  - 6.4.5 Tool box meetings p. 104
  - 6.4.6 Emergency communication conventions p. 104
  - 6.4.7 Training p. 104
  - 6.4.8 Rescue planning p. 105
  - 6.4.9 Medical support p. 106

- 6.4.10 Reference booklet p. 106
- 6.5 Work Scope and Associated Risks p. 106
- 6.5.1 Freezing of work scope p. 106
- 6.5.2 Work scope changes during the shutdown p. 106
- 6.6 Quality p. 107
- 6.6.1 Quality targets and performance indicators p. 107
- 6.6.2 Competence p. 108
- 6.6.3 Records and traceability--positive material identification p. 108
- 6.7 Organization p. 108
- 6.8 Execution p. 109
- 6.8.1 Safety aspects p. 109
- 6.8.2 Competence p. 110
- 6.8.3 Overlaps and interference p. 110
- 6.8.4 Productivity p. 110
- 6.8.5 Closing-up procedures p. 111
- 6.8.6 Area clean-up p. 111
- 6.9 Specialized Equipment Overhauls p. 112
- 6.10 Cost Control p. 112
- 6.11 Communication p. 112
- 6.12 Contractors p. 113
- 6.13 Shutdown Reports p. 113
- 6.14 Post-Shutdown Review p. 114
- 6.15 Chapter Summary p. 114
- Chapter 7 Facets of risk p. 117
- 7.1 Understanding Risk p. 117
- 7.2.3 Control of situation p. 120
- 7.2 Descriptive or Qualitative Risk p. 118
- 7.2.1 Framing effects p. 118
- 7.2.2 The influence of choice p. 119
- 7.2.4 Delayed effects on health p. 121
- 7.2.5 Voluntary risks p. 121
- 7.2.6 Risks posed by natural phenomena p. 121
- 7.2.7 Subjectivity p. 122
- 7.2.8 Morality p. 122
- 7.2.9 Dreaded consequences p. 122
- 7.3 Factors Influencing Decision-Making p. 122
- 7.4 The Quantitative Aspects of Risk p. 123
- 7.4.1 Failure p. 123
- 7.4.2 Exposure p. 124
- 7.5 Chapter Summary p. 125
- Chapter 8 The escalation of events p. 127
- 8.1 Learning from Disasters p. 127
- 8.1.4 Milford-Haven refinery explosion p. 134
- 8.1.1 The Challenger space shuttle explosion p. 128
- 8.1.2 The Piper Alpha Explosion p. 128
- 8.1.3 King's Cross underground station fire p. 133

- 8.1.5 Bhopal p. 134
- 8.1.6 Chernobyl p. 134
- 8.2 Hindsight Is 20-20 Vision p. 135
- 8.3 Foresight-Can We Improve It? p. 137
- 8.4 Event Escalation Model p. 138
- 8.5 Damage Limitation Model p. 142
- 8.6 Failure of Barriers p. 143
- 8.7 Event Escalation Relationship p. 144
- 8.8 Evaluating Test Frequencies p. 145
- 8.9 Incipency Period p. 146
- 8.10 Chapter Summary p. 146
- Chapter 9 Maintenance p. 149
- 9.1 Maintenance at the Activity Level - An Explanation of Terminology p. 151
- 9.1.1 Types of maintenance--terminology and application rationale p. 151
- 9.1.2 Applicable maintenance tasks p. 152
- 9.1.3 How much preventive maintenance should we do? p. 153
- 9.2 The Raison D'etre of Maintenance p. 153
- 9.3 The Continuous Improvement Cycle p. 156
- 9.3.1 Planning p. 156
- 9.3.2 Scheduling p. 158
- 9.3.3 Execution p. 159
- 9.3.4 Analysis p. 161
- 9.4 System Effectiveness and Maintenance p. 163
- 9.4.1 Testing of pressure relief valves p. 163
- 9.4.2 Duty-standby operation p. 168
- 9.4.3 End-to-end testing of control loops p. 170
- 9.5 Chapter Summary p. 172
- Chapter 10 Risk reduction p. 177
- 10.1 Frequency or Severity? p. 177
- 10.2 Reliability Block Diagrams and Mathematical Modeling p. 179
- 10.3 Hazard and Operability Studies p. 182
- 10.4 Fault Tree Analysis (FTA) p. 182
- 10.5 Root Cause Analysis p. 183
- 10.6 Total Productive Maintenance p. 187
- 10.7 Reliability-Centred Maintenance p. 188
- 10.7.1 Functional block diagrams p. 189
- 10.7.2 Failure mode and effect analysis p. 189
- 10.7.3 Failure characteristic analysis (FCA) p. 190
- 10.7.4 Applicable and effective maintenance tasks p. 193
- 10.7.5 Cost-effective maintenance tasks p. 197
- 10.7.6 Task selection p. 197
- 10.7.7 Preventive maintenance routines p. 198
- 10.7.8 Structural and Zonal RCM Analysis p. 200
- 10.8 Compliance and Risk p. 200
- 10.9 Reducing Perceived Risks p. 200
- 10.9.1 David and Goliath scenarios p. 201

- 10.9.2 Influence of perceptions p. 202
- 10.9.3 Public goodwill p. 202
- 10.10 Chapter Summary p. 202
- Chapter 11 Information for decision making p. 205
- 11.1 Work and the Generation of Data p. 205
- 11.2 The Collection of Quantitative Data p. 206
- 11.3 The Collection of Maintenance Data p. 207
- 11.3.1 Failure reduction p. 207
- 11.3.2 Reducing the consequence of failures p. 208
- 11.3.3 Cost data p. 209
- 11.4 The Collection of Qualitative Data p. 211
- 11.5 Errors in Data Collection p. 212
- 11.6 Fixed Format Data Collection p. 213
- 11.7 Obtaining Information from Data p. 215
- 11.8 Decision Support p. 216
- 11.9 Procedures p. 217
- 11.10 Business Process Management p. 217
- 11.11 Chapter Summary p. 217
- Chapter 12 Improving system effectiveness p. 225
- 12.1 System Effectiveness p. 225
- 12.2 Integrity and System Effectiveness p. 227
- 12.3 Managing Hazards p. 227
- 12.3.1 Identification of hazards p. 227
- 12.3.2 Control of hazards p. 227
- 12.3.3 Minimization of severity of incidents p. 228
- 12.4 Reducing Risks - Some Practical Steps p. 228
- 12.4.1 Appreciating life cycle risks p. 228
- 12.4.2 Tools and techniques p. 228
- 12.4.3 The process of carrying out maintenance p. 229
- 12.4.4 Managing maintenance costs p. 229
- 12.8 Chapter Summary p. 231
- 12.5 Communicating Risk Reduction Plans p. 229
- 12.6 Bridging the Chasm Between Theory and Practice p. 230
- 12.7 Maintenance as an Investment p. 230
- 12.9 Book Summary p. 231
- Glossary p. 239