# CONTENTS

List of Figures                                  xvii  
List of Tables                                   xviii 
Acronyms and Abbreviations                       xx    
Glossary                                         xxviii  
Acknowledgments                                  xxxii   
Files on the Web                                 xxxiv   
Preface                                          xxxvi   

## 1 INTRODUCTION

1.1 Background and Scope                        2  
1.2 Why Integrating Process Safety is Important 3  
1.3 What Type of Projects Are Included?         5  
1.4 Project Life Cycle                          7  
1.5 Relationship to Other Programs              10  
1.6 Structure of this Document                  13  

## 2 PROJECT MANAGEMENT CONCEPTS AND PRINCIPLES

2.1 Common Principles and Structure             16  
   2.1.1 Statement of Requirements               16  
   2.1.2 Project Scope                          17  
   2.1.3 Basis of Design                        17  
   2.1.4 Project Budget                         18  
   2.1.5 Project Plan                           18  
   2.1.6 Project Life Cycle                     19  
2.2 Project Management                         20  
2.3 Project Governance                          21  
2.4 Types of Project                           22  
   2.4.1 Greenfield Projects                    22  
   2.4.2 Brownfield Projects                    22
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.3  Retrofit / Expansion Projects</td>
<td>23</td>
</tr>
<tr>
<td>2.4.4  Control System Upgrade Projects</td>
<td>24</td>
</tr>
<tr>
<td>2.4.5  Demolition Projects</td>
<td>24</td>
</tr>
<tr>
<td>2.4.6  Management of Change Projects</td>
<td>24</td>
</tr>
<tr>
<td>2.4.7  Mothballing Projects</td>
<td>25</td>
</tr>
<tr>
<td>2.4.8  Re-Commissioning Projects</td>
<td>25</td>
</tr>
<tr>
<td>2.4.9  Restarting a Project</td>
<td>25</td>
</tr>
<tr>
<td>2.4.10 Post-Incident Projects</td>
<td>26</td>
</tr>
<tr>
<td>2.5    Project Organization</td>
<td>26</td>
</tr>
<tr>
<td>2.5.1  Pre-Project Team</td>
<td>26</td>
</tr>
<tr>
<td>2.5.2  Typical Project Team</td>
<td>27</td>
</tr>
<tr>
<td>2.5.3  Unit Based Team</td>
<td>28</td>
</tr>
<tr>
<td>2.5.4  Equipment Based Team</td>
<td>28</td>
</tr>
<tr>
<td>2.5.5  Site Based Team</td>
<td>28</td>
</tr>
<tr>
<td>2.5.6  Small Projects</td>
<td>28</td>
</tr>
<tr>
<td>2.5.7  Roles and Responsibilities</td>
<td>29</td>
</tr>
<tr>
<td>2.6    Strategies for Implementation</td>
<td>32</td>
</tr>
<tr>
<td>2.6.1  Contractor Selection</td>
<td>35</td>
</tr>
<tr>
<td>2.6.2  Engineering Only</td>
<td>36</td>
</tr>
<tr>
<td>2.6.3  Engineering and Procurement</td>
<td>36</td>
</tr>
<tr>
<td>2.6.4  Engineering, Procurement and Construction</td>
<td>36</td>
</tr>
<tr>
<td>2.6.5  Operation</td>
<td>37</td>
</tr>
<tr>
<td>2.6.6  Contractor Oversight</td>
<td>37</td>
</tr>
<tr>
<td>2.7    Risk Management</td>
<td>38</td>
</tr>
<tr>
<td>2.8    Project Controls</td>
<td>40</td>
</tr>
<tr>
<td>2.8.1  Planning and Progress</td>
<td>40</td>
</tr>
<tr>
<td>2.8.2  Estimates, Budgets and Cost Control</td>
<td>41</td>
</tr>
<tr>
<td>2.8.3  Reporting</td>
<td>41</td>
</tr>
<tr>
<td>2.8.4  Metrics</td>
<td>41</td>
</tr>
<tr>
<td>2.8.5  Action Tracking</td>
<td>42</td>
</tr>
<tr>
<td>2.8.6  Change Management</td>
<td>42</td>
</tr>
<tr>
<td>2.9    Other Considerations</td>
<td>43</td>
</tr>
<tr>
<td>2.9.1  Materials Management</td>
<td>43</td>
</tr>
<tr>
<td>2.9.2  Quality Management</td>
<td>43</td>
</tr>
<tr>
<td>2.9.3  Lessons Learned</td>
<td>43</td>
</tr>
<tr>
<td>2.9.4  Post-Project Close-Out</td>
<td>44</td>
</tr>
<tr>
<td>2.10  Stage Gate Reviews</td>
<td>44</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

## 3  FRONT END LOADING 1

3.1 Preliminary Hazard Identification 48
3.2 Preliminary Inherently Safer Design Review 49
3.3 Concept Risk Analysis 51
3.4 Other Activities 52
  3.4.1 Process Safety and EHS Plan 52
  3.4.2 Risk Register 52
  3.4.3 Action Tracking 52
3.5 Stage Gate Review 53
3.6 Summary 54

## 4  FRONT END LOADING 2

4.1 Evaluation of Development Options 58
  4.1.1 Hazard Identification 59
  4.1.2 Preliminary Inherently Safer Design Review 59
  4.1.3 Concept Risk Analysis 60
  4.1.4 Selection of the Development Option 60
4.2 Further Definition of the Selected Option 63
  4.2.1 Design Hazard Management Process 63
  4.2.2 Preliminary Inherently Safer Design (ISD) 68
  4.2.3 Hazard Identification and Risk Analysis (HIRA) 68
  4.2.4 Engineering Design Regulations, Codes, and Standards 69
  4.2.5 Design Philosophies/Strategies 70
  4.2.6 Preliminary Facility Siting Study 71
  4.2.7 Preliminary Fire and Explosion Analysis 72
  4.2.8 Transportation Studies 72
  4.2.9 Preliminary Blowdown and Depressurization Study 74
  4.2.10 Preliminary Fire & Gas Detection Study 74
  4.2.11 Preliminary Fire Hazard Analysis 74
  4.2.12 Preliminary Firewater Analysis 75
  4.2.13 Preliminary Security Vulnerability Analysis 75
  4.2.14 Other Engineering Design Considerations 75
4.3 Other Activities 76
  4.3.1 EHS and Process Safety Plan 76
  4.3.2 Risk Register 76
  4.3.3 Action Tracking 76
  4.3.4 HIRA Strategy 76
  4.3.5 Documentation 77
5 FRONT END LOADING 3

5.1 Evaluation of Development Options 82
5.2 Further Definition of the Selected Option 82
  5.2.1 Design Hazard Management Process 84
  5.2.2 Inherently Safer Design Optimization 85
  5.2.3 Facility Siting and Layout 86
  5.2.4 Refine Design Safety Measures 93
  5.2.5 Set Performance Standards 94
  5.2.6 Hazard Identification and Risk Analysis (HIRA) 95
  5.2.7 Safety Assessments 102
  5.2.8 Re-Evaluate Major Accident Risk 113
  5.2.9 Finalize Important Safety Decisions 113
  5.2.10 Finalize Basis of Design 113
5.3 Other Engineering Considerations 114
  5.3.1 Asset Integrity Management 114
  5.3.2 Quality Management 115
  5.3.3 Contractor Selection 115
  5.3.4 Brownfield Developments 116
5.4 Other Activities 116
  5.4.1 EHS and Process Safety Plans 116
  5.4.2 Risk Register 116
  5.4.3 Action Tracking 116
  5.4.4 Change Management 116
  5.4.5 Documentation 117
  5.4.6 Preparation for Project Execution 117
5.5 Case for Safety 119
5.6 Stage Gate Review 119
5.7 Summary 120

6 DETAILED DESIGN STAGE 121

6.1 Detailed Design 124
  6.1.1 Design Hazard Management Process 124
  6.1.2 Inherently Safer Design Optimization 125
  6.1.3 Site Layout 126
  6.1.4 Design Safety Measures 126
## 6.1 Procurement and Asset Integrity Management

6.1.5 Set Performance Standards 127  
6.1.6 Hazard Identification and Risk Analysis (HIRA) 127  
6.1.7 Safety Assessments 128  
6.1.8 Re-Evaluate Major Accident Risk 129  
6.1.9 Other Design Reviews 129

6.2 Procurement 130

6.3 Asset Integrity Management 131

6.4 Other Process Safety Activities 132

6.4.1 Case For Safety 132

6.5 Other Project Activities 133

6.5.1 EHS and Process Safety Plans 133  
6.5.2 Risk Register 134  
6.5.3 Action Tracking 134  
6.5.4 Change Management 134  
6.5.5 Documentation 135  
6.5.6 Constructability 136  
6.5.7 Contractor Selection 137

6.6 Preparation for Construction 138

6.7 Preparation for Pre-Commissioning, Commissioning, and Startup 139

6.8 Stage Gate Review 140

6.9 Summary 141

## 7 CONSTRUCTION

7.1 Planning 146

7.2 Pre-Mobilization 147

7.3 Mobilization 149

7.4 Execution 150

7.4.1 Procurement 151  
7.4.2 Fabrication 151  
7.4.3 Safety Culture 151  
7.4.4 Workforce Involvement 152  
7.4.5 Stakeholder Outreach 152  
7.4.6 Contractor Management 152  
7.4.7 Transportation 153  
7.4.8 Equipment and Materials Handling 153  
7.4.9 Hazard Evaluation 154  
7.4.10 Engineering Design 156
7.4.11 Safe Work Practices 157
7.4.12 Operating, EHS and Process Safety Procedures 159
7.4.13 Training and Competence Assurance 159
7.4.14 Asset Integrity Management 160
7.4.15 Change Management 161
7.4.16 Emergency Response 162
7.4.17 Incident Investigation 163
7.4.18 Auditing 164
7.4.19 Performance Measurement 164
7.4.20 Operations Case for Safety 165
7.4.21 Pre-Commissioning 166
7.4.22 Mechanical Completion 170
7.4.23 Documentation 171

7.5 Other Project Activities 172
7.5.1 EHS and Process Safety Plans 172
7.5.2 Risk Register 172
7.5.3 Action Tracking 172
7.5.4 General Construction Management 172

7.6 De-Mobilization 173
7.7 Preparation for Commissioning and Startup 174
7.8 Final Evaluation and Close-out 175
7.9 Stage Gate Review 175
7.10 Summary 177

8 QUALITY MANAGEMENT 178
8.1 Design/Engineering 183
8.2 Procurement 186
8.3 Fabrication 187
8.4 Receipt 189
8.5 Storage and Retrieval 190
8.6 Construction and Installation 191
8.7 Operation 193
8.8 Documentation 194
8.9 Summary 194

9 COMMISSIONING AND STARTUP 196
9.1 Preparation 199
9.1.1 Planning 199
9.1.2 Safety 201
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.2</td>
<td>Operational Readiness</td>
<td>202</td>
</tr>
<tr>
<td>9.2.1</td>
<td>Pre-Startup Stage Gate Review</td>
<td>203</td>
</tr>
<tr>
<td>9.2.2</td>
<td>Operational Readiness Review</td>
<td>204</td>
</tr>
<tr>
<td>9.2.3</td>
<td>Start-Up Efficiency Review</td>
<td>207</td>
</tr>
<tr>
<td>9.3</td>
<td>Commissioning</td>
<td>208</td>
</tr>
<tr>
<td>9.3.1</td>
<td>Equipment Testing</td>
<td>209</td>
</tr>
<tr>
<td>9.3.2</td>
<td>Commissioning Procedures</td>
<td>211</td>
</tr>
<tr>
<td>9.4</td>
<td>Startup</td>
<td>213</td>
</tr>
<tr>
<td>9.4.1</td>
<td>Preparation for Startup</td>
<td>213</td>
</tr>
<tr>
<td>9.4.2</td>
<td>Calibration of Instruments and Analyzers</td>
<td>213</td>
</tr>
<tr>
<td>9.4.3</td>
<td>Startup with Process Chemicals/Fluids</td>
<td>214</td>
</tr>
<tr>
<td>9.5</td>
<td>Common Process Safety Elements</td>
<td>215</td>
</tr>
<tr>
<td>9.5.1</td>
<td>Hazard Evaluation</td>
<td>215</td>
</tr>
<tr>
<td>9.5.2</td>
<td>Safe Work Practices</td>
<td>216</td>
</tr>
<tr>
<td>9.5.3</td>
<td>Procedures</td>
<td>217</td>
</tr>
<tr>
<td>9.5.4</td>
<td>Training and Competence Assurance</td>
<td>217</td>
</tr>
<tr>
<td>9.5.5</td>
<td>Management of Change</td>
<td>218</td>
</tr>
<tr>
<td>9.5.6</td>
<td>Incident Investigation</td>
<td>219</td>
</tr>
<tr>
<td>9.5.7</td>
<td>Emergency Response</td>
<td>220</td>
</tr>
<tr>
<td>9.5.8</td>
<td>Auditing</td>
<td>221</td>
</tr>
<tr>
<td>9.5.9</td>
<td>Documentation</td>
<td>221</td>
</tr>
<tr>
<td>9.5.10</td>
<td>Performance Measurement</td>
<td>222</td>
</tr>
<tr>
<td>9.6</td>
<td>Other Project Activities</td>
<td>222</td>
</tr>
<tr>
<td>9.6.1</td>
<td>EHS and Process Safety Plans</td>
<td>222</td>
</tr>
<tr>
<td>9.6.2</td>
<td>Risk Register</td>
<td>223</td>
</tr>
<tr>
<td>9.6.3</td>
<td>Action Tracking</td>
<td>223</td>
</tr>
<tr>
<td>9.7</td>
<td>Performance Test Runs</td>
<td>223</td>
</tr>
<tr>
<td>9.8</td>
<td>Handover</td>
<td>224</td>
</tr>
<tr>
<td>9.9</td>
<td>Preparation for Ongoing Operation</td>
<td>225</td>
</tr>
<tr>
<td>9.10</td>
<td>Project Close-Out</td>
<td>226</td>
</tr>
<tr>
<td>9.10.1</td>
<td>Close Out Report</td>
<td>226</td>
</tr>
<tr>
<td>9.10.2</td>
<td>Post-Project Evaluation</td>
<td>226</td>
</tr>
<tr>
<td>9.11</td>
<td>Summary</td>
<td>227</td>
</tr>
</tbody>
</table>

#### 10 OPERATION

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1</td>
<td>Process Safety Management System</td>
<td>231</td>
</tr>
<tr>
<td>10.1.1</td>
<td>Process Safety Culture</td>
<td>233</td>
</tr>
<tr>
<td>10.1.2</td>
<td>Compliance with Standards</td>
<td>233</td>
</tr>
</tbody>
</table>
10.1.3 Process Safety Competency 233
10.1.4 Workforce Involvement 234
10.1.5 Stakeholder Outreach 234
10.1.6 Process Knowledge Management 234
10.1.7 Hazard Identification and Risk Analysis 234
10.1.8 Operating Procedures 235
10.1.9 Safe Work Practices 235
10.1.10 Asset Integrity and Reliability 236
10.1.11 Contractor Management 238
10.1.12 Training and Performance Assurance 239
10.1.13 Management of Change 239
10.1.14 Operational Readiness 239
10.1.15 Conduct of Operations 240
10.1.16 Emergency Management 240
10.1.17 Incident Investigation 240
10.1.18 Measurement and Metrics 241
10.1.19 Auditing 242
10.1.20 Management Review and Continuous Improvement 242
10.1.21 EHS and Process Safety Procedures 243

10.2 Other Project Activities 243
10.2.1 EHS and Process Safety Plans 243
10.2.2 Risk Register 243
10.2.3 Action Tracking 243

10.3 Technical Support 243
10.4 Performance Test Runs 244
10.5 Operation Stage Gate Review 244
10.6 Post-Operational Review 245
10.7 Project Close-Out 246
10.8 Summary 246

11 END OF LIFE 247
11.1 Design for Decommissioning 249
11.2 Planning for Decommissioning 250
11.2.1 Engineering Survey 251
11.2.2 Hazard Evaluation 254
11.2.3 Hazardous Materials 254
11.2.4 Process Safety Plan 255
11.2.5 Utilities 255
11.4.1 Deconstruction
11.4.2 Demolition

11.5 Process Safety for Decommissioning
11.5.1 Contractor Management
11.5.2 Safety Culture
11.5.3 Workforce Involvement
11.5.4 Stakeholder Outreach
11.5.5 Hazard Evaluation
11.5.6 Safe Work Practices
11.5.7 EHS and Process Safety Procedures
11.5.8 Training and Competence Assurance
11.5.9 Asset Integrity Management
11.5.10 Change Management
11.5.11 Operational Readiness Review
11.5.12 Emergency Management
11.5.13 Incident Investigation
11.5.14 Auditing
11.5.15 Disposal
11.5.16 Remediation

11.6 Other Project Activities
11.6.1 EHS and Process Safety Plans
11.6.2 Risk Register
11.6.3 Action Tracking
11.6.4 General Decommissioning Management
11.6.5 Stage Gate Reviews

11.7 Summary

12 DOCUMENTATION
12.1 Document Management
12.2 Process Knowledge Management
12.2.1 Front End Loading 1 Stage
12.2.2 Front End Loading 2 Stage 279
12.2.3 Front End Loading 3 Stage 280
12.2.4 Detailed Design Stage 281
12.2.5 Construction Stage 283
12.2.6 Commissioning and Startup Stage 286
12.2.7 Handover 287
12.2.8 Operation Stage 288
12.2.9 End of Life Stage 291
12.3 Summary 292

APPENDIX A. TYPICAL PROCESS SAFETY STUDIES OVER PROJECT LIFE CYCLE 293

APPENDIX B. PROJECT PROCESS SAFETY PLAN 295

APPENDIX C. TYPICAL HAZARD & RISK REGISTER 298

APPENDIX D. SAFETY CHECKLIST FOR PROCESS PLANTS 301

APPENDIX E. EXAMPLE OF SITE-SPECIFIC DECOMMISSIONING CHECKLIST / QUESTIONNAIRE 315

APPENDIX F. TYPICAL PROJECT DOCUMENTATION 322

APPENDIX G. STAGE GATE REVIEW PROTOCOL FOR PROCESS SAFETY 337

REFERENCES 365

INDEX 379