



*Technology Training that Works*

---

# Practical Hazops, trips and alarms

---

## Contents

<b>Preface</b>	<b>i</b>
<b>1 Introduction to hazard studies</b>	<b>1</b>
1.1 Scope and objectives of this chapter	1
1.2 Introduction to hazards and risk management	1
1.3 Risk assessment	11
1.4 Concepts of ALARP and tolerable risk	15
1.5 Regulatory frameworks and examples from EU and USA	23
1.6 Methods of identifying hazards	28
<b>2 Hazard studies at levels 1 &amp; 2</b>	<b>33</b>
2.1 Introduction	33
2.2 Methodologies for hazard study 1	40
2.3 Process hazard study 2	44
2.4 Practical example of hazard 2 application	57
2.5 Case study	68
2.6 Conclusion on hazard studies 1 and 2	68
<b>3 Risk reduction measures using alarms and trips</b>	<b>71</b>
3.1 Risk reduction measures	71
3.2 Terminologies and standards for safety systems	72
3.3 Equipment Under Control (EUC)	74
3.4 Protection layers	79
3.5 The role of alarms in safety	85
3.6 Alarm types and do they qualify as safeguards?	88
3.7 Identification and design of safety related alarms	89



*Technology Training that Works*

3.8	Key design principles for alarms	95
3.9	Safety instrumented systems, principles of separation	97
3.10	Simple and complex shut-down sequences, examples	100
3.11	Conclusions: The role of Hazops in defining alarms and trips	103
<b>4</b>	<b>Hazop method</b>	<b>105</b>
4.1	Introduction	105
4.2	Introduction to Hazop	106
4.3	Overview of Hazop method	107
4.4	Points to note on the examination procedure	127
4.5	Practical Exercise: Continuous process example	130
4.6	Hazop for batch processes and sequential operations	131
4.7	Hazops for other disciplines	135
4.8	Conclusions	140
<b>5</b>	<b>Planning and leadership of Hazops</b>	<b>141</b>
5.1	Introduction	141
5.2	Organizing the HAZOP	141
5.3	The team leader and the team	144
5.4	Practical exercise: Hybrid batch process example	153
<b>6</b>	<b>Specifying safety instrumented systems</b>	<b>155</b>
6.1	Introduction	155
6.2	Risk reduction by instrumented protection	156
6.3	What affects the safety integrity of an instrument trip?	161
6.4	Overview of IEC 61508	162
6.5	Determining the safety integrity	168
6.6	Design essentials to meet SIL targets	172
6.7	Specifying the SIS requirements	182
6.8	Documenting the SRS	188
6.9	Conclusions	194



*Technology Training that Works*

<b>7</b>	<b>Hazard analysis methods</b>	<b>195</b>
7.1	Introduction	195
7.2	Outline of methods	196
7.3	Fault tree analysis	200
7.4	Practical exercise in FTA	209
7.5	Conclusions	209
<b>8</b>	<b>Factors in the choice of protection system</b>	<b>211</b>
8.1	Introduction and objectives	211
8.2	Equipment selection	215
8.3	Key Points about sensors and actuators	226
8.4	Guidelines for the application of field devices in the SIS	229
8.5	IEC 61508 requirements for field devices	236
8.6	Technology issues	237
8.7	Guidelines for final elements	238
8.8	Summary of technology and applications	246
8.9	Summary of SIL versus cost	247
<b>9</b>	<b>Exercise in specifying an SIS from the Hazop</b>	<b>249</b>
9.1	Introduction	249
9.2	Process description	249
9.3	Safety requirements specifications	255
9.4	Conclusion	261
<b>10</b>	<b>Appendices</b>	<b>263</b>
	Appendix A – References	263
	Appendix B – Safety systems web sites	265
	Appendix C – Regulations on hazards and safety management	269
	Appendix D – Software tools for hazard studies	275
	Appendix E – EPA case study of phenol resin hazards	277
	Appendix F – Expanded guideword table for continuous processes	279



*Technology Training that Works*

Appendix G – Methods of reporting	281
Appendix H – Design and calibration of a risk graph	283
Appendix I – Data capture sheet	287
Appendix J – Glossary of terms	289
Appendix K – Safety requirements specification: Checklist	295

---

<b>11</b>	<b>Practical exercises</b>	<b>301</b>
	Practical problem 1	301
	Practical problem 2	303
	Practical problem 3	307
	Practical problem 4	317
	Practical problem 5	323
	Practical problem 6	331
	Practical problem 7	335
	Practical solution 1	343
	Practical solution 2	345
	Practical solution 3	347
	Practical solution 4	353
	Practical solution 5	359
	Practical solution 6	365
	Practical solution 7	369