



RISK-REDUCTION METHODS

FOR OCCUPATIONAL
SAFETY AND HEALTH

Roger C. Jensen



Risk-Reduction Methods for Occupational Safety and Health

Roger C. Jensen

Montana Tech of the University of Montana



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Risk-Reduction Methods for Occupational Safety and Health

Preface

My initial motive for developing this book was to provide a textbook for the next generation of Occupational Safety and Health (OSH) professionals to learn systematic methods that will help them throughout their career. As work progressed, I came to realize the book's content could also be useful to anyone with OSH responsibilities in companies currently building or upgrading their OSH programs, including many companies located in later developing countries such as India and China.

Most of the material in the book presents well-established methods and practices familiar to professionals with broad backgrounds that include industrial hygiene, occupational safety, and occupational ergonomics—three specialties I collectively refer to as OSH. I included a few innovations that I think OSH professional and students will find useful, particularly in the rigor used to define fundamental terms, the modeling method for analyzing incidents, and the consistent use of nine risk-reduction strategies.

I wrote this book for three types of readers. For students preparing for a career in OSH, the book can help them learn to approach OSH in a systematic manner. For people with OSH responsibilities in companies going through the process of upgrading their OSH programs, this book can serve as a resource to help pull together the program components needed to meet the basic safety and health needs of their employees. For OSH professionals who know everything about safety, health, and environment in the industrial sector where they work, reading this book may help them see how the OSH practices used in their industry are instances of the practices used in many sectors.

I organized the 27 chapters into five parts: (I) background, (II) analysis methods, (III) programmatic methods for managing risk, (IV) risk reduction for energy sources, and (V) risk reduction for other than energy sources. Part I provides general background for appreciating the later chapters and clarifies the fundamental terms hazard, risk, and risk reduction. Part II describes some system safety tools OSH professionals should know. Part III describes some common components of OSH programs and synthesizes all risk-reduction tactics into nine risk-reduction strategies used extensively in subsequent parts of the book. Part IV contains chapters on the hazard sources involving energy exchange—kinetic energy, electrical energy, acoustic energy, thermal energy, fires, explosions, pressure, electromagnetic energy, and severe weather and geological events. Part V addresses hazard sources other than energy sources—hazardous conditions found in workplaces, chemical substances, biological agents, musculoskeletal stressors, and the violent actions of people. Each chapter points out applications of how known practices fit within the nine risk-reduction strategies.

My thinking is that this book differs from other books on OSH and system safety in three primary ways. First, unlike other books, this one uses a deductive approach—starting with fundamental definitions and nine risk-reduction strategies, the book demonstrates that thousands of the hazard control measures familiar to OSH professionals are instances of these strategies. Second, the book takes an international approach by not treating any particular set of regulations, directives, or standards as authoritative.

A third unique feature is treating as one field the presently distinguished specialties of occupational safety, industrial hygiene, and ergonomics. During my long career working in OSH, I have witnessed a trend in which each specialty develops its own identity, holds its own conferences, has its own journals, and operates its own professional credentialing program. I would like to see this silo-building trend replaced by a shift toward unifying into one overarching field. Although I do not use this book to expressly advocate for this position, I hope that reading the entire book will convince some readers to share my viewpoint.

It is my hope that professors who teach a course in system safety will adopt this book. It is appropriate for undergraduate seniors or graduate students who have previously completed introductory courses on OSH topics. Studying this book should provide students enough system safety expertise for an OSH career and help them appreciate how the material learned in prior courses fits into a cohesive package. Students will find the book more relevant to OSH than books written for system safety professionals, and doing the end-of-chapter exercises (as explained in chapter 1) will help them improve their cognitive abilities for application, analysis, synthesis, and evaluation.

ROGER C. JENSEN

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I am fortunate to have a wonderful wife, Marian, who put up with my extended hours working on this book project and too few hours spent sharing the fun things in life. Our daughter Lea Jensen, an industrial hygienist, provided inspiration for this extended undertaking. I owe much to another relative, my cousin Jeffrey Lee, for making me aware of the career opportunities in occupational safety and health.

During my career, I have been fortunate to associate with some high-quality people who enabled me to grow professionally. While working 22 years with the National Institute for Occupational Safety and Health, I had some supervisors and mentors I want to acknowledge. Francis Dukes-Dobos and Austin Henschel introduced me to ergonomics. James Oppold, as Director of the Division of Safety Research, allowed me to develop new lines of research on the topics of safety training effectiveness, symbols on warning signs, stairway falls, machine safeguarding, and effects of climatic factors on safety-related behavior. Some of the associates I worked most closely with were John Etherton, Timothy Pizzatella, James McGlothlin, Patrick Coleman, and James Collins. After my NIOSH experiences, I joined a technical services company where I had the privilege of working with John Howard, Julian Christensen, Bill Askren, and Gary Williamson doing diverse projects on product safety, occupational safety, and ergonomics. Since 1999 I have been on the faculty of Montana Tech of the University of Montana, where I have enjoyed working with some wonderful and supportive associates in the Safety, Health, and Industrial Hygiene Department.

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Part I

Background

Part I lays the foundation for the entire book. Chapter 1 explains the multidisciplinary perspective used throughout—a perspective built on traditional occupational safety and health (OSH), enhanced by contributions from system safety, public health, and educational psychology. Chapter 2 delves into definitions of three terms used extensively in this book—hazard, risk, and risk reduction. Chapter 3 provides examples of common types of conceptual models and charting methods used in the book and the safety and health professions.

These background topics are fundamental building blocks for the four subsequent parts of the book that provide the content applicable to the practice of occupational safety and health. Part II explains several practical systematic methods for anticipating hazards, assessing risks, and analyzing systems encountered in occupational settings. Part III discusses programmatic and managerial methods for reducing risks. Part IV gets into the technical aspects of reducing risks associated with various forms of energy. Finally, part V addresses risk reduction for occupational hazards not directly linked to energy.

Chapter 1

Multidisciplinary Perspective

Throughout this book, the field of OSH is viewed broadly to include traditional occupational safety, industrial hygiene, occupational ergonomics, and, to a lesser extent, environmental pollution. To make the book internationally applicable, governmental regulations of the United States and other countries are rarely mentioned. All mathematics uses international units. In this and other chapters, italic font is used for titles of books and journals, and for the first use of technical terms defined at the end of the chapter.

Much of part I is based on information covered in traditional OSH books and journal articles. Concepts and methods from three other fields—system safety, public health, and education—are used to enrich and expand the basic OSH concepts and methods described in this book. Contributions from these three fields are provided in the following three sections.

1.1 SYSTEM SAFETY CONTRIBUTIONS

The specialty known as system safety developed in response to needs of the defense and aerospace industries to reduce the enormous costs from failed missile launches and crashed aircraft. After World War II, the United States and the Soviet Union engaged in a race to gain a military advantage. During this period of rapid technological advances, safety took a back seat, and numerous failures occurred during the testing and operational phases of these new systems.¹ Safety remained in the background during the 1950s and 1960s when a common practice was to design and build missiles and aircraft, fly them, investigate crashes, identify the apparent problems, fix those problems, and continue operations. This “fly–fix–fly” approach killed many pilots and destroyed many expensive missiles and aircraft.

The U.S. Air Force took the lead in changing the fly–fix–fly approach to one involving increased safety input during the design and testing phases of missiles, aircraft, and other major acquisitions. In particular, the Air Force published two sets of requirements: (1) *System Safety Engineering for the Development of Air Force*

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