



# Occupational Safety Management and Engineering

Fifth Edition

Willie Hammer  
Dennis Price

Prentice Hall International Series in  
Industrial and Systems Engineering

W. J. Fabrycky and J. H. Mize, Editors

# Contents

<b>PREFACE</b>	<b>xv</b>
<b>CHAPTER 1 ACCIDENT LOSSES</b>	<b>1</b>
Costs of Well-Being	1
The Industrial Revolution and Accidents	2
Increasing Hazards	3
Physical Effects of Accidents	4
Numbers of Accidents vs. Costs	6
Lessening Safety Costs	9
Accident Losses for Personnel vs. Equipment and Facilities	9
Increasing Magnitude of Accident Losses	11
Awards for Injuries	12
Bibliography	13
Exercises	13
<b>CHAPTER 2 LIABILITIES AND SAFETY LEGISLATION</b>	<b>15</b>
Statute Law	15
Common Law	16
Misadventure (Accident)	17
Strict Liability	17
Industrial Revolution	19
Negligence	19
American Laws	22
Steam Engines, Boats, and Locomotives	22
The Fourteenth Amendment and Safety	23
Liability Laws	23
Workers' Compensation Laws	24
Later Actions	25
Resurgence of Strict Liability	25
Limited Liability	27
Excused Negligence	27
Bibliography	27
Exercises	28

**CHAPTER 3 WORKERS' COMPENSATION**

**29**

Obligations to Employees 29  
Workers' Compensation Laws 30  
Problems of Nonuniformity 32  
Coverages 34  
Workers' Compensation Insurance 34  
Costs of Workers' Compensation Insurance 34  
Insurance Rating Systems 37  
Keeping Workers' Compensation Costs Down 37  
Workers' Compensation Reform 39  
Requirements for Benefits 40  
Disagreements 40  
Injury Resulting from an Accident 41  
Injury Arising out of Employment 41  
Types of Disabilities 43  
Monetary Disability Benefits 44  
Death Benefits 44  
Extent of Medical Benefits 44  
Injury and Claim Notices 45  
Hearings 45  
Action against a Third Party 46  
Inadequacy of Workers' Compensation 49  
Bibliography 50  
Exercises 50

**CHAPTER 4 OSHACT AND ITS ADMINISTRATION**

**52**

New Concepts of Accident Avoidance 53  
Enactment of the Occupational Safety and Health Act (OSHAct) 55  
Other Organizations 55  
State Industrial Safety Programs 56  
Responsibilities of Employers and Employees 58  
Inspections 58  
Violations and Penalties 59  
Standards 62  
Record Keeping 62  
Impact of OSHA 62  
OSHA and Hazard Minimization 64  
Antagonism toward OSHA 64  
The New Millennium 67  
The New OSHA 68  
Exercises 72

<b>CHAPTER 5 STANDARDS, CODES, AND OTHER SAFETY DOCUMENTS</b>	<b>73</b>
Uses for Standards and Codes	74
Mandatory vs. Voluntary Standards	76
Objections to Consensus Standards	79
Test Standards	80
Differences in Standards	81
Changing Standards	83
Inadequacies of Standards	83
Standards and Analyses	84
Proliferation of Standards	84
Status of OSHA Standards	84
Bibliography	85
Exercises	86
<b>CHAPTER 6 ENGINEERS AND SAFETY</b>	<b>87</b>
Accomplishments of Engineers	87
Engineering and Accidents	88
Steam Equipment and Accidents	88
Technical Societies and Safety	89
Inadequacy of Engineering Schools	89
Engineers as Causers of Accidents	90
Registration of Engineers	91
Possible Improvements in Registration	95
Bibliography	97
Exercises	97
<b>CHAPTER 7 MANAGEMENT AND ITS RESPONSIBILITIES</b>	<b>98</b>
Safety Policies	98
OSHAct and Management	100
Actions against Managers	100
Management Attitudes toward Safety	102
Middle Managers	106
Foremen/Forewomen and Safety	106
Procedural Safeguards	107
Management and Supervision	108
Safety Efforts of Other Managers	110
Hazardous Operations	112
Personnel	113
Personal Protective Equipment	114
Checklist for Managers	115

Safety Information System 115  
Bibliography 118  
Exercises 119

**CHAPTER 8 THE CHANGING ROLES OF SAFETY PERSONNEL 120**

Safety Laws and Safety Engineers 121  
Safety Personnel 122  
“Safety Man” 123  
Safety Engineer 123  
Production and Processing Losses 125  
Growing Areas within Safety 125  
Bibliography 126  
Exercises 126

**CHAPTER 9 PERSONNEL 127**

Disabled Personnel in the Workplace 128  
Older Personnel in the Workforce 130  
Human Error 130  
Designing and Planning Errors 131  
Production Errors 132  
Operations Errors 135  
Two-Person Concept 136  
Human vs. Machine 136  
The Biochemical Machine 137  
Motivation 138  
Violence in the Workplace 139  
Judgment 141  
Accident-Prone Persons 142  
Quantitative Error Prediction 144  
Human Factors Engineering 145  
Procedural Means of Accident Prevention 146  
Critical Operations 146  
Responsibilities of the Individual Worker 149  
Procedure Analysis 151  
Outputs of Procedure Analysis 155  
Contingency Analysis 155  
Bibliography 157  
Exercises 157

**CHAPTER 10 PROMOTING SAFE PRACTICES 159**

The Behavior-Based Safety Approach 160  
The Regulatory Approach: Safety Rules 162  
Employee Participation 162

Critical Incident Technique	163
Other Methods	164
Suggestion Programs	164
Union Participation	165
Safety Training	165
In-depth Training	167
Maintaining Awareness	168
General Comments on Safety Committees	168
Safety Committee Duties	169
Bibliography	170
Exercises	170

## **CHAPTER 11 APPRAISING PLANT SAFETY**

171

New Plants and Equipment Designs	172
Existing Plants and Equipment	172
Indicating Plant Hazards	173
Safety Inspections	174
Checklists	175
Quantitative Appraisals	176
Problems with Validity of Statistics	176
Problems with Quantitative Rates	178
Validity of Statistical Comparisons	179
Risk Assessments	180
Acceptance of Risk	184
Risk Communication	186
Bibliography	187
Exercises	187

## **CHAPTER 12 HAZARDS AND THEIR CONTROL**

189

Determining Existence of Hazards	190
Eliminating and Controlling Hazards	192
Isolation, Lockouts, Lockins, and Interlocks	194
Failure Minimization	200
Safety Factors and Margins	200
Monitoring	203
Warning Means and Devices	206
Safe Procedures	207
Backout and Recovery	207
Damage Minimization and Containment	211
Physical Isolation	211
Weak Links	212
Escape, Survival, and Rescue	213
Bibliography	214
Exercises	214

**CHAPTER 13 PLANNING FOR EMERGENCIES 215**

Medical Responses in Emergencies 215

Bibliography 228

Exercises 228

**CHAPTER 14 ACCIDENT INVESTIGATIONS 229**

Investigating Board Chairman's Responsibilities 232

Contributing Personnel 232

Conducting the Investigation 234

Accident Reports 235

Corrective Actions 237

Insurance Claims 237

Other Aspects of Accident Investigations 239

Exercises 239

**CHAPTER 15 SAFETY ANALYSIS 240**

General 240

Preliminary Hazards Analysis 241

Failure Modes and Effects Analysis 245

Fault-Tree Analysis (FTA) 245

Fault Tree Symbols 246

Safety Analysis Methods Mandated for Process

Safety Management 254

Bibliography 257

Exercises 258

**CHAPTER 16 ACCELERATION, FALLS, FALLING OBJECTS,  
AND OTHER IMPACTS 259**

Falls 259

Preventive Measures Against Falls 262

Impacting Objects 265

Other Acceleration Effects 267

Bibliography 270

Exercises 270

**CHAPTER 17 MECHANICAL INJURIES 271**

Cutting and Tearing 271

Shearing 272

Crushing 272

Breaking 273

Machine Guards and Safety Devices	273
Guards	274
Precautionary Measures	276
Exercises	277

## **CHAPTER 18 WORK-RELATED MUSCULOSKELETAL DISORDERS 279**

Musculoskeletal Disorders (MSDs): Work Related or Not Work Related?	280
The Effects of WMSDs	281
Worker-related Factors Associated with MSDs	282
Carpal Tunnel Syndrome	283
Nonoccupational Factors of CTS	283
Low Back Pain	284
Back Belts	286
Ergonomics: A Program to Control WMSDs	287
Bibliography	290
Exercises	290

## **CHAPTER 19 HEAT AND TEMPERATURE**

291

Effects on Personnel	291
Classification of Burn Severities	296
Burns to the Eye	297
Other Temperature Effects on Personnel	297
High Temperatures	298
Additional Effects	305
Bibliography	311
Exercises	311

## **CHAPTER 20 PRESSURE HAZARDS**

312

Unfired Pressure Vessels	314
Discharges from Safety Valves	317
Dynamic Pressure Hazards	317
Water Hammer	319
Negative Pressure (Vacuums)	320
Testing of Pressure Systems	320
Leaks	321
Effects of Leakage	323
Leak Detection	324
Dysbarism and Decompression Sickness	324
Compressed-Gas Cylinders	328
Bibliography	336
Exercises	340



**CHAPTER 21 ELECTRICAL HAZARDS 341**

- Shock 341
- Other Factors 342
- Causes of Shock 344
- Electrical Insulation Failures 346
- Equipment Failures 347
- Other Shock Protection 349
- Static Electricity 354
- Lightning 359
- Ignition of Combustible Materials 361
- Containment of Discharges 361
- Inherently Safe Devices 361
- Heating and Overheating 365
- Circuit and Equipment Protection 366
- Unit Protection 367
- Why an Open Circuit? 368
- Exercises 374

**CHAPTER 22 FIRES AND FIRE SUPPRESSION 375**

- Fuels 375
- Oxidizers 378
- Gases 379
- Flammable and Combustible Liquids 379
- Flammable Solids 386
- Ignition 387
- Ignition Sources 394
- Ignition Delay 394
- Effects of Fire on Personnel 396
- Fire Detection Systems 399
- Fire Classifications 400
- Fire Suppression 401
- Extinguishing Systems 408
- Bibliography 419
- Exercises 419

**CHAPTER 23 EXPLOSIONS AND EXPLOSIVES 425**

- Industrial Usage and Problems 425
- Materials That Will Explode 429
- Explosive Effects 431
- Preventing Explosion Damage 434
- Bibliography 439
- Exercises 439

**CHAPTER 24 HAZARDS OF TOXIC MATERIALS 440**

- Toxic Materials 440
- Routes to Injury Sites 441
- Hypoxia 441
- Hypoxic Hypoxia 445
- Mechanisms of Toxic Agents 448
- Measurement of Toxicity 458
- Detection of Toxic Agents 461
- Respiratory Protective Equipment 461
- Bibliography 475
- Exercises 476

**CHAPTER 25 ENVIRONMENTS 477**

- OSHA and EPA 477
- Types of Environments 480
- Natural and Induced Environments 480
- Controlled Environments 484
- Closed or Free Environments 484
- Hazards of the Environment 486
- Detecting Adverse Environments 486
- Protection against the Environment 489
- Industrial Ecology 492
- Bibliography 495
- Exercises 496

**CHAPTER 26 CONFINED-SPACE ENTRY 497**

- What Is a Confined Space? 498
- Atmospheric Hazards 500
- Physical Hazards 501
- Chemical, Biological, Radiation 501
- Management Responsibilities for Confined Spaces 501
- Bibliography 504
- Exercises 505

**CHAPTER 27 RADIATION 506**

- Ionizing Radiation 508
- Factors Affecting Exposure and Risk 512
- Sources of Ionizing Radiation 512
- Beneficial Uses of Ionizing Radiation 515
- Fears of Nuclear Radiation 515
- Ionizing/Nonionizing Interface 519

Nonionizing Radiations 519  
Radio Frequency Radiation of Wireless Communication  
Devices 527  
Bibliography 531  
Exercises 531

**CHAPTER 28 VIBRATION AND NOISE 532**

Effects of Vibration, Sound, and Noise 533  
Mechanism of Hearing Injuries 541  
Elements of a Hearing Conservation Program (HCP) 542  
Annoyance 547  
Distraction 547  
Interference and Masking 548  
Other Vibration Effects 548  
Bibliography 554  
Exercises 554

**CHAPTER 29 COMPUTERS AND SAFETY 557**

Safety Uses of Computers 558  
Safety Problems to Workers 559  
Accidents with Computerized Equipment 559  
Computer Inabilities 559  
Programming Errors 562  
Avoiding Human Errors 562  
Safety Data Processing 562  
Avoiding Safety Problems 563  
Computer Controls against Hazards 563  
Computers and Hazard Analyses 564  
Simulations 564  
Software Hazard Categories 565  
Software Analysis 565  
Software Hazard Analysis Techniques 567  
Tailoring Software Analysis 572  
Robots and Accidents 573  
For the Future 575  
Bibliography 575  
Exercises 575

**BIBLIOGRAPHY 577**

**INDEX 583**