The Basics of Occupational Safety

David L. Goetsch
Vice President Emeritus and Professor, Northwest Florida State College

Pearson
330 Hudson Street, NY, NY 10013
BACKGROUND

The field of occupational safety and health has undergone significant change over the past three decades. There are many reasons for this. Some of the more prominent reasons include technological changes that have introduced new hazards in the workplace; proliferation of health and safety legislation and corresponding regulations; increased pressure from regulatory agencies; realization by executives that workers in a safe and healthy workplace are typically more productive; healthcare and workers’ compensation cost increases; increased pressure from environmental groups and the public; a growing interest in ethics and corporate social responsibility; professionalization of health and safety occupations; increased pressure from labor organizations and employees in general; rapidly mounting costs associated with product safety and other types of litigation; and increasing incidents of workplace violence.

All of these factors, when combined, have made the job of the modern safety and health professional more challenging and more important than it has ever been. These factors have also created a need for an up-to-date book on the basics of workplace safety and health that contains the latest information needed by people who will have responsible positions in today’s fast-paced, competitive workplace.

WHY IS THIS BOOK WRITTEN AND FOR WHOM?

This book is written to fulfill the need for an up-to-date, practical teaching resource that focuses on the basic safety-related needs of people in the workplace. It is intended for use in universities, colleges, community colleges, technical schools, and corporate training settings that offer programs, courses, workshops, and seminars in occupational safety and health. Educators and students in such disciplines as safety engineering, engineering, industrial technology, manufacturing technology, industrial engineering, safety engineering, engineering technology, occupational safety, management, and supervision will find this book both valuable and easy to use. The direct, straightforward presentation of material focuses on making the theories and principles of occupational safety and health practical and useful in a real-world setting. Up-to-date research has been integrated throughout in a down-to-earth manner.

ORGANIZATION OF THE BOOK

The text contains 20 chapters, each focusing on a major area of concern in workplace safety and health. The chapters are presented in an order that is compatible with the typical organization of a college-level safety and health course. A standard chapter
format is used throughout the book. There is a list of learning objectives at the beginning of each chapter. All chapters include review questions, key terms and concepts, and endnotes. These materials are provided to encourage review, stimulate additional thought, and provide opportunities for applying what has been learned.

INSTRUCTOR RESOURCES

To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc to register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, locate your text in the online catalog and click on the Instructor Resources button on the left side of the catalog product page. Select a supplement and a login page will appear. Once you have logged in, you can access instructor material for all Pearson textbooks. If you have any difficulties accessing the site or downloading a supplement, please contact Customer Service at http://support.pearson.com/getsupport.

HOW THIS BOOK DIFFERS FROM OTHERS

This book is written because, in the age of global competition, safety and health in the workplace have changed drastically. Many issues, concerns, and factors relating specifically to modern workplace environments have been given more attention, greater depth of coverage, and more illumination here than in other textbooks. Some of the areas receiving more attention and specific occupational examples include the following:

- The Occupational Safety and Health Act (OSH Act) and Occupational Safety and Health Administration (OSHA)
- Standards and codes
- Laws and liability
- Stress-related problems
- Fire hazards and life safety
- The evolving roles of health and safety professionals
- Health and safety training
- Human factors in safety
- Bloodborne pathogens in the workplace
- Ergonomics and safety
- Workers’ compensation
- Repetitive strain injuries (RSIs)

NEW TO THIS EDITION

The third edition of The Basics of Occupational Safety is a major revision encompassing new regulations, revised regulations, and other new and updated material of importance for the students of occupational safety and health. Specifically, the following revisions are made in the third edition:
CHAPTER 1:
1. Added a section about safety applying to all work sectors: manufacturing, retail, hospitality, healthcare, etc.
2. Added information on the Chemical Safety Board.
3. Added information on ergonomics as a trend in safety in the 1990s.
4. Added information on the West Fertilizer Company tragedy.
5. Added information on whether the accident rate has decreased because America has lost so many manufacturing jobs.

CHAPTER 2:
1. Moved “Heat Burns and Chemical Burns” sections to Chapter 15.
3. Added a reference year to Figures 2–1, 2–2, and 2–3 so students know when the data was compiled.
4. Added a brief section on OSHA reports and logs here (and reference where they appear in detail in Chapter 5).
5. Converted Figure 2–4 into a chart.

CHAPTER 3:
1. Bolded the sentence about Heinrich’s Theory being discounted by contemporary research for emphasis.
2. Added information on James Reason’s Swiss Cheese Model of accident causation.
3. Changed the section on “Drugs and Accident Causation” to “Individual Factors and Accident Causation” (includes drugs, depression, obesity, fatigue, personality, etc.).

CHAPTER 4:
1. Added information on the importance of the employee on safety teams and the employee’s role in safety.
2. Replaced Figures 4–9 and 4–10 with photographs.

CHAPTER 5:
1. Added information on indirect costs of OSHA fines (bad PR, loss of goodwill, corporate image, legal fees, paperwork, etc.).
2. Replaced Figure 5–4 with instructions for finding consultation services in your state.
3. Revised Figure 5–5 to include website addresses for each agency instead of street addresses.
4. Updated the OSHA standard subparts listed to ensure they are up to date.
5. Added information on where the fines go when OSHA collects them and discussion plus examples about the size of fines.
CHAPTER 6:
1. Replaced Figure 6–1 with a figure showing how students can access workers’ compensation information for their states.
2. Added information on workers’ compensation abuse (employees trying to take advantage of the system).
3. Replaced Figure 6–2 with a photograph.

CHAPTER 7:
1. Added information about why safety professionals who do accident reports need to be familiar with common causes of accidents (added to the “Common Causes of Accidents” section).
2. Added a section on “Who is responsible for reporting.”
3. Added an accident investigation exercise to the end of the chapter.

CHAPTER 8:
1. Added information on ergonomic assessment tools such as NIOSH guidelines, RULA, and REBA.
2. Moved section on “lifting” from Chapter 11 to this chapter and expanded the content of the section.
3. Expanded the section on “Human Factors and Safety.”
4. Added information on choosing which workstations/operations to evaluate for ergonomics to the section on “Worksite Analysis Program.”
5. In the section titled “Training and Education,” referred students to using recommended training materials from OSHA.
6. In the section on “Identifying Specific Ergonomic Problems” added material on “anthropometry” (body size).
7. In the section on “Helpful Assessment Tools: NIOSH, RULA, REBA, and HAL” (added information on analysis tools including RULA, REBA, HAL, and Strain Index).

CHAPTER 9:
1. Explained how the list of “common causes” can be used and how it relates to the rest of the chapter.
2. Added explanations for the strategies for dealing with stress.
3. Added physiological measures of stress (heart rate, pupil dilation, perspiration, etc.).
4. Added information about 24/7 use of technology and multitasking as causes of stress.
5. Added information about Employee Assistance Programs (EAPs) and company wellness programs for dealing with stress.

CHAPTER 10:
1. Added information about how a given type of machine guard is chosen.
2. Added information on advanced sensors and Bluetooth technology.
CHAPTER 11:
1. Dropped “Lifting” from the title to this chapter, and moved the section on lifting to Chapter 8.
2. Changed title to “Falling, Impact, Acceleration, and Vision Hazards with Appropriate PPE.”

CHAPTER 12:
1. Added information on Clo as a unit for measure for PPE temperature protection.
2. Added a section on OSHA recommendations and guidelines for temperature hazards.
3. Added a note to “Chemical Burns” explaining why it is in this chapter and not in the chapter on fire safety.

CHAPTER 13:
1. Added a note that refers students to Chapter 16 for coverage of “Confined Spaces.”
2. Added information on 29 CFR 1910 Subpart H (OSHA’s standards on pressure hazards).

CHAPTER 14:
1. Added information about power strips and daisy chains.
2. Made minor updates corrections to the text.

CHAPTER 15:
1. Added information about the number of fire extinguishers needed, how to choose the type, and where they should be located in a facility.
2. Moved sections on “Chemical Burns” from Chapter 2 to this chapter.
3. Added information to the “egress” section about lighting and signage.
4. Strengthened the material on “egress.”

CHAPTER 16:
1. Added information to describe TWA in more detail.
2. Removed the underline from the TWA side of the equation.

CHAPTER 17:
1. Expanded the explanations of risk reduction strategies.

CHAPTER 18:
1. Added a section about “earbuds” from handheld devices and potential hazards.
2. In the section on “Hazard Levels and Risks” added information from Chapter 16 on calculating TWA.
3. In the section on “Vibration Hazards” added information about tools insulation, tool mounting, and job rotation.
Preface

4. In the section on “Noise Control Strategies” added information on specific engineering controls (e.g., mufflers, insulation, wall panels, and sound absorption).
5. Added information about calculating Noise Reduction Rating (NRR) and how to evaluate PPE based on the NRR.
6. Moved the section on “Fit Testing” to earlier in the chapter.

CHAPTER 19:

1. Added a section on “active shooter” response.
2. Added a section on “reporting suspicious activities.”

ABOUT THE AUTHOR

David L. Goetsch is vice president Emeritus of Northwest Florida State College and professor of safety, quality, and management. In addition, Dr. Goetsch is president and CEO of the Institute for Organizational Excellence (IOE), a private consulting firm dedicated to the continual improvement of organizational competitiveness, safety, and quality. Dr. Goetsch is cofounder of The Quality Institute, a partnership of the University of West Florida, Northwest Florida State College, and the Okaloosa Economic Development Council and founder of the Leadership Institute of Northwest Florida State College and founder of the Leadership Institute of Northwest Florida State College.

ACKNOWLEDGMENTS

The author acknowledges the invaluable assistance of the following people in developing this book: Dr. Lissa Galbraith, Florida A&M/Florida State University, for the material she contributed on electrical and fire hazards in the first edition.
Introduction

SAFETY VERSUS HEALTH

Throughout the text, the titles “safety and health professional” and “safety and health manager” are used. This, too, is done by design. This approach underscores the point that the field of occupational safety has been broadened to encompass both safety and health. Consequently, managers, technical personnel, and engineers in this field must be knowledgeable about safety and health and be prepared to oversee a program that encompasses both areas of responsibility.

Safety and health, although closely related, are not the same. One view is that safety is concerned with injury-causing situations, whereas health is concerned with disease-causing conditions. Another view is that safety is concerned with hazards to humans that result from sudden severe conditions; health deals with adverse reactions to prolonged exposure to dangerous, but less intense, hazards. Both of these views are generally accurate in portraying the difference between safety and health. However, the line between these two concepts is not always clearly marked.

For example, stress is a hazard that can cause both psychological and physiological problems over a prolonged period. In this case, it is a health concern. On the other hand, an overly stressed worker may be more prone to unintentionally overlook safety precautions and thus may cause an accident. In this case, stress is a safety concern.

Because personnel in this evolving profession are likely to be responsible for safety and health, it is important that they have a broad academic background covering both. This book attempts to provide that background.
## Brief Contents

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety and Health Movement, Then and Now</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Accidents and Their Effects</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>Theories of Accident Causation</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>Roles and Professional Certifications for Safety and Health Professionals</td>
<td>53</td>
</tr>
<tr>
<td>5</td>
<td>The OSH Act, Standards, and Liability</td>
<td>81</td>
</tr>
<tr>
<td>6</td>
<td>Workers’ Compensation</td>
<td>137</td>
</tr>
<tr>
<td>7</td>
<td>Accident Investigation and Reporting</td>
<td>165</td>
</tr>
<tr>
<td>8</td>
<td>Ergonomic Hazards: Musculoskeletal Disorders (MSDS) and Cumulative Trauma Disorders (CTDS)</td>
<td>185</td>
</tr>
<tr>
<td>9</td>
<td>Stress and Safety</td>
<td>227</td>
</tr>
<tr>
<td>10</td>
<td>Mechanical Hazards and Machine Safeguarding</td>
<td>241</td>
</tr>
<tr>
<td>11</td>
<td>Falling, Impact, Acceleration, and Vision Hazards with Appropriate PPE</td>
<td>265</td>
</tr>
<tr>
<td>12</td>
<td>Hazards of Temperature Extremes</td>
<td>299</td>
</tr>
<tr>
<td>13</td>
<td>Pressure Hazards</td>
<td>317</td>
</tr>
<tr>
<td>14</td>
<td>Electrical Hazards</td>
<td>331</td>
</tr>
<tr>
<td>15</td>
<td>Fire Hazards and Life Safety</td>
<td>353</td>
</tr>
<tr>
<td>16</td>
<td>Industrial Hygiene and Confined Spaces</td>
<td>387</td>
</tr>
<tr>
<td>17</td>
<td>Violence in the Workplace</td>
<td>433</td>
</tr>
<tr>
<td>18</td>
<td>Noise and Vibration Hazards</td>
<td>455</td>
</tr>
<tr>
<td>19</td>
<td>Preparing for Emergencies, Disasters, and Terrorism</td>
<td>487</td>
</tr>
<tr>
<td>20</td>
<td>Bloodborne Pathogens and Bacterial Hazards in the Workplace</td>
<td>515</td>
</tr>
</tbody>
</table>

**Glossary** 537  
**Index** 549
## Contents

### CHAPTER 1  Safety and Health Movement, Then and Now 1
- Developments Before the Industrial Revolution 2
- Milestones in the Safety Movement 3
- Tragedies That Have Changed the Safety Movement 5
- Role of Organized Labor 9
- Role of Specific Health Problems 10
- Safety and Health Standards Apply to More Than Just Manufacturing 11
- Development of Accident Prevention Programs 11
- Development of Safety Organizations 13
- Safety and Health Movement Today 15
- Integrated Approach to Safety and Health 15
- New Materials, New Processes, and New Problems 15
- Rapid Growth in the Profession 16
- Does Moving Manufacturing Jobs Overseas Reduce the Accident Rate? 16

### CHAPTER 2  Accidents and Their Effects 19
- Costs of Accidents 20
- Accidental Deaths in the United States 21
- Accidents Versus Other Causes of Death 22
- Work Accident Costs and Rates 22
- Time Lost Because of Work Injuries 23
- Deaths in Work Accidents 23
- Work Injuries by Type of Accident 23
- Death Rates by Industry 24
- Parts of the Body Injured on the Job 25
- Estimating the Cost of Accidents 26
- Global Impact of Accidents and Injuries 29
- OSHA Reports and Logs 29

### CHAPTER 3  Theories of Accident Causation 31
- Domino Theory of Accident Causation 32
- Human Factors Theory of Accident Causation 34
- Accident/Incident Theory of Accident Causation 36
- Epidemiological Theory of Accident Causation 39
- Systems Theory of Accident Causation 41
- Combination Theory of Accident Causation 44
- Behavioral Theory of Accident Causation 45
- Individual Factors and Accident Causation 46
- Management Failures and Accident Causation 47
- Obesity and Accident Causation 49
- Swiss Cheese Model of Accident Causation 49
- Summary of Accident Causation Models and Applications 50

### CHAPTER 4  Roles and Professional Certifications for Safety and Health Professionals 53
- Modern Safety and Health Teams 54
- Safety and Health Manager 54
- Engineers and Safety 64
- Industrial Hygienist 69
- Health Physicist 69
- Occupational Physician 69
- Occupational Health Nurse 70
- Risk Manager 71
- Employees and Safety 72
- Certification of Safety and Health Professionals 72
Contents

Other Safety and Health-Related Certifications 77
Emerging Role of Safety Professionals 77

CHAPTER 5 The OSH Act, Standards, and Liability 81
Rationale for the OSH Act 82
OSHA’s Mission and Purpose 82
OSHA Act Coverage 83
OSHA Standards 84
OSHA’s Record Keeping and Reporting 90
Keeping Employees Informed 99
Workplace Inspections and Enforcement 99
OSHA’s Whistleblower Program 100
OSHA’s Enhanced Enforcement Policy 101
Citations and Penalties 102
OSHA Fines: How Much and Where Does the Money Go? 103
Appeals Process 104
State-Level OSHA Programs 105
Services Available from OSHA 107
Employer Rights and Responsibilities 109
Employee Rights and Responsibilities 111
Keeping Up-to-Date on OSHA 112
Problems with OSHA 113
Other Agencies and Organizations 114
OSHA’s General Industry Standards 119
OSHA’s Maritime Standards 126
OSHA’s Construction Standards 128
Standards and Codes 129
Laws and Liability 131
OSHA’s Stand on Safety Incentives 134

CHAPTER 6 Workers’ Compensation 137
Overview of Workers’ Compensation 138
Historical Perspective 140
Workers’ Compensation Legislation 142
Modern Workers’ Compensation 143
Workers’ Compensation Insurance 144
Resolution of Workers’ Compensation Disputes 146
Injuries and Workers’ Compensation 146
Disabilities and Workers’ Compensation 147
Monetary Benefits of Workers’ Compensation 152
Medical Treatment and Rehabilitation 154

CHAPTER 7 Accident Investigation and Reporting 165
Types of Accident Investigations 166
When to Investigate 166
What to Investigate 168
Who Should Investigate 172
Conducting the Investigation 173
Interviewing Witnesses 175
Reporting Accidents 177
Ten Accident Investigation Mistakes to Avoid 182

CHAPTER 8 Ergonomic Hazards: Musculoskeletal Disorders (MSDS) and Cumulative Trauma Disorders (CTDS) 185
Ergonomics Defined 186
Human Factors and Ergonomic Hazards 187
Factors Associated with Physical Stress 189
Ergonomics: A Political Football 190
OSHA’s Voluntary Ergonomics Guidelines 191
OSHA’s Ergonomics Standard (Voluntary Guidelines) 192
Worksite Analysis Program for Ergonomics 196
Hazard Prevention and Control 199
Medical Management Program 200
Training and Education 203
Common Indicators of Problems 204
Identifying Specific Ergonomic Problems 206
Ergonomic Problem-Solving Strategies 208
Economics of Ergonomics 214
Cumulative Trauma Disorders/Soft Tissue Injuries 214
Lifting Hazards 219
Helpful Assessment Tools: NIOSH, RULA, REBA, and HAL  223
Participatory Ergonomics  224

CHAPTER 9 Stress and Safety  227
Workplace Stress Defined  227
Sources of Workplace Stress  228
Common Causes of Stress in the Workplace  230
Human Reactions to Workplace Stress  232
Measurement of Workplace Stress  232
Shift Work, Stress, and Safety  233
Improving Safety by Reducing Workplace Stress  234
Stress in Safety Managers  238
Stress and Workers’ Compensation  239

CHAPTER 10 Mechanical Hazards and Machine Safeguarding  241
Common Mechanical Injuries  242
Safeguarding Defined  245
OSHA’s Requirements for Machine Guarding  245
Risk Assessment in Machine Operation  246
Design Requirements for Safeguards  249
Point-of-Operation Guards  249
Point-of-Operation Devices  250
How to Choose a Machine Guard or Device  253
Machine Guarding Self-Assessment  254
Feeding and Ejection Systems  255
Robot Safeguards  255
Control of Hazardous Energy (Lockout/Tagout Systems)  256
Permanent Electrical Safety Devices in Lockout/Tagout Programs  259
General Precautions  261
Basic Program Content  262
Taking Corrective Action  262

CHAPTER 11 Falling, Impact, Acceleration, and Vision Hazards with Appropriate PPE  265
Causes of Falls  266
Kinds of Falls  266
Walking and Slipping  266
Slip and Fall Prevention Programs  269
OSHA Fall Protection Standards  271
ANSI Z359 Fall Protection Code  274
Ladder Safety  275
What to Do After a Fall  277
Monitor Fall Protection Equipment and Know Why It Fails  277
Impact and Acceleration Hazards  277
Standing Hazards  285
Hand Protection  287
Personal Protective Equipment  290
Forklift Safety (Powered Industrial Trucks)  292

CHAPTER 12 Hazards of Temperature Extremes  299
Thermal Comfort  299
Heat Stress and Strain  300
Cold Stress  305
Burns and Their Effects  309
Chemical Burns  311
OSHA’s Guidelines for Hazards of Temperature Extremes  313

CHAPTER 13 Pressure Hazards  317
Pressure Hazards Defined  317
Sources of Pressure Hazards  318
Boilers and Pressure Hazards  320
High-Temperature Water Hazards  320
Hazards of Unfired Pressure Vessels  321
Hazards of High-Pressure Systems  321
Cracking Hazards in Pressure Vessels  321
Nondestructive Testing of Pressure Vessels  323
Pressure Dangers to Humans  324
Decompression Procedures  325
Measurement of Pressure Hazards  326
Reduction of Pressure Hazards  327
OSHA’s Standard and Guidelines for Pressure Hazards  329
Confined Spaces and Pressure Vessels  329

CHAPTER 14 Electrical Hazards  331
Electrical Hazards Defined  332
Sources of Electrical Hazards  335
Electrical Hazards to Humans  339
## Contents

Detection of Electrical Hazards 340  
Reduction of Electrical Hazards 341  
OSHA’s Electrical Standards 343  
Electrical Safety Program 344  
Electrical Hazards Self-Assessment 345  
Prevention of Arc Flash Injuries 346  
Training Requirements for Workers 347  
Permanent Electrical Safety Devices 348  
Hazards of Power Strips and Daisy Chains 349  

CHAPTER 15 Fire Hazards and Life Safety 353  
Fire Hazards Defined 354  
Sources of Fire Hazards 357  
Fire Dangers to Humans 360  
Detection of Fire Hazards 361  
Reduction of Fire Hazards 362  
Development of Fire Safety Standards 368  
OSHA Fire Standards 368  
OSHA and Fire Prevention Plans 369  
OSHA Requirements for Exit Routes 370  
Life Safety 371  
Basic Requirements 371  
Flame-Resistant Clothing 375  
Fire Safety Programs 376  
Response and Fire Drills 378  
Explosive Hazards 378  
OSHA’s Firefighting Options 380  
Self-Assessment in Fire Protection 382  
Hot Work Program 382  

CHAPTER 16 Industrial Hygiene and Confined Spaces 387  
Overview of Industrial Hygiene 388  
Industrial Hygiene Standards 389  
OSH Act and Industrial Hygiene 389  
Hazards in the Workplace 393  
Toxic Substances Defined 396  
Enter Points for Toxic Agents 396  
Effects of Toxic Substances 398  
Relationship of Doses and Responses 399  
Airborne Contaminants 400  
Effects of Airborne Toxics 401  
Effects of Carcinogens 402  
Asbestos Hazards 402  
Indoor Air Quality and “Sick-Building” Syndrome 405  
Toxic Mold and Indoor Air Quality 407  
ASTM D7338: Guide for the Assessment of Fungal Growth in Buildings 409  
Threshold Limit Values 409  
Hazard Recognition and Evaluation 411  
Prevention and Control 412  
NIOSH and Industrial Hygiene 414  
NIOSH Guidelines for Respirators 415  
Standards and Regulations 417  
Environmental Protection Agency Risk Management Program 418  
General Safety Precautions 419  
Nanoscale Materials and Industrial Hygiene 421  
Confined Space Hazards 422  
OSHA Confined Space Standard 423  
OSHA’s Hazard Communication Standard 427  

CHAPTER 17 Violence in the Workplace 433  
Occupational Safety and Workplace Violence: The Relationship 434  
Workplace Violence: Definitions 434  
Legal Considerations 434  
Risk-Reduction Strategies 436  
OSHA’s Voluntary Guidelines on Workplace Violence 438  
Active Shooter Response 448  
Role of Supervisors 448  
Workplace Violence: Policy, Plan, and Programs 449  
Communicating With Personnel in the Aftermath of a Violent Incident 452  

CHAPTER 18 Noise and Vibration Hazards 455  
Hearing Loss Prevention Terms 456  
Characteristics of Sound 458  
Hazard Levels and Risks 459  
Standards and Regulations 461  
Workers’ Compensation and Noise Hazards 467  
Identifying and Assessing Hazardous Noise Conditions 467  
Noise Control Strategies 469  
Vibration Hazards 475