ON THE PRACTICE
OF SAFETY

THIRD EDITION
To Irene
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Commencing a third edition of *On the Practice of Safety* was prompted by comments independently made to me by three professors who are using the book in their baccalaureate and master’s degree safety programs. This is a composite of their message: The book is great, but some of your chapters need updating.

This third edition continues to address those subjects that the author believes must be mastered by those who strive to attain professional status in the practice of safety. In the essay form used, most of these subjects are not addressed elsewhere. Their purpose is to provide

- A basis for introspection by those safety professionals who seek to improve their performance, to be perceived by management as providing value, and to achieve professional recognition
- A solid foundation with respect to the practice of safety for students in safety degree programs

The second edition of *On the Practice of Safety* was written in 1995 and 1996. Each chapter has been updated in this third edition and has also been extended or revised as needed. In several chapters, this work is extensive. Also, research I conducted on pertinent safety management subjects since 1996 provided new chapters, of which there are five. They are

- Chapter 7, “Heinrich Revisited: Truisms or Myths”
- Chapter 8, “Addressing Severe Injury Potential”
- Chapter 15, “Acceptable Risk”
- Chapter 21, “A Safety Management Standard: A Futuristic View” (This is a replacement for a chapter in the second edition which pertained to an expected safety and health standard to be issued by the
Occupational Safety and Health Administration [OSHA], the possibility of which is remote, at least temporarily.

- Chapter 23, “Behavior-Based Safety”

This book is unique in its style, purpose, and content. This is what one college professor said about it. “Your book has made me think differently about safety management, and what I want my students to learn. I hope you keep the present format in which each chapter is a stand-alone essay. I know that requires some repetition but the reader benefits by not having to refer to other chapters while reading the chapter at hand.” With partial success, that format has been retained.

Recognition has been given in several chapters to a transition that continues to move forward, and that is the bringing together under one management the staff responsibilities for safety, occupational health, and environmental affairs. Often in the book, safety is the only term used, but it connotes all of the foregoing responsibilities.

As has been the case in previous editions, this third edition emphasizes the need to balance the design and engineering aspects, the management and operations aspects, and the task performance aspects of the practice of safety.

Fred A. Manuele
Four plus years have passed since the first edition of this book was published. And transitions in the practice of safety have continued to take place, requiring some revisions in all of the essays originally written and the addition of new ones. These are the new or significantly revised chapters.

“Transitions in the Practice of Safety” is the first chapter in this edition, and it replaces the first chapter in the previous edition. It addressed the changes that have taken place in the business climate and their effect on career planning. It also discusses how those changes require having a practice that has a sound theoretical and practical base, and the opportunities they present. This new chapter also includes the substance of the last chapter in the first edition, which was “On Management Fads.”

The chapter on the “Principles for the Practice of Safety: A Basis for Discussion” should be of interest to those who think about the substance of what safety professionals do and want to move the state of the art forward.

In recognition of the need to further our knowledge of hazards-related incident causation, a chapter offers “A Systemic Causation Model for Hazards Related Occupational Incidents.”

“Designer Incident Investigation” is to help safety personnel craft practical and realistic incident investigation systems, after considering the resources available and organizational sophistication.

The chapter “Guidelines: Designing for Safety” is a concept paper that is to assist those whose responsibilities are extended into the design processes.

In the first edition, there were separate chapters offering comments on hazards and risks. They have been combined into one chapter titled “Comments on Hazards and Risks.”

The original chapter “Anticipating OSHA’s Standard for Safety and Health Program Management” has been extended to include comments
on the safety management audit system that OSHA is exploring.

Having sound safety performance measurement systems has become more important: thus the new chapter “Measurement of Safety Performance.”

This second edition emphasizes the need to keep in balance the design and engineering aspects and the management and task performance aspects of the practice of safety.

Fred A. Manuele
Throughout a rewarding career as a safety professional, I have observed with pride the achievements of the many who have contributed to the recognition of the practice of safety as a profession. We’ve come a long way. It is my hope that through this book I can assist in furthering that progress.

Ours is a profession in transition, with many additional opportunities for professional involvement, accomplishment, and recognition. In light of the transitions in progress, the essays in this book propose an extension of knowledge by those engaged in the practice of safety, through which they can enhance their careers, become more effective, and be perceived as greater contributors toward achieving organizational goals.

This is also a book about fundamental principles and practices. It is addressed to students, educators, and practicing safety professionals. I hope that readers will welcome a review of our fundamentals, intended to improve the theoretical and practical base for our practice. I have attempted to argue systematically and consistently for hazards management ideas of substance in relation to our history, opportunities, and needs.

I expect that these essays will be slightly controversial since some long-accepted concepts are put to question. Some practices that have become fashionable are not sound. I understand that what I propose will be perceived by some to be heresy. Some readers will presume that I have put their finest ideals under scrutiny and proposed significantly different concepts.

In an atmosphere of quiet deliberation, my best hope is that what I have written will be perceived as thought-provoking and will serve to further the professional practice of safety.

Fred A. Manuele
ACKNOWLEDGMENTS

To properly recognize all who have contributed to this book, I would have to cover a period of 78 years and the list of people deserving appreciation would be endless. Particularly, though, to the people who gave of their time in past years and critiqued individual essays, as well as to the people who made written contributions to individual chapters, I express my sincere thanks and gratitude.

FRED A. MANUELE
INTRODUCTION

Chapters in this book cover a broad range of subjects pertaining to the practice of safety, and I thought it would be helpful to readers—safety professionals, educators, and students—if I provided guidance on their content through a brief synopsis of each of the them.

1. SUPERIOR SAFETY PERFORMANCE: A REFLECTION OF AN ORGANIZATION’S CULTURE

An organization’s culture determines the probability of success of its hazards management endeavors. What the board of directors or senior management decides is acceptable for the prevention and control of hazards is a reflection of its culture. That theme is established. Also, results of interviews conducted with safety personnel in organizations where the culture requires highly successful safety performance are set forth, along with comments on how safety management programs are made to work successfully.

2. TRANSITIONS AFFECTING THE PRACTICE OF SAFETY

Higher performance expectations have resulted from changes that have taken place in the business climate in recent years. How safety professionals can respond effectively to those expectations is discussed. Changes that have occurred also promote the development of personal career enhancement plans, for which an outline is provided. Opportunities
presented by what is new in the emerging safety technology are also addressed.

3. DEFINING THE PRACTICE OF SAFETY

We who call ourselves safety professionals will never be accepted as a profession until we agree on a definition of the practice of the safety, make it known, and meet its requirements. This chapter identifies the societal need fulfilled by safety professionals, establishes why safety professionals exist, and sets forth the fundamentals of the practice of safety.

4. PRINCIPLES FOR THE PRACTICE OF SAFETY:
A BASIS FOR DISCUSSION

For the practice of safety to be recognized as a profession, it must have a sound theoretical and practical base. I propose that there is a generic base for the work of safety professionals that must be understood and applied if we are to be effective. We take a variety of approaches to achieve safety, and they can’t all be right. To promote discussion, a listing of general principles, statements, and definitions is given.

5. ACADEMIC AND SKILL REQUIREMENTS
FOR THE PRACTICE OF SAFETY

Reviews are given of the academic knowledge and skills that must be acquired to prepare one to enter the practice of safety, and of the knowledge and skill requirements for the applied practice of safety, using the term broadly. An updating will include a review of the curricula for safety degree programs approved by the American Board of Engineering and Technology.

6. ON BECOMING A PROFESSION

Safety practitioners will attain professional recognition only when the practice of safety meets the regimens of a profession. Recognizing first the great accomplishments thus far toward achieving professional recognition, a review of our present status, needs, and actions that we should consider are encompassed in a discussion outline.
7. HEINRICH REVISITED: TRUISMS OR MYTHS

H. W. Heinrich has had more influence on the practice of safety than any other writer. His concepts are set forth in four editions of Industrial Accident Prevention: A Scientific Approach. Copyright dates are 1931, 1941, 1950, and 1959. It has been known that some of his concepts, accepted by many as truisms, are not sustainable under scrutiny. Research for this chapter was done as a result of discussions with a learned colleague during which we agreed that for our practice to be recognized as a profession, age-old but continued-in-use premises that, upon examination, would be judged invalid must be eliminated. Furthermore, the case is made that we must be capable of discarding those premises that scrutiny reveals to be unsustainable.

8. ADDRESSING SEVERE INJURY POTENTIAL

This chapter derives from the research done on the Heinrich concepts, one of which is that “The predominant causes of no-injury accidents are, in average cases, identical with the predominant causes of major injuries — and incidentally of minor injuries as well.” That premise is unsound, and the application of it by many safety practitioners has resulted in misdirection of efforts and an ineffective use of resources. This author’s research and that of others (Petersen, Allison, Ferry, Benner, and Norman) is cited.

Much is made of the fact that the types of accidents resulting in severe injury are different from those resulting in lesser injury. Also, it is established that many severe injuries occur from certain, identifiable high-risk types of activities. A pre-job safety analysis guideline to address the hazards and risks prior to commencing such activities is presented.

9. OBSERVATIONS ON CAUSATION MODELS FOR HAZARDS-RELATED INCIDENTS

If several safety professionals investigate a given hazards-related incident, they should identify the same causal factors, with minimum variation. That is unlikely if the thought processes they use have greatly different foundations. At least 25 causation models have been published. Since many of them conflict, all of them cannot be valid. A review of some of them is followed by a discussion of principles that should be contained in a causation model.
10. A SYSTEMIC CAUSATION MODEL FOR HAZARDS-RELATED INCIDENTS

In the causation model presented in this chapter, there is a plea for recognition of the impact an organization’s culture has on causal factor development, as well as for a balanced, systemic approach that addresses the design and engineering, the management and operational, and the task performance causal factors.

11. INCIDENT INVESTIGATION: STUDIES OF QUALITY

Hazard analysis is the most important safety process. If that process fails, all others processes are likely to be ineffective. Incident investigation serves as one vital basis for hazard analysis. Initially, a collection of 537 actual incident investigation reports was made from 11 companies for a study of their quality. This chapter gives the findings of the study, provides a self-evaluation outline through which the quality of incident investigation can be assessed, and discusses how incident investigation can be improved. A subsequent study was made of the quality of incident investigation in 6 companies that have superior achievements in safety, and the findings of that study are recorded.

12. DESIGNER INCIDENT INVESTIGATION

Because of the variances in safety cultures and the resources available, it is folly to suggest that an incident investigation system could be crafted that would universally apply in all organizations. Guidance is given for a safety professional to assess that which is attainable and to draft an incident investigation system that relates realistically to organizational culture and sophistication.

13. COMMENTS ON HAZARDS AND RISKS

Hazards are the justification for the existence of all safety professionals—whatever titles they have. Hazards are defined as the potential for harm or damage to people, property, or the environment. Hazards include the characteristics of things and the actions and inactions of people. This chapter stresses that safety professionals must have an understanding of the relation of hazards to risks. It is established that all risks with which safety professionals deal derive from hazards. There are no exceptions.
14. HAZARD ANALYSIS AND RISK ASSESSMENT

Safety professionals cannot properly give advice on hazards and risks unless the hazards are analyzed and the risks deriving from them are assessed as to their significance. This chapter works through the process of hazard analysis and subsequent risk assessment. It explores hazard analysis and risk assessment methods, discusses the jeopardy in using some published techniques, and concludes with a practical methodology outline. Since there has been a proliferation of risk assessment matrices in recent years, some of them are examined, for their pros and cons.

15. ACCEPTABLE RISK

Regularly at safety conferences and in the work of committees drafting safety standards, controversy develops over the level of risk that is acceptable. This chapter presents a thought-provoking review of the levels of risk acceptable in various enterprises (space travel, auto racing, various manufacturing and business entities) and for product safety. It also provides a practical, useable framework for safety practitioners to use in determining acceptable risk levels.

16. SAFETY PROFESSIONALS AND THE DESIGN PROCESS

The greatest strides forward with respect to safety, health, and the environment are being made in the design processes. An awareness of the soundness of that premise is emerging. A review of developments in the past few years [i.e., a European influence that requires hazard analysis and risk assessments for products shipped to European Union (EU) countries, new ANSI standards and guidelines that include hazard identification and analysis in the design process] is given. The first safety decisions are made in the design process. Discussions establish why safety professionals should become involved in the design processes, how to get there, and the skills needed.

17. GUIDELINES: DESIGNING FOR SAFETY

Since transitions in the practice of safety are leading safety professionals into greater involvement in the design processes, readily available guidelines on the concepts of designing for safety would serve them well. Since a search for such guidelines was unproductive, an informational,
educational reference chapter was written for those who participate in having safety designed into processes, the workplace, and the work methods — applying proactive and cost-effective concepts.

Risk, in the context of the work of safety professionals, requires a measure of the probability of hazards-related incidents occurring and of the severity of harm or damage that could result. Thus, a case is made that the two distinct aspects of risk must be considered by safety professionals in fulfilling their responsibilities: (1) avoiding, eliminating, or reducing the probability of a hazard being realized and (2) minimizing the severity of adverse results if an incident occurs.

18. SYSTEM SAFETY: THE CONCEPT

Lessons can be learned from the successes attained by system safety practitioners. System safety is hazards-based and design-based. So is the entirety of the practice of safety. This chapter establishes why it is important for generalist safety professionals to acquire knowledge of system safety principles, and it outlines the system safety idea. As opportunities arise for generalist safety professionals to participate in the design processes, the need for system safety skills will be apparent.

19. APPLIED ERGONOMICS: SIGNIFICANCE AND OPPORTUNITY

Ergonomics has emerged to become a major element in the practice of safety. Many ergonomics revisions in workplace and work methods redesign that were initiated to resolve injury and illness problems have also achieved increases in productivity and reductions in costs. That gets management attention, and it provides opportunities for extended involvement by safety professionals and recognition. This chapter looks to the future and explores the long-term impact of ergonomics on the content of safety practice. It will be significant.

20. ON QUALITY MANAGEMENT AND THE PRACTICE OF SAFETY

This chapter establishes the similarities between the principles of quality management and the principles for the practice of safety; explores the theoretical ideal for quality and safety; reviews the criteria for The Malcolm
Baldrige National Quality Award; and comments on the work of Deming, Crosby, Juran, Gryna, and Winn, as well as on that of Brown, Hitchcock, and Willard. Comments are also made about the Six-Sigma quality management program established at Motorola and adopted by many others. Why some quality management and safety management initiatives succeed or fail is discussed.

21. A SAFETY MANAGEMENT STANDARD: A FUTURISTIC VIEW

In June of 2001, the International Labour Office (Geneva) issued a far-reaching document titled Guidelines on Occupational Safety and Health Management Systems. Also, the American Industrial Hygiene Association has received approval from the American National Standards Institute to serve as the Secretariat to produce a comparable document. This chapter explores the fundamental extensions of typical safety management systems that can be anticipated. Particularly, emphasis is given to the measures designed to prevent bringing hazards into the workplace.

22. ON SAFETY, HEALTH, AND ENVIRONMENTAL AUDITS

Most safety, health, and environmental audits, which are to measure the quality of hazards management in place, are deficient in purpose and content. Shortcomings in those audits addressed in this chapter are: the assessments given to organizational culture, management commitment, and design and engineering practices; the inadequate attention given to low probability–high consequence events; and prioritizing risk reduction measures. Principal purposes of an audit, what an audit should accomplish, and the criteria that a safety audit should meet are discussed.

23. BEHAVIOR-BASED SAFETY

The current status of behavioral safety is reviewed. Comments are made on: the changes in approaches that have taken place; how the message has changed somewhat from emphasis on worker behavior to management systems; the interface of the worker with the workplace environment; and performance improvement. Also, the behavioral aspect of accident causation and where behavioral safety fits in an overall, effective safety management system are put in perspective.
This chapter responds to a renewed interest in having measurement systems that are universally applicable, effectively assess occupational safety performance, and communicate well in terms that managements understand. Several safety measurement systems are discussed. A relatively new emphasis in safety performance measurement — leading indicators — is discussed.
SUPERIOR SAFETY PERFORMANCE: A REFLECTION OF AN ORGANIZATION’S CULTURE

INTRODUCTION

In previous editions of this book, this chapter was titled Successful Safety Management: A Reflection of an Organization’s Culture. Note that in this edition successful has been replaced by superior. In discussions with some safety practitioners, I found that what they considered successful might really be only slightly better than average and not superior.

What is described here is a reflection of the safety initiatives in a few large, worldwide companies where the safety record truly is superior, meaning outstanding in relation to others in similar businesses. It’s my view that if an entity wants to achieve superior safety results, compared to the best in the world, the concepts and procedures set forth here must be adopted. As the term safety is used in this chapter, it encompasses environmental affairs, occupational health and safety, and product safety.

In determining whether the safety results are superior, the incident experience and the costs, measured over a sufficiently long term, are the principle determinants. Subjective judgments won’t qualify for this purpose. But, it is not suggested that achieving outstanding or excellent safety results is easy, whatever measures are applied.

I refer to an article titled Safety and Health Excellence Proves Elusive. It appeared in the July 2002 issue of Occupational Hazards (p. 28). Compilations are given of the reader responses to the Occupational Hazards’
National Safety Survey. One of the questions asked was, How would you rate the safety and health program at your facility/organization? These are the composite responses:

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<thead>
<tr>
<th>Grade</th>
<th>Percent</th>
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<tr>
<td>Excellent</td>
<td>20.5</td>
</tr>
<tr>
<td>Good</td>
<td>51.8</td>
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<tr>
<td>Average</td>
<td>19.6</td>
</tr>
<tr>
<td>Fair</td>
<td>5.6</td>
</tr>
<tr>
<td>Poor</td>
<td>1.9</td>
</tr>
<tr>
<td>No answer</td>
<td>0.5</td>
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Giving generous credibility to the quality of the survey and to the subjective judgments that resulted in 20.5% of the responders rating their safety and health programs Excellent, it nevertheless occurred that 79.5% gave themselves a rating lower than Excellent. That is a realistic split. Being in the top 20% of safety performers, or better, is what this chapter is all about. As the term superior is used here, it means achieving incident experience and costs very much lower than the average for an industry or business.

I wrote in the second edition of this book that several transitions had taken place in the applied practice of safety since the first edition was published. To expand on what I had observed, I sought input on their current practices from safety professionals in five companies whose safety performance has been consistently outstanding within their business categories. They are very large conglomerates; a list of all their business categories would fill several pages.

Each company had been through at least one downsizing, and staffs were lean. Throughout their operations, more is expected of fewer people. Although their safety achievements were superior, in all five companies executive-led improvement activity was in progress. I discussed how, at that time, the model companies achieved outstanding safety performance, and I set forth the comments I would make to safety professionals on what is necessary with respect to specific elements of safety systems to achieve superior results.

Similar discussions took place in 2002 with safety professionals in four of the five companies with whom conversations had previously taken place: One of the companies disappeared in a merger. Another was added to replace it. What did they say? Strong pressure on the organization to produce financial results existed in 1996; it’s stronger in 2002. Turmoil as to mergers and acquisitions, splitting of companies, and staffing levels is to be expected. Staffs are lean, and even more is expected of them.
INTRODUCTION

My principal question was, What significant changes or additions have been made with regard to elements in your safety management systems? That produced a surprising response from all of them: none. They did say that emphasis on specific safety management elements varied from year to year. As one safety professional said:

Not one new safety program element has been added in several years. We thought we were doing well, until a new member arrived on our board of directors who took the position that we could do better. Through his influence, a culture change has taken place that heavily influenced senior management and its accountability system. The same, good safety management systems we had in place are now more effective, and our results show it. Managers are held accountable in a way that was difficult for them to accept at first.

But, I need to say that emphasis on some of the safety system elements has varied over the past few years. For instance, we had a strong push for a while to overcome our ergonomics risks, and we’ve come a long way. Now, we’re concentrating on what we know to be the improvement needed in our accident investigation process, and on our high-risk jobs.

In a company that has achieved a 90% reduction in incident experience and in costs over a period of 15 years, the safety professional with whom I spoke said:

Our incident experience and our costs are so low that achieving a twenty percent reduction in costs would not result in a number large enough to influence senior management to undertake further expenditures principally to get costs down further. In relation to our industries, we think our incident rates and costs are less than one-sixth of the average. We are feeling the effects of world competition, as is every one else. Staffing is lean throughout our companies. But the CEO hasn’t let up on his insistence that we keep the incident rates as low as they are. We’re fortunate that he knows it will be very difficult to get them lower. He maintains his position as the leader for safety, health, and environmental affairs, and the managers know that they are being held accountable for results.

As to new safety system elements, we don’t have any. But we do try different things. You know that we use a lot of chemicals and we are reexamining our permissible exposure levels because we are determined to do better than the world standards. You’ll be interested in this one new approach we’re taking—we are addressing the gap between theory and reality, trying to do a better job of incorporating elements in our environmental, health, and safety systems within the concept of operational excellence. [Editorial note: Wow!]
All of the safety professionals with whom I spoke were affected by the World Trade Center tragedy, but not as much as I expected. They are employed in large companies that have extensive security staffs, on whom the responsibility for additional security measures fell. There is an overlapping of responsibility with security personnel since an element in all of their safety management systems pertains to “Emergency and Disaster Planning,” which will be addressed later.

All of these safety professionals are aware that the culture in their organizations demands superior safety results, and we will start our review of what it takes to be an outstanding safety performer with a discussion of culture. (While safety alone as a term may appear in this chapter, it is to encompass all of the aspects of environmental, health, and safety matters.)

CULTURE DEFINED AND ITS SIGNIFICANCE

In all of the model companies, safety is culture-driven. Senior management is personally and visibly involved and holds employees accountable for results. The senior executive staffs display by what they do that hazards management is a subject to be taken very seriously, a subject that is considered in performance measurement along with other organizational goals.

What is meant by “culture”? An organization’s culture consists of its values, beliefs, legends, rituals, mission, goals, performance measures, and sense of responsibility to its employees, customers, and community, all of which are translated into a system of expected behavior.

An organization’s culture determines the level of safety to be obtained. What the board of directors or senior management decides is acceptable for the prevention and control of hazards is a reflection of its culture. Management attains, as a derivation of its culture, the hazards-related incident experience it establishes as tolerable. For personnel in an organization, “tolerable” is their interpretation of what management does. This phrase is often heard: You will achieve the level of safety that you demonstrate you want to achieve.

Several companies produce annual environmental, health, and safety reports that demonstrate the place that safety has within their cultures. Some of those reports are on the Internet and downloadable.

Excerpts of five such reports are given here, reproduced with permission, from Bayer, Air Products and Chemicals, Intel, Johnson & Johnson, and DuPont. In those reports, a pattern is evident that represents the absolutes necessary to attain superior safety results:
• Safety considerations are incorporated within the company’s culture, within its expressed vision, values, beliefs, core values, and system of expected behavior.

• The board of directors and senior management lead the safety initiative and make clear by what they do that safety is a fundamental within the organization’s culture.

• There is a passion for and a sense of urgency for superior safety results.

• Safety considerations permeate all business decision-making, from the concept stage for the design and development of new products, processes, and procedures, through to the disposal of the products made and the facilities in which the products are made.

• An effective performance measurement system is in place.

• All levels of personnel are held accountable for results.

Whatever the size of an organization — 10 employees or 100,000 — the foregoing principles apply to achieve superior safety results. Safety is culture-driven, and the board of directors and senior management define the culture and the expected pattern of behavior.

Health, Environmental and Safety at Bayer: Changing the World with Great Care, 2001

At Bayer Corporation, we are strongly dedicated to protecting and improving health and the environment. Our commitment goes beyond our products—which range from aspirin and antibiotics to pigments and plastics—to include safeguarding the health of our employees, our customers and business partners, our community members and plant neighbors, and the environment in which we all live. We meet this goal through one of the industry’s most successful safety programs, a comprehensive waste reduction initiative and a nationally recognized environmental stewardship program.

We consider it our responsibility to protect the environment and health and safety of our employees, customers, business partners and communities; to comply with all applicable laws and regulations; and to establish and implement responsible practices where laws and regulations do not exist. Only by upholding these responsibilities can we continue to change the world with great care.

Protecting the Environment

It is because of our desire to protect the world we will pass on to our children that we strive to maintain a balance between manufacturing products we depend on in our modern world and safeguarding our environment.
Through sustainable development, industry can continue to grow while also protecting the environment.

**Staying Safe**

For decades, Bayer’s safety record has been one of continuous improvement. Rarely has a year gone by without seeing a reduction in the number and severity of on-the-job injuries. Today, our award-winning program is an outstanding success and a model for other companies.

During the 1990s, our safety program reduced injuries by two-thirds, saving more than 2,000 employees pain and suffering. It is not unusual for our plants to go millions of hours without a lost workday due to an on-the-job injury. At some locations, years pass without an employee being hurt on the job.

Process safety is a prerequisite to worker safety and begins when the plant or manufacturing line is on the drawing board. From comprehensive design and hazard analysis through preventive maintenance and employee training, we assure our operations not only meet the Occupational Safety & Health Administration’s (OSHA) Process Safety Management standard, but also are intrinsically safe.

The most important safety benefit is the improvement in the day-to-day health and safety of our employees. We not only want our employees to return home safely to their families, we want them to remain safe when they are outside their work environments. Many of our safety lessons can be applied at home as well as in the work place.

**Taking Responsibility**

At Bayer, we believe our responsibility does not end when we place our materials on a truck, barge or train for transport to the customer. Even when the product is in the hands of the customer, it is part of our commitment to product stewardship and the Responsible Care® program to help ensure the product is used correctly. We provide a full complement of safety information and extensive training to our customers, whether they are manufacturing tires or administering a life-saving drug to a child.

The following excerpts are from the *Bayer Corporation, Annual Report 2001*. Its theme is “Bayer: Success Through Expertise with Responsibility.”

**Substantial Reduction in Emissions Since 1990**

We are among the leaders in our industry with a nearly 50 percent reduction in greenhouse (Kyoto) gases since 1990. Special emphasis is placed on “in-process environmental protection,” a progressive concept we have rigorously pursued since the early 1980s.
Record Safety Performance

Bayer also made further progress in the areas of process, plant and occupational safety. The number of industrial injuries resulting in absence from work has been halved since 1990 and the number of recordable environmentally relevant incidents at Bayer sites has fallen more than 70 percent over the same period, despite the application of much stricter reporting criteria since 1998. Bayer’s U.S. operations have the lowest injury rate. There, the number of injuries per million hours worked is less than half the Group average—the result of a highly developed safety culture. For two straight years (1999 and 2000), Bayer Corporation was rated by the American Chemistry Council (ACC) as the second safest large chemical company in the United States. Our aim now is to again halve, by 2004, the Group’s MAQ (Million Working Hour Quota) and the total number of workdays lost through accidents.

Air Products and Chemicals — Environmental, Health, and Safety Policy

We will be an industry leader in environmental, health, and safety performance and are committed to the following basic principles in managing our business worldwide:

- Compliance with all applicable environmental, health, and safety laws and regulations.
- Continual improvement in environmental, health, and safety performance with the ultimate goal of zero injuries and zero emissions of toxic and hazardous materials.
- Design and operation of our plants and facilities in a manner that protects the environment and the health and safety of our employees and the public.
- Development and production of products that can be manufactured, distributed, used and recycled or disposed of in a safe and environmentally sound manner.
- Open discussion of our environmental, health, and safety practices and performances.
- Active participation in Responsible Care and similar initiatives in the countries in which we operate.

Excerpts from the Report Titled Air Products and Chemicals Inc. — Where We Stand 2001

Safety Performance: Number One Again

We had an outstanding year in terms of the overall safety of our employees. For the second consecutive year, Air Products was named the safest large-scale chemical manufacturer in the U.S. according to the American Chemical Council.
In earning that designation, we achieved the industry’s best record in key categories, including lost-time injuries and recordable accidents, the category cited most often when comparing safety records inside the chemical industry.

In 2000, our total recordable incidence rate of 1.02 per 200,000 employee hours worked bettered our 1999 rate and was well ahead of the industry average for large companies of 2.26 recordable injuries per 200,000 employee hours worked. For the 2001 fiscal year, results continued to improve, with recordable accidents dropping to a rate of 0.82 per 200,000 hours worked. Lost-time injuries, the most serious accident category, improved slightly to a rate of 0.18 per 200,000 hours worked compared with a rate of 0.19 in the 2000 fiscal year.

The superb results we recorded this year were marred by a few serious accidents. While these were isolated incidents in a company with more than 17,000 employees, they were stark reminders that safety needs to be in the forefront of our minds at all times. We must be—and we are—focused on safety and our ultimate goal of zero injuries.

Intel Corporation’s Environmental, Health and Safety Report 2001. As this report indicates, Intel has achieved remarkable results in safety management.

At Intel, we pursue EHS performance the same way we pursue performance in the marketplace. We have worked to become global leaders in EHS. This commitment is integrated throughout the corporation, from our executives to every employee.

— Craig R. Barrett
Chief Executive Officer

Intel is setting the benchmark for world-class safety performance. We benchmark our performance across all industries as well as with leading semiconductor manufacturers.

Intel employees continue to improve on their world-class safety performance. OSHA recordable injuries have decreased an average of 30 percent each of the last five years.

Despite the lowest injury and illness rate in the semiconductor industry—and possibly the lowest rates in any industry—we continue to improve our illness and injury performance. In 2001, we reduced our already world-class OSHA recordable rate by an additional 33% to 0.19 injuries per 100 employees. Said another way, Intel’s safety performance is about 4,500% better than that of the average U.S. manufacturing company. [Editorial note: Intel’s Lost-Day case rate in 2001 was 0.04, which is truly superior.]
Intel’s Environmental, Health, and Safety Policy follows. It appears in the 2001 report under the signature of the CEO. The combined environmental, health, and safety policy was prepared in 1991 and was last revised in March 1998. Individual environmental, safety, and health policies predate 1991. From their inception, application of the policy statements has significantly affected the culture at Intel.

**Environmental, Health, and Safety Policy**

We are committed to conserving natural resources, reducing the environmental burden of waste generation and emissions to the air, water and land. Through continuous improvement methodologies, we will develop environmentally compatible products and processes. We will strive to be leaders in reducing, reusing and recycling, and will ensure that any wastes remaining are properly disposed of in a safe and environmentally sound manner.

We will be a responsible member of the communities in which we live and work. We will continue to expand our knowledge and understanding of the effect of our operations on safety, health and the environment. We are committed to continuous improvement in our operations and to sharing the knowledge we gain with our employees, customers, suppliers, the communities in which we live and work, the scientific community, government and industry.

We will establish and maintain appropriate controls including periodic review, to ensure that this policy is being followed.

— Craig R. Barrett
Chief Executive Officer

As the report says, Intel is setting the benchmark for world-class safety performance. Its safety efforts are obviously driven by its culture, which is demonstrated by its board of directors and the senior executive staff.

**Johnson & Johnson’s Environmental, Health, and Safety 2001 Sustainability Report**

In this report, a letter signed by both the Chairman of the Board and Chief Executive Officer and the Senior Vice Chairman of the Board, who is the Chairman of the Worldwide Environmental Steering Committee, follows a lead-in titled — *Healthy people, healthy planet*. They mention living their Credo promise every day. They say that:

Our people have demonstrated an unwavering dedication to environmental protection, employee wellness, workplace safety and community outreach. Johnson & Johnson’s commitment to leadership in environmental, health and safety performance will continue in the future. We encourage all employees to be involved and work together so Johnson & Johnson continues to be a good neighbor and an exemplary corporate citizen.
Johnson & Johnson operates as a global organization with a decentralized management philosophy. Throughout our extensive network of companies, however, certain fundamental principles guide our daily activities. By establishing management structures that drive environmental, health and safety performance, we seek to integrate respect for people and the planet into our business practices worldwide.

**Policies and Organization**

Johnson & Johnson’s policies and practices originate with Our Credo, a statement of the Company’s responsibilities to customers, employees, communities and shareholders. Our Credo expresses the company’s commitment to product quality, employee health and well-being, environmental protection, social outreach and sustainable business practices.

**Environmental Strategic Vision**

*We are committed to environmental leadership, instituting the highest environmental values in all employees, utilizing the best environmental practices in all we do and focusing on sustainable growth.*

**Health and Wellness Strategic Vision**

*We are committed to optimizing the health, well-being and productivity of Johnson & Johnson employees.*

**Safety and Industrial Hygiene Strategic Vision**

*We are committed to making Johnson & Johnson the world leader in health and safety by creating an injury-free workplace.*

At Johnson & Johnson, our commitment to environmental, health and safety leadership begins at the highest levels of the corporation. The Public Policy Advisory Committee of the Board of Directors oversees the Company’s policies, programs and practices on public health issues regarding the environment and employee safety. This committee includes three board members and our Vice President, Administration, and Executive Committee Member, Russell C. Deyo.

The Technical Resources Group and Worldwide Benefits & Health Resources provide leadership, governance and support to Johnson & Johnson operating companies around the globe. Environmental, Health & Wellness, and Safety Professionals worldwide work to implement our programs in the operating companies.

For emphasis, I repeat from the foregoing: “By establishing management structures that drive environmental, health and safety performance, we seek to integrate respect for people and the planet into our business practices worldwide.”
DuPont's Sustainable Growth 2001 Progress Report—Safety, Health & Environmental Section. These are excerpts from a letter from the Chief Executive.

As a company preparing to celebrate our 200th anniversary in 2002, we hold as fundamental a culture that values the safety and health of people.

Our safety and health performance remains significantly better than the industry average. As a company, we have historically had very strong policies and actions related to the safety and treatment of our employees and the ethical conduct of our business.

The signature on the letter is interesting and unique. It is as follows: Charles O. Holiday, Jr., Chairman and Chief Executive Officer and Chief Safety, Health and Environmental Officer. DuPont has made a point for years that its CEO is also the chief safety, health, and environmental officer, and that is known throughout the organization. DuPont employees profess that safety is a part of its heritage, that safety is good business, and that safety makes the company credible.

Additional excerpts from the DuPont report that are pertinent to this chapter follow.

The DuPont Commitment

We affirm to all our stakeholders, including our employees, customers, shareholders, and the public, that we will conduct our business with respect and care for the environment. We will implement those strategies that build successful businesses and achieve the greatest benefit for all our stakeholders without compromising the ability of future generations to meet their needs. We will continuously improve our practices in light of advances in technology and new understandings in safety, health and environmental science. We will make consistent, measurable progress in implementing the Commitment throughout our worldwide operations.

Highest Standards of Performance, Business Excellence

We will adhere to the highest standards for the safe operation of facilities and the protection of the environment, our employees, our customers and the people of the communities in which we do business.

Management and Employee Commitment, Accountability

The Board of Directors, including the Chief Executive Officer, will be informed about pertinent safety, health and environmental issues and
will ensure that policies are in place and actions taken to achieve this Commitment.

Compliance with this Commitment and applicable laws is the responsibility of every employee and contractor acting on our behalf and a condition of their employment or contract. Management in each business is responsible to educate, train and motivate employees to understand and comply with this Commitment and applicable laws.

DuPont’s Commitment statement is believed by its employees to be sincerely presented, and it is applied by management as written. It establishes a proactive rather than a reactive posture and implies anticipatory hazard prevention and control and the allocation of the resources necessary for accomplishment.

DuPont’s emphasis on off-the-job safety is an additional indication of its culture. Off-the-job safety is treated as importantly as on-the-job safety. It is recognized that the factors influencing behavior and beliefs are the same in both environments. Companies that stress off-the-job safety are the exceptions.

Chapters of books and articles have been written with titles such as “The Hazard Control Process,” “Basic Safety Programming,” “Managing Safety Performance,” “Management of Loss Control,” and “Safety Performance.” But none of the authors considered the impact of an organization’s culture on the safety performance attainable. To achieve superior safety results, the system of expected behavior deriving from the culture must demonstrate that such results are to be attained.

In the model companies, safety professionals are expected to perform so as to be perceived as a part of the management team and as assisting the decision-makers in fulfilling their expectations. If accomplishment is the safety professional’s purpose, then an understanding must be attained of the priorities of managers at a given time (expansion, contraction, capital expenditure restrictions, staffing constraints) and of the organization’s culture and how to work effectively within it.

A principal goal for safety professionals should be to influence the organization’s culture as it pertains to safety decision-making. Understandably, this goal may not be reached easily. Effecting a culture change doesn’t get done quickly (a supertanker can’t make a sharp right turn). An organization will experience the impact of the culture in place for quite some time. Significant cultural improvement or deterioration occurs only in the long term.

Because of rising costs, public embarrassment, or a number of other factors, management may decide that dramatic improvements in safety
must be attained in a rather short time. A bit of skepticism is appropriate when that occurs.

**MANAGEMENT COMMITMENT, DIRECTION, AND INVOLVEMENT**

In the model companies, senior management assumes responsibility for safety and provides the leadership necessary to achieve the superior results expected. Management has ownership of safety as a part of operating responsibility. It’s understood that management commitment, direction, and involvement are the sine qua non, the prime requirement for effectiveness in safety. If superior results are desired, there must be a long-term commitment to long-term goals. That’s an absolute.

*What management does, rather than what management says,* defines the actuality of commitment or noncommitment to safety. What management does permeates the thousands of decisions made that create the work environment, set design specifications for facilities and equipment, establish fire protection standards, respond to environmental needs, and so on. What senior management does is interpreted by the organization as the role model to be followed. It’s at the senior management level that measurable goals are established for performance expectations.

**ESTABLISHING ACCOUNTABILITY**

Accountability for safety performance in the superior performing companies is clearly established with line management at every level. Safety performance is one of the elements scored in the organization’s overall performance measurement system. Favorable or unfavorable results influence salaries, bonuses, and promotion potential.

One of the principal indicators of management commitment to safety is the inclusion of safety performance in the performance review system. Management commitment to safety is questionable if the accountability system does not include safety performance measures that impact financially and on the promotion potential of those responsible for results.

Here are two real-life indicators of the impact on managers of accountability systems in practice.

1. A plant manager, speaking at a conference, said that the first items discussed in his annual performance review were his achievements in relation to previously established goals for employee injuries and illnesses, environmental occurrences, and fires. Meeting or not meeting those goals
had a bearing on his salary. He was very much informed about incidents that had occurred, and his involvement was readily apparent. He could quote fire losses per 100 dollars of plant value to the mil.

2. A company became displeased with its employee injury, motor vehicle, and product liability incident experience. Its senior executives arranged a visit to a facility of another organization, known to have a superior incident record. When discussions commenced, visitors were surprised that the meeting was run by the manager of the host location. It became obvious that the safety program was the manager’s program and that he considered himself to be accountable for it. The facility manager spoke in depth of his personal involvement in capital expenditure considerations for hazards management, of his requirements for the safety and health professional staff, of the system in place through which he maintained accountability, and of his expectations of the staff immediately reporting to him. During the plant tour, which he led, he commented extensively on the specifics of hazard prevention and control measures in the facility, displaying his personal involvement.

SAFETY ORGANIZATION AND STAFF

Fewer safety professionals are employed now in most of the major companies with which I have had association in the past few years. Nevertheless, the superior performers still maintain a top-quality staff, which is a requisite for the accomplishment level defined by the culture. The safety staff is expected to earn recognition and respect and establish their capabilities, thereby being sought by decision makers for their views. They are a part of management and have ready access to senior executives.

An organization’s personnel will “read” the import given to safety by management through its appraisals of the qualifications of the safety staff and their reporting place in the management structure. If the safety director’s position is treated as insignificant, management instructs the organization that safety is insignificant. There is no one magic reporting structure for the safety function, except that the senior safety executive is not far from the top in companies where results are superior.

In one such organization, the vice president for safety, health, and the environment reports to the senior vice president for human resources and corporate plans who reports to the chief executive officer. In another company, the vice president for environmental affairs and safety reports to the executive vice president who reports to the chairman.

In both of these organizations, safety, health, and environmental affairs have been brought together under a single management. That is the
trend—largely influenced by economics and the recognition that the arrangement presents synergy opportunities. An awareness has developed that the basic sciences of safety, health, and the environment overlap considerably and that greater management effectiveness can be attained under a single direction.

Equally important is the need for effective communication among the professionals involved in each hazards-related function. A case can be made for a unified management that includes all hazards-related professionals.

Professional requirements for safety personnel with regard to education, experience, accomplishment, and executive ability in those organizations whose cultures require superior safety performance have been moved up a few notches in recent years. Model companies expect their safety personnel to maintain professional competency and provide opportunities to do so. Their safety professionals are expected to be active in safety committees of trade associations and in technical societies. Also, they are encouraged to (a) expand their horizons through additional education and (b) increase their knowledge of operations so as to better understand and relate to the organization.

TECHNICAL INFORMATION SYSTEMS

In all organizations where safety expectations are high, technical information systems exist to serve as resources on hazard prevention and control. Personnel at all levels come to rely on those resources.

The extent of use of the technical information system is a reflection of the effectiveness of the safety, health, and environmental affairs staff.

COMMUNICATION AND INFORMATION SYSTEMS

Communication on safety by all levels of employment is encouraged as a part of the organization’s culture. Management promotes a continuing and open discussion of hazards, incidents, and concerns about risks. At all levels, personnel are informed of the hazards of operations and of what is expected concerning them. Progress relative to established goals is published, discussed, and routinely communicated to employees. Two-way open communications exist throughout the organization. Thus, the knowledge and experience of employees is brought to bear to improve safety.

DESIGN AND ENGINEERING

In the model companies, the first outward indications of their culture with respect to safety are demonstrated through the superiority of their design
processes and decisions affecting new and altered facilities, equipment, processes, and products. Their design and engineering specifications are established to go beyond legal requirements and are intended to avoid unacceptable risk.

Where hazards are given the required consideration in the design and engineering processes, a foundation is established that gives good probability to favorable hazards-related incident avoidance. Also, the potentially large expenses of retrofitting are thus avoided.

This subject, until recently, has not been given sufficient attention by safety professionals. Design and engineering practices do not typically appear in outlines of safety management systems. Nor would the subject ordinarily be included in safety audits. Yet design and engineering decisions are primary in determining the eventual risk level, and they are most often made without input from safety professionals. Thus, safety professionals are typically confronted with the workplace, equipment, and products as givens, with thousands of design and engineering decisions affecting safety having been made without their counsel.

As a better understanding has developed of the phenomena of hazards-related incident causation and as ergonomics has emerged to have greater importance, safety professionals are required to give greater attention to design decisions. It has been a rewarding experience when safety professionals have been sought for their counsel in concept and design decision-making. There is both need and opportunity here for advice-giving by safety professionals.

HAZARD ANALYSIS AND RISK ASSESSMENT

Including hazards analyses in design concept discussions, in design and engineering decisions, and in process reviews is more frequently the practice. There is opportunity here for safety professionals to be perceived as providing a consultancy that produces economic benefits, in addition to improving safety. Those benefits, in addition to reduced costs for injuries and illnesses, are measured by (a) the costs avoided by not having to retrofit to remove hazards brought into the workplace and (b) improved productivity and cost efficiency.

Hazards analyses may be completed through mechanisms as simple as check lists, something more detailed such as Job Hazard Analyses or Preliminary Hazard Analyses, or in complex cases, Failure Mode and Effect Analyses. Whatever the mechanism, the goals are that hazards are to be anticipated, identified, and evaluated, and the appropriate avoidance, elimination, or control measures are to be determined and taken so that the risks deriving from the hazards are at an acceptable level.
MANAGEMENT OF CHANGE

Although the title of OSHA’s standard for *Process Safety Management of Highly Hazardous Chemicals* suggests a limited application, over 50,000 employment locations could be affected by it. At many of those locations, such as public utilities and paper manufacturers, the final products are not chemicals.

OSHA’s standard requires that “The employer shall establish written procedures to manage changes...” The principle involved here is important and is having its impact far beyond chemical companies. What is required is that hazards be identified and evaluated when changes are made in design criteria, operations, procedures, and facilities. That’s a good thing to do, and I recommend a broad application of the principle. It is a concept that can be applied in all businesses and industries, as the top performers have learned.

Many companies have said to OSHA personnel that complying with the management of change requirement would take considerable time. In effect, they are saying that the requirement is contrary to the typical practice and that a culture change would have to be achieved to put the required procedures in place. Getting a management of change element adopted in any safety management system extends the knowledge of personnel about hazards and risks, actually reduces risk, and reinforces safety policy.

ERGONOMICS AND HUMAN FACTORS ENGINEERING

A conclusion drawn from a study made by a major workers compensation insurer was that about 50% of reported claims and about 60% of their attendant costs had ergonomics implications. Similar data have been frequently published. As this information developed, safety professionals were required to undertake serious introspection concerning the content of their practice and how they spent their time.

Ergonomics has emerged to become a major element in the practice of safety. That is obvious in the model companies. As its significance grew, ergonomics promoted a greater recognition of the impact of workplace design decisions on both risk reduction and productivity. And safety professionals who acquired the additional knowledge and skill required to be proficient in ergonomics found that decision makers had a greater interest in their work because of its productivity and cost limitation implications. Ergonomics and human factors engineering have become synonymous and interchangeable terms. One university gives courses in both ergonomics and human factors engineering. The difference is that ergonomics covers workplace design and human factors engineering extends the study to include product design.
PURCHASING STANDARDS

A few safety professionals are proud of the greater influence they have had in recent years on the purchasing standards that are in effect in their companies. Working with design and engineering personnel and with senior executives, they have achieved a culture change that results in fewer hazards being brought into their operations when equipment and materials are purchased.

Including safety-related specifications in purchasing standards assists in attaining corporate goals for superior performance. There is great opportunity here for recognition and accomplishment by safety professionals. In a few companies, suppliers of equipment are not to ship the ordered items until visited by the purchaser’s safety personnel, who are to sign off on acceptance.

PREVENTIVE MAINTENANCE

The quality of maintenance obviously impacts greatly on hazards management. It sends messages to the entire staff, informing them of the reality of a company’s intent to keep or not to keep physical hazards at a minimum. While maintenance departments also struggle to get things done with slimmer staffs, safety professionals with whom I recently had discussions say that their companies have not experienced the problem of having hazardous situations given a low priority by maintenance staffs.

Visit a location where the culture demands good safety practice and immediately, from the appearance of the exterior premises, you will get a “feel” for the quality of maintenance. That isn’t necessarily an absolute indicator, but the opposite is almost always true; if the exterior of the premises is shabby, safety maintenance will likely be inadequate. In the best operations, cleanliness is truly a virtue, maintenance schedules are adhered to, and personnel are encouraged to report on and seek elimination of hazards.

Consider this situation for an opposite and real picture. A safety professional is making an audit of the quality of hazards management. The maintenance superintendent displays an elaborate computer-based maintenance program, of which he is very proud. During the plant tour, many hazardous conditions are observed. A supervisor is asked why work orders aren’t being sent to the maintenance department to have those conditions corrected. And the response is, “We don’t do that anymore. Safety work orders are the last priority for the maintenance department.” Later it is determined that a great number of safety-related work orders are over six
months old. But the maintenance program, on paper, was supposed to prevent that sort of thing from happening.

A negative message is delivered in a situation of that sort. If the staff is to believe that hazards management is to be taken seriously, management must maintain a safe environment and continuously demonstrate its commitment to do so.

SAFETY COMMITTEES

Although many articles questioning the value of safety committees have been written, in entities where superior results are expected and achieved, safety committees are made to work. For the superior performers, it is a common practice for the management committee to also serve as a safety committee, with safety being an early item on meeting agendas.

Safety committees exist at several levels in the model companies. Where they are programmed to achieve, they do the following:

- Serve as a means of communicating that hazard prevention and control is important within the organization’s culture
- Provide opportunity for participation in safety efforts by a large number of employees
- Can be structured to allow greater employee involvement and upward communication
- Are well-organized
- Have clearly understood purposes
- Find that their recommendations are seriously considered and resolved at appropriate management levels

Where safety committees are effective, they add to the element of trust, from the top down and the bottom up. Surely, if they are not effective, their existence can further the belief that management is not serious when it says it is concerned about safety.

SUPERVISORY PARTICIPATION AND ACCOUNTABILITY

Supervisors in the top performers are conveyors of the element of trust between management and operations employees. Participation by supervisors in hazards management directly reflects the perception their superiors have of what the organization’s culture expects and what they understand to be the actual performance measures.

Supervisors will do what they perceive to be important to their superiors. If their superiors convey, by what they do, that hazard prevention
and control is important, be assured that supervisors will so respond. If supervisors are held accountable for the prevention and control of hazards, success will result.

Expectations of supervisors, by their superiors and by society in general, have unfortunately become complex and difficult to attain — which means that supervisors must have a sound support structure to be successful. That support structure begins with the location manager and the staff immediately subordinate to the manager. It includes depth of training, a good communication system on hazards, up and down, and the resources of qualified safety professionals as consultants.

TRAINING

In companies with superior safety records, training is serious business. Unfortunately, safety training is often much talked and written about but poorly done. Senior management in the model companies is well-trained. It all starts here. All levels of management become aware of the risks of their businesses and acquire the necessary knowledge of the hazards management needs. They cannot be role models and provide the necessary leadership if they are not schooled in how the hazards management job is to be done.

Training takes place in many ways — in formal classroom settings and on the job by demonstration and observation. It is a continuing and never-ending process.

Safety training must be well-planned, continuous, and measured for results. Supervisors and employees have to believe that the content of the training program is what management expects them to apply, and that it serves real knowledge and skill requirements.

Employees cannot be expected to follow safe work practices if they have not been instructed in the proper procedures. They need to understand when they begin employment that they have entered an organization that gives high priority to safe performance. It’s typical to have a very thorough indoctrination procedure for new employees. As they pass through indoctrination and are assigned to a supervisor, they are able to evaluate the level of safety expected very quickly.

Too much emphasis cannot be given to the importance of the supervisor in employee training, or to the priority given to training in those companies where successes in hazards management are noteworthy. Supervisors, as well as experienced employees serving as lead persons, are the role models that new employees will follow.

But consider this situation as representative of a reality that is too prevalent. Early during a safety audit, an industrial relations director proudly
reviewed with the auditor a marvelous indoctrination and safety training program for new employees. During the audit, an interview was arranged with an employee who had been in the shop for about three months. The intent was to determine what he thought of the indoctrination and safety-training program.

His response was, “What indoctrination and safety training program?” This employee had bid up to his third job, had never gone through the indoctrination and safety training program, complained that he never saw his supervisor, and didn’t know how to get anyone to pay attention to gear box covers that had been removed and not replaced. Situations of that sort define the organization’s culture for hazard prevention and control.

Training needs are always in transition, and recent developments require different emphases. Safety professionals interviewed spoke of these situations.

- New technology is continuously developed that may not have been evaluated for safety. Thus, safety professionals are more often engaged in preoperational hazards analyses, job hazard analysis, and the additional training that those analyses indicate is necessary.
- It is more common for employees with seniority to be assigned new jobs without adequate training, and that requires particular attention by the safety staff.
- Demographics and the greater differences in spoken and written languages in the changing work force stretch training capacity to its limits.

Overall, safety professionals say that it has become very difficult to keep up with training needs. Safety training, given as a substitute for other hazard prevention and control actions that should be taken, will be recognized as the deception it is. Several authors have cautioned that employers should not consider safety training as the primary method for preventing workplace incidents. That premise is sound. Rather, when considering hazards, the first course of action should be to determine whether they can be eliminated through workplace and work methods redesign. Training will be less effective if known hazards are not corrected. If those hazards continue to exist, the purposes of the training initiative will be questioned.

**EMPLOYEE INVOLVEMENT**

Safety professionals in the superior performing companies agree that effective employee involvement builds confidence and trust in the organization,
develops more enthusiastic and productive employees, and supports the position that all are working together to achieve understood objectives. Employees must believe that they also are responsible for their safety, and they must be provided with the training, tools, and the necessary authority to act.

Given the necessary training and opportunity, employees can make substantive contributions in hazard identification, in proposing solutions to problems, and as participants in applying those solutions. Safety and health initiatives obviously are more effective if employees have “bought into them.”

As an example, practitioners in ergonomics tell countless stories of work practice innovations originating from first-line employees. Many are easy to apply, inexpensive, and effective, and they often result in greater productivity. There is an asset here, in effective employee involvement, that could be better utilized to achieve more effective hazards management.

CONTROL OF OCCUPATIONAL HEALTH HAZARDS

A major emphasis of OSHA since its beginning has been the control of occupational health hazards. These high-performance companies have given the subject priority attention. Each of the safety professionals interviewed for the third edition of this book say that their companies are operating well below worldwide permissible limits with respect to occupational health hazards. Surely, keeping occupational health hazards at an acceptable risk level is a must, even though expenditures to control health hazards can be great.

ENVIRONMENTAL CONTROLS

As a matter of good citizenship and because of concerns over costly penalties that might be imposed by the environmental agencies in the countries in which a company does business, avoiding environmental incidents often gets greater senior management attention than other aspects of hazards management. It is common in the best situations for those responsible for environmental affairs to have senior-level credentials, and they have management support to achieve.

SAFE PRACTICE STANDARDS

A safety initiative cannot succeed without soundly established and implemented safe work practices. How well that’s done is another reflection of
an organization’s culture. It is understood in superior performing companies that establishing, communicating, and implementing prescribed work practices is to be taken very seriously at all employment levels. Developing safe practice standards more often includes some form of employee involvement through which their input is sought. These work standards become the substance of training programs and of expectations by supervisors.

**INSPECTION PROGRAMS**

Well-managed inspection programs will exist at several levels where hazard prevention and control is managed best. They have many purposes, one of the most important being that they display and communicate management’s determination that hazardous conditions and practices are to be identified and corrected. They also provide meaningful opportunities for participation by a cross section of all employment levels. No inspections are more effective than those in which senior executives participate. Correcting observed hazards is a demonstration of the culture. Failure to follow through, of course, gives negative messages.

**INCIDENT REPORTING AND INVESTIGATION**

For several reasons, greater emphasis is being given to incident reporting and investigation in the model companies with which discussions were recently held. What gets done when a hazards-related incident occurs is one of the major influences that determine how the staff “reads” what level of hazards management is really acceptable. Do it poorly, and poor readings are inevitable.

How does it get done well? Management has to be a part of the accountability system for incident investigations. In one company, the plant manager is expected to participate in at least 10% of incident investigations. In another worldwide company, the location manager (not the safety director) must report to headquarters within 48 hours on any injury resulting in a lost workday.

Far greater use is being made of incident investigation teams. Safety professionals say that the time expended by those teams is a worthwhile investment since the activity communicates management’s intent to avoid hazards-related incidents. Over time, large numbers of personnel are involved.

Absolutely, there has to be a documented incident reporting and investigation procedure. But, that’s not enough. It’s recognized in the model companies that specialized training is necessary to achieve sophistication
in incident investigation. Incidents don’t occur in a given area very often, and those who investigate them have limited investigation experience. Thus, the necessary training must be repeated.

Most importantly, results of investigations and the actions to be taken concerning causal factors are publicized. Quality of incident reporting and investigation required or tolerated is a principal measure of the accountability system, and of the culture of which the accountability system is a part. It’s very difficult to achieve effectiveness in other aspects of hazards management if corrective action is not taken concerning the causal factors for the incidents that do occur.

RECORDING, ANALYSIS, AND USE OF INCIDENT DATA

If the accountability system is to work, there has to be an effective incident information-gathering and analysis system. Those systems are effective in the model companies. Performance reviews that hold management personnel accountable for meeting or not meeting agreed-upon goals rely on these systems. Also, the analytical data produced is vital in determining where hazard prevention and control emphasis needs to be given.

PERFORMANCE MEASUREMENT

Data produced by the incident recording and analysis system are, of course, a principal aspect of performance measurement. But, additional proactive measurement and communication systems are used in the model companies — such as those discussed in Chapter 24, “Measurement of Safety Performance.”

Because of the emphasis given to them in discussions with safety professionals, two performance measurement systems deserve further comment. Scheduled safety audits are performed in every superior performing company. Through a formal process, they provide management with a determination that expectations are or are not being met. In that process a systems aura prevails — an aura of plan, do, check, and improve.

And, for performance, those companies benchmark with others in similar businesses, formally and informally. They publish and exchange statistics on incident experience. Through their trade associations and professional society meetings and publications, they explore ideas on how safety can be improved.

MEDICAL AND FIRST-AID FACILITIES

At both a corporate and at a location level, medical and first aid facilities are superior where a sense of responsibility to employees permeates the culture.
EMERGENCY AND DISASTER PLANNING

Those companies dedicated to protecting its employees and their communities provide the resources necessary to establish and maintain sound emergency and disaster planning. But, with sympathy, it needs to be said that it’s very difficult to put in place and maintain activities that are seldom used. Expectations of emergency and disaster plans cannot be fulfilled without regularly testing their ability to deliver. Establishing communications with the community resources is necessary, without which the actions expected when an emergency occurs will not take place. Training and practice requirements are considerable.

Many companies have reviewed and updated their emergency and disaster plans since the World Trade Towers event. In the superior performing companies, which have extensive security departments, the safety professionals were impacted and participated in the updating, but most of the work fell to the security staff.

For safety practitioners in smaller companies, the involvement in security may be much greater. To assist at that level, the National Safety Council issued a revision of its publication *On-Site Emergency Response Planning Guide*. For response planning, it’s quite good. For emergency and disaster prevention purposes, including terrorist activities, the help of a consultant may be needed.

COMPLIANCE WITH GOVERNMENT REGULATIONS

While last in this chapter, compliance with government regulations is important at a corporate level, and the needed attention to them percolates down through entities that are to maintain a top quality of hazards management. But, compliance programs do not determine operating standards. It’s common in the best situations for government regulations to be considered basic standards, with actual design and operating requirements exceeding them.

SUMMARY

Listings of the elements of successful safety management systems most always commence with management commitment and involvement. One could argue that management commitment and involvement is not an element to be placed on a par with other elements in the listing. Rather it is the foundation, reflection, and extension of the organization’s culture from which all hazards management activities derive. Management involvement and commitment is absolutely required.
In entities that have achieved outstanding safety records, all employees know that management is held accountable, is involved, and holds subordinates responsible for their results. If incident experience is considered to be unsatisfactory by management, safety professionals should promote, with great tact and diplomacy, the asking of the obvious but difficult questions. Has that experience resulted from an absence of management commitment to hazard prevention and control? Has the adverse experience been programmed into operations, by implication?

It is impossible for superior safety performance to be attained if executive personnel do not display, by their actions, that they intend to achieve it. Management is what management does. What management does establishes the organization’s culture. If what management does gives positive impressions, it is more than likely that a safety initiative will succeed.

REFERENCES


INTRODUCTION

To obtain a view of the changes that have taken in the business climate in the past few years, I interviewed a highly successful executive in a global company to obtain his comments on what the work world has become. This is what he said.

- Demands for continuing improvement in financial performance have never been greater.
- Global competition is a hard-driving reality.
- Advances in communication capability (e.g., broadband) result in a much faster information flow, and decisions and actions are expected in a short time.
- A more rapid pace has evolved, making it more difficult to successfully manage several major projects simultaneously.
- Time to get new products to market has been reduced.
- Expense controls require that more be done with less.
- Quality demands are higher, reflecting global competition, liability concerns, the fear of adverse publicity, and regulatory pressures.
- His CEO is driving for improvements in the worldwide environmental, safety, and health record.
My impression, having had discussions with divisional and corporate safety directors about their work environments, is that the executive I interviewed describes quite well the current business climate. To say that there has been volatility and transition in the business world in the past several years is an understatement. In relation to those transitions, for introspection by safety practitioners, this chapter will explore the following:

- The transitions that have taken place
- Possible future changes
- How those transitions impact on the practice of safety
- Fields of opportunity
- The importance of understanding the basics of financial management

As a result of the turmoil created by mergers and acquisitions and the pressures put on managements for reducing costs and for continued improvement in financial performance, the terms downsizing, right-sizing, and dumb-sizing entered the common language. Globalization, while not a new idea, has become a much talked about and controversial reality. All that has occurred has produced an unstable employment climate.

Predictions of the future by business writers vary greatly. A few are predicting less turmoil and more stability. Yet, Peter F. Drucker, in *Managing in a Time of Great Change*, a November 1995 publication, made this comment:

In fact, if you make a wager on any big company, the chances of it being split within the next ten years are better than the chances of it remaining the way it is [p. 4].

Current announcements by a few companies indicate that Drucker’s prediction has some merit. Although the press continues to report on newly planned mergers and acquisitions, splitting up of some major companies is now in progress. Understandably, the safety staffs in those companies are under a bit more stress. But, if breaking up major companies into still sizeable entities becomes the vogue, additional employment opportunities for safety practitioners may result.

Nevertheless, it can be expected with a great deal of certainty that there will be a continuum of economic ups and downs and a never-ending proliferation of management fads — all having an impact on business practices and career potentials. More than in the past, astute professionals will
recognize that their interests are best served by being attentive to their marketability and preparing for the reality of the world that is.

This requires a continuing introspection concerning their knowledge and skills and keeping current with the evolving technology in the practice of safety. Significantly, they must assess the perceptions others have of the substance and worth of the consultancies they provide.

While the business climate has been volatile, I suggest a positive approach to career potential by safety professionals since a broad range of opportunities exists for expansion of their capabilities, greater effectiveness, and recognition.

Unfortunately, we safety professionals do not have a history of anticipating developing needs and of taking the leadership in providing solutions to fulfill those needs. Typically, we are reactors. In the current and foreseeable business climate, we must anticipate what is needed for career security and be initiators of imaginative solutions in relation to evolving technological developments.

MAJOR INFLUENCES ON THE PRACTICE OF SAFETY

In the past few years, the practice of safety has been greatly influenced by five major developments. They are as follows:

- The emergence of a more demanding business climate that requires greater management effectiveness, a part of which is a stringent measurement of the contributions of individuals toward achieving entity goals
- The extended impact of applied ergonomics on the practice of safety
- The realization that quality management principles and safety management principles have a remarkable kinship
- The frequent bringing together of the functions of safety, health, and environmental affairs under a single management
- The proliferation of a variety of behavioral safety models

IMPACT OF THE TRANSITIONS IN BUSINESS PRACTICES

Several authors have addressed the popular management themes, their effectiveness or ineffectiveness, and their impact on employees. These are examples, paraphrased, of what has been recently written.

- Contrary to conventional wisdom, corporations that have used the latest management wrinkles and trends have not become more efficient, flexible, or competitive.
Empowerment, the buzzword for participatory management that reverberates throughout the boardrooms of corporate America, is not working.

Restructuring not only fails to create new forms of participation, it destroys old forms of cooperation that kept good bureaucracies working reasonably well in the past.

Because of the way restructuring and reengineering have been done, the American work force is filled with legitimate fear and cynicism.

As I did in earlier editions of this book, I suggest that safety professionals be alert to the new management fads that surely will be adopted and produce their own turmoil. Throughout that volatility, their best interests are served by having a sound knowledge and skill base, both in management practices and in safety technology.

Of the several thousand management books published each year, I chose two from which to take excerpts. Being opposites in a way, the two are indicative of the great variations that can be expected in what is written by authors of management books. One is a real downer: It unfortunately continues to reflect the views of most of the management-level safety professionals with whom I have recently had discussion. The other is speculatively encouraging.

_White-Collar Blues_ by Charles Heckscher resulted from a study of 14 large organizations to determine the effects on middle managers of corporate restructuring. Those companies had gone through reengineering, reorganizing to achieving flatter organizations, downsizing, right-sizing, or dumb-sizing — as have many safety professionals.

Briefly, Heckscher found that: loyalty, downward or upward, had diminished greatly; pressure is great to work harder, for higher productivity, and for beating out fellow workers; coaching and focus groups are in, but they do not always solve problems; worker participation (empowerment) has become a widely accepted principle but less widely implemented in practice; and restructuring and downsizing have actually reinforced corporate bureaucracy instead of eliminating it (p. 17).

This general observation by Heckscher gives an indication of what the future business climate may be like.

The problem is that today’s business environment, if not the world in general, is characterized by (this) condition: we don’t know what we’re doing; at best we’ll figure it out when we get there. No large company that I know of, and certainly none in my sample, had confidence in even a rough picture of what markets and economic conditions would be in five years. They are searching for a way to be continuously adaptable [p. 117].
Note Heckscher’s last comment: They are searching for a way to be continuously adaptable. That indicates constant change, which is the norm in many companies. Heckscher observed that “without a shared ethic, groups fragment and individuals feel lost” (p. 175) and that “most people appear to have a powerful need to feel that they are part of an contributing to something larger than themselves” (p. 179). Unfortunately, recent trends indicate that as the loyalty factor diminishes, so also does the shared ethic. Individuals are less committed to any company but, rather, to a personal set of skills, goals, interests, and affiliations.

Heckscher also noted that building a personality that is tough enough and flexible enough to avoid dependence on an organization is a difficult process.

Be assured that the management practices in place today will be replaced in time by yet another scheme. Furthermore, contrary views on what constitutes good management will emerge, as in The Loyalty Effect: The Hidden Force Behind Growth, Profits, and Lasting Value by Frederick F. Reichheld, with Thomas Teal. The authors suggest that companies that care about long-term growth and profits should reconsider what they are doing to loyalty. Reichheld is a director of Bain & Company, a consulting firm in Boston, and the leader of the firm’s worldwide Loyalty Practice. He writes:

Firms that earned superior levels of customer loyalty and retention also earned consistently higher profits — and they grew faster as well [p. viii].

Loyalty as we conceive it is critically important as a measure of value creation and as a source of growth and profit [p. ix].

Reichheld says that there is plenty of evidence that something about the current business paradigm is wrong. His solution is a return to loyalty-based management. Assuredly, other solutions will be proposed by other consultants.

**MANAGEMENT FADS**

A management fad is a new scheme, a panacea, proposed by consultants or educators that is to provide a quick fix to solve management problems. Often the fad is the subject of a best-selling book. With the new management scheme in place, employees will be happier, with improved morale and loyalty. Productivity and quality will surge. Growth and margins will be better than ever. And, the consultants say, managers will embrace the new ideas with enthusiasm since their advantages will be
apparent and the new scheme will be perceived by them as making their jobs easier.

Managements seem to have a never-ending passion for a panacea to resolve their insecurity with whatever management practices are in place. And the consultants and educators accommodate their passions. Management fads last but a few years, for only as long as the executives in charge continue to have an interest in them.

For each of the management fads that have surfaced in the last half of the past century, there has been an initial burst of excitement, a broad adoption of the fad by many organizations, and then a quiet fading away. We do what the fads require, only to find later that what we were doing becomes unimportant. But, a few fads leave some good behind.

Seldom does management determine the impact that the new management practices will have on the organization’s culture and plan well for their integration into the culture. Thus, the new fad creates anxiety and fear. Safety professionals cannot help but be caught up in them. If their own practices have a sound theoretical and practical base, it will be obvious to them that quick fixes will not achieve what needs to be done.

Within the practice of safety, it’s probable that, in time, behavioral safety will be identified as another management fad. Behavior modification and a psychological approach to safety are the vogue in some places. More on this later.

A BIT OF HISTORY ON MANAGEMENT FADS

With nearly an absolute certainty, it can be said that the never-ending parade of management fads will continue. Many of the management fads that became popular, for a while, in the second half of the last century had their beginnings in Douglas McGregor’s Theory X and Theory Y concepts. As new management fads arise, safety professionals may want to reflect on that background.

McGregor’s book *The Human Side of Enterprise* was published in 1960. His view was that the leadership approach managers took was based on assumptions they made about the people they managed. McGregor grouped possible assumptions in what he called Theory X and Theory Y categories.

**Theory X Assumptions**

1. People do not like work and try to avoid it.
2. People do not like work, so managers have to control, direct, coerce, and threaten employees to get them to work toward organizational goals.
3. People prefer to be directed, to avoid responsibility; they want security; they have little ambition [p. 33].

Theory Y Assumptions

1. People do not naturally dislike work; work is a natural part of their lives.
2. People are internally motivated to reach objectives to which they are committed.
3. People are committed to goals to the degree that they receive personal rewards when they reach their objectives.
4. People will both seek and accept responsibility under favorable conditions.
5. People have the capacity to be innovative in solving organizational problems.
6. People are bright, but under most organizational conditions their potentials are under utilized [p. 47].

McGregor’s view was that if a manager believed that workers had Theory X characteristics, they would provide close direction and control. But, McGregor believed that Theory Y characteristics prevail. His premise is that people can be self-actualizing, exercise intellectual capacities, and more fully utilize their capabilities—if they are given opportunities to participate in establishing goals and commit to them, and to influence the nature of their work.

In the Introduction to a later book by McGregor titled The Professional Manager, Edgar H. Schein made these comments about The Human Side of Enterprise.

Doug’s book has been seen as a plea for an attitude, a set of values toward people, symbolized by the term Theory Y. The essence of this attitude is to trust people, to grant them power to motivate and control themselves, to believe in their capacity to integrate their own personal values with the goals of the organization. Doug believed that individual needs can and should be integrated with organizational goals. In the extreme, Theory Y has meant democratic processes in management, giving people a greater voice in the making of decisions and trusting them to contribute rationally and loyally without surrounding them with elaborate control structures [Introduction].

The concepts of employee empowerment and the many forms of participative management that have been tried over the years are reflections of McGregor’s Theory Y.

How many management fads have American business applied and discarded in the past 50 years? Here are the ones with which I am familiar:
Management by Committee; Management by Consensus; Centralization and Decentralization; Quantitative Management; Pay For Performance; Intrapreneuring; Management by Walking Around; Theory Z; Transactional Analysis; Zero Defects; Quality Circles; The One-Minute Manager (the biggest rip-off I ever experienced in buying books); Matrix Management; Excellence (as in the book In Search of Excellence); the Managerial Grid; Employee Empowerment; and in some companies, Total Quality Management.

Reengineering the Corporation was written by James Champy and Michael Hammer and published in 1993. And for some time reengineering was a prominently adopted fad. The authors proposed a method of reorganizing business around “processes” rather than around the traditional functions of marketing, selling, and so on.

John Micklethwait and Adrian Wooldridge say in The Witch Doctors: Making Sense of the Management Gurus that “reengineering was the first great management fad of the 1990s” (p. 125) and that reengineering practices proposed by Champy and Hammer “would work if people were unthinking automations, without hearts and souls” (p. 35). They also say that, as is the case with most management fads, reengineering “is good at some things and not so good at others” (p. 31).

Micklethwait and Wooldridge also say that “By late 1994 even Michael Hammer and James Campy were admitting that many attempts at reengineering were falling short” (p. 31).

Knowing that the parade of management fads will go on and on, safety professionals serve their own interests well if their professional practices are soundly based and if their work is perceived to be in support of management goals.

**HOW WE ARE PERCEIVED**

Because of the turmoil in the business climate, it would be prudent for us to explore how we are perceived by those who have management responsibility for operations. Arthur D. Little issued a news release titled “Green Wall Between Companies’ Environmental and Business Staffs Creates Major Roadblock to Successful Environmental Management.” It pertained to a survey made, in which this question was asked of managers of environmental, health, and safety: Within companies, what is the greatest impediment to integrating environmental, health, and safety into business?

More than seven out of ten responded that there was either a lack of acceptance of environmental, health, and safety by the business staff or that a culture of separateness had been created by the EH&S staff.
Furthermore, in a published review by human resources directors of what activity could readily be outsourced, opposite “health and safety,” the indication is “no value added” (Vision of the Future: Role of Human Resources in the New Corporate Headquarters).

Does this problem of lack of acceptance by the business staff and of separateness and culture walls still exist? Yes, in many cases. This problem of perception—the problem of others believing that we have created a culture of separateness, that we are not engaged in the business of the enterprise in which we are employed, and that we do not provide value—must be taken seriously. This matter of perception requires that we assess what our goals should be.

GOALS TO BE ACHIEVED BY SAFETY PROFESSIONALS

For some, what I propose here is substantially different from their perception of their roles. I believe that safety professionals should aspire to be perceived as

- Participants in effectively and economically applying available and limited resources to eliminate or reduce risk so that the greatest possible good to employees, employers, and to society is obtained from those endeavors
- Contributing effectively to productivity, cost efficiency, and quality management, in addition to safety
- Active participants in achieving management goals

I will refer often to being effective. If we say that we are professionals and that what we do is effective, we imply that our knowledge base is sound and that the measures we propose to reduce risk produce results.

BEING PARTICIPANTS IN ACHIEVING MANAGEMENT GOALS

To establish what I believe are the paramount requirements of those having responsibility for operations, those with whom we are to participate in meeting their goals, I will refer to two highly respected writers: Peter F. Drucker and W. Edwards Deming. Both of these authors have had a major influence on my understanding of management concepts and practices.

For knowledge of sound business practices that will stand the test of time, I highly recommend the writings of Peter Drucker, not just those referenced here. This is what is said of Drucker in The Witch Doctors: Making Sense of the Management Gurus in the chapter titled “Peter Drucker: The Guru’s Guru.”
In the world of management gurus, however, there is no debate. Peter Drucker is undisputed alpha male. He is also one of the few thinkers from any discipline who can claim to have changed the world; he is the inventor of privatization, the apostle of a new class of knowledge workers, the champion of management as a serious intellectual discipline [p. 63].

Drucker is the one management theorist who every reasonably well-educated person, however contemptuous of business or infuriated by jargon, really ought to read [p. 63].

Drucker, in his book *Post-Capitalist Society*, said this:

Economic performance is the first responsibility of a business. (Without economic performance) a business cannot discharge any other responsibilities, cannot be a good employer, a good citizen, a good neighbor [p. 101].

What I have quoted from Drucker is in the same class as the first point in W. Edward Deming’s often quoted “Condensation of the 14 Points of Management,” as listed in his book *Out of the Crisis*. W. Edwards Deming is world renowned with respect to quality management. The first of his 14 management premises is that an entity should establish the following:

constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs [p. 23].

We safety professionals must understand and function within the charge given to management to achieve economic goals, be competitive, stay in business, and provide jobs. If economic performance goals are not met and an organization does not stay in business, obviously, its safety professionals won’t be needed.

American business is operating in a harsher climate with leaner staffs — a reality that requires more effective management. In that context, those who develop multiple skills, those who are problem solvers, and those who produce results surely will be perceived as more valuable.

In the real world of decision-making, for entities of every description, the following must be recognized: Some risks are more significant than others; resources are always limited; and the greatest good to employees, employers, and society is attained if resources are effectively applied to avoid, eliminate, or control hazards, and the risks that derive from them.

Safety professionals have a participatory obligation concerning the effective utilization by management of the resources available. Since resources are always limited and since some risks are more significant
than others, safety professionals must be capable of distinguishing the 
more important from the lesser important, identifying the potentials for 
the greatest harm or damage, and ranking risks in priority order.

We must also understand that business executives are risk takers who, 
appropriately, may not perceive that what we safety professionals propose 
must be given the highest priority at a given time within the spectrum of 
all the operating decisions they must consider.

But, in reality, we safety professionals are also risk takers. It is not 
possible to attain a risk-free environment, even in the most desirable sit-
uations. Setting a goal to achieve zero risk may seem laudable, but it 
requires chasing a myth. We must understand that even after the best 
practical methods are applied to what we propose, there will always be 
residual risk. And we are participants in accepting those risks.

Demands imposed by a highly competitive economy for more effec-
tive management performance are not going to go away. They compel 
safety professionals to seek to be perceived as problem solvers whose 
counsel is sought because of their successes as participants in achieving 
management goals.

**DRUCKER ON A SIGNIFICANT SOCIETAL TRANSITION**

Peter Drucker also stated, in *Post-Capitalist Society*, that the world is in 
transition to a knowledge society, that the primary resource in the post-
capitalist society will be knowledge, and that the leading social group will 
be knowledge workers. He writes:

> In the post-capitalist society, it is safe to assume that anyone with knowl-
edge will have to acquire new knowledge every four or five years, or 
become obsolete [p. 58].

> In *Managing in a Time of Great Change*, Drucker predicted in 1995 that 
by the end of the century, knowledge workers would amount to a third or 
more of the work force. And I think he got it right for the United States. 
He also says that knowledge is the only meaningful resource today and 
that continuing to expand learning is critical to knowledge workers.

All that Drucker says applies to the practice of safety. Very few safety 
professionals would say that they are not knowledge workers or that the 
content of their work does not continuously change. Since transitions in 
the practice of safety will surely take place, it follows that our knowledge 
base needs a constant examination as to its applicability and effectiveness. 
Obviously, safety professionals must endlessly acquire new knowledge 
and skills to maintain a proper level of professional practice.
If the application of our knowledge is not effective, does not prove itself in action, and does not produce results, can we expect, realistically, that what we do will be considered valuable?

MAINTAINING A SOLID CAREER BASE

There has been a proliferation of business writings advising professionals that they cannot design their lives around organizations that may not exist in the future, that loyalty is a thing of the past, that one can expect to have several employers, and that knowledge and skill needs to grow exponentially. Writers then proceed to give advice on how to maintain a solid career base.

Dr. Roger Brauer, executive director of the Board of Certified Safety Professionals, gave a presentation titled “Challenges and Opportunities” at the 1996 Professional Development Conference held by the American Society of Safety Engineers. Since I thought his presentation contained sound advice, I am summarizing his outline, with slight updating for this edition, and adding my own current views.

To maintain a solid career base, a professional should

- Have a plan that considers family, community, knowledge of capabilities and limitations, and professional career desires — and visit that plan regularly.
- Never stop learning, develop a solid professional knowledge and skill base, anticipate changes and creatively develop the new solutions they require, learn by doing and benefit from the mistakes that will be made, and, above all, strive for excellence. Having a master’s degree has become a more frequently cited employment desirable.
- Have a good understanding of sound management practices, knowing that many management fads will be experienced during one’s career.
- Acquire knowledge of the basics of financial management.
- Build a network of contacts and associations.
- Be active in professional organizations for an exchange of knowledge concerning new developments in technology and also for the networking opportunities that this provides.
- Take care of yourself — physically, mentally, and emotionally.
- Obtain professional credentials — particularly the Certified Safety Professional designation, which has grown in significance as employment criteria.
- Be alert to and be prepared for opportunities, knowing that career changes are likely to take place.
All professionals should understand that they have to take responsibility for their own employment security, and that it would be folly to program their careers within an organization that may exist only temporarily. Also, they must realize that their continued employment potential is being determined by whether their skills and capabilities are viewed by their employers as supportive in achieving entity goals. Transitions in recent years in the technical requirements for the practice of safety require that safety professionals expand their skills, and doing so results in their having additional opportunities to be perceived as more valued employees.

**IMPACT OF APPLIED ERGONOMICS**

Why make comments on a particular technical subject in this chapter? Because musculoskeletal injuries dominate within the entire spectrum of the types of work injuries and illnesses that occur. Estimates differ on what percentage of injuries and illnesses are ergonomically related, and the percentages differ by occupation. An April 10, 2002 Bureau of Labor Statistics (BLS) news release says that, for the year 2000:

Sprain and strain was, by far, the leading nature, or physical effect, of injury and illness in every major industry division, ranging from over 33 percent in agriculture, forestry, and fishing to over 50 percent in services and in transportation and public utilities [p. 3].

Table 4 in the BLS report is titled “Number of Nonfatal Occupational Injuries and Illnesses Involving Days Away from Work by Selected Injury or Illness Characteristics and Industry Division, 2000.” For private industry as a whole, strains and sprains, carpal tunnel syndrome, and tendonitis were 46.3% of total cases. Similar figures are commonly expressed. For example, Dr. Franklin Mirer, Director of the UAW Health and Safety Department, says that for about 700,000 auto workers, over 50% of all incidents reported are musculoskeletal. And the costs for musculoskeletal injuries tend to run high, especially for serious back injuries.

Understandably, applied ergonomics has become a major element in the practice of safety, and effective safety practitioners will sense the opportunity that provides and acquire extensive knowledge in the field.

Ergonomics developed out of the need to make work less stressful and more comfortable. And these are laudable goals that can be more effectively achieved if managements understand that the application of ergonomics principles also serves their productivity and cost efficiency goals. Case histories are now prevalent describing ergonomics applications that were initiated to resolve injury and illness problems and also achieved improvements in productivity and cost efficiency.
Emphasizing the possible productivity and cost efficiency gains from applied ergonomics is a somewhat different approach from that found in the prominent ergonomics literature. This novel idea gets management attention.

I had previously defined ergonomics as the art and science of designing the work to fit the worker. I now use this definition:

Ergonomics is the art and science of designing the work to fit the worker—to achieve optimum productivity and cost efficiency, and minimum risk of injury.

There is a developing recognition of the benefits to be obtained by scoping ergonomics designs to encompass productivity, cost efficiency, quality, and safety as parts of an interrelated whole. Relating ergonomics to safety, productivity, and quality in that manner spells opportunity for safety professionals who seek to be perceived as supporting entity goals and who want to build solid job security. (See Chapter 19.)

ABOUT QUALITY MANAGEMENT

Involvement in quality management presents extended career opportunities for safety practitioners. A review of the considerable literature on quality management leads to this conclusion: For paragraph after paragraph in most texts and papers, the word “quality” can be replaced with “safety,” and the premise being discussed remains sound. There is a remarkable kinship between sound quality management principles and sound hazards management principles.

Many safety professionals are now engaged in quality management initiatives. Some say that they derive greater satisfaction from their work, that their status within their organizations has improved, and that they are viewed as more effective members of the management team.

Methods to achieve product quality are identical in most respects with the methods used to achieve superior results in safety. Also, the processes addressed in a continuous improvement initiative to minimize product defects are the same processes in which injuries, illnesses, and environmental incidents occur. Is the practice of safety, as suggested by Dr. Thomas A. Selders, simply another means of achieving quality performance?

Safety professionals engaged in sound quality management initiatives think differently about the root causal factors for incidents that result in injury or damage. They become indoctrinated in the concept of continuous improvement of processes to improve quality and safety.
Where does this “thinking differently” take them? A thought process evolves whereby, when a risk situation arises, they pose questions concerning the system, rather than focusing on the behavior of individuals. That leads to a more realistic identification and analysis of hazards, which is vital to successful safety practice.

W. Edwards Deming has had a great influence on quality management throughout the world. I admit to being much impressed by his work. In Out of the Crisis, he stated his belief that a large majority of operational problems are systemic and can be resolved only by management, and that responsibility for only a relatively small remainder lies with the worker.

I believe that Deming’s premise is valid. Serious thought needs to be given to it by safety professionals since it applies to the practice of safety. Deming’s emphasis on constantly improving the system rather than expecting employees to do what they cannot do poses questions that safety professionals should consider concerning the content and effectiveness of their work. Out of that thinking should come an awareness of opportunities. (See Chapter 20.)

COMBINED RESPONSIBILITIES FOR ENVIRONMENTAL AFFAIRS, HEALTH, AND SAFETY

In 1998, I undertook a study to identify emerging knowledge needs in the practice of safety. Interviews were held with 17 divisional and corporate safety professionals and two university professors. Estimates given by safety directors concerning the safety practitioners at locations in their companies who had responsibilities including environmental, safety, and health matters varied from 60% to 90%. At some of the headquarters of their companies, the bringing together of the three responsibilities under one management had also occurred.

In the August 2002 issue of Occupational Hazards, an editorial by Stephen G. Minter states that “Approximately two-thirds of Occupational Hazards readers are involved with environmental compliance” (p. 8).

Combining environmental, health, and safety affairs under one management allows the development of one objective strategy and one source of advice. It makes no sense, from economic or effectiveness viewpoints, to look at only one aspect of a situation when there is an overlapping of safety, health, and environmental risks.

Whatever the professional history of those now having expanded responsibilities for environmental affairs, safety, and health, an urgency developed with the new assignments for additional technical knowledge and skills, and for more effective capabilities in people relations and communications.
As a matter of career development and job security, safety professionals should consider reaching out to take environmental affairs into their responsibilities. That spells opportunity.

**BEHAVIORAL SAFETY**

What is behavioral safety? Take care: There are many consultants in the field of behavioral safety, and their premises and programs very greatly. Chapter 23 reviews the subject in depth. For the purposes of this chapter, only brief, introductory comments on behavioral safety will be made.

It is important for safety practitioners to understand that most all of the varied consultancies being offered fall within one of two diverse schools of thought. One school advances a culture change model; the other advocates a worker-focused behavior-based model.

Dr. Steven Simon explored the differences in the two schools of thought in a speech he gave at a behavioral safety conference held by the American Society of Safety Engineers in February 1998. Simon indicated that there are two approaches in the behavior-based safety field. One takes a macro approach — the view that operation improvement is accomplished through a culture change. The other takes a micro approach and assumes that such improvement can occur by changing the behavior of hourly workers.

Simon expressed the view that the culture drives behavior and that a culture change is required for success in behavior-based safety. Simon’s speech became a paper that was published by the American Society of Safety Engineers in the *Proceedings — A Behavioral Safety Symposium, 1998*. These are excerpts from Simon’s paper titled “The Culture Change Model of Behavioral Safety.”

In sum, Behavioral Safety offers two different models to choose from: behavior modification or culture change. Culture change is a distinct model for the continuous improvement of safety performance. Whereas behavior modification is an individual-based training method in behavioral observation, analysis and feedback, culture change is a system-wide change effort, and the “organizational culture” is the client system. A behavior modification project could increase the number of safe behaviors while stopping short of changing the organization’s core values. Culture change requires analysis of systems that hold norms, assumptions and beliefs in place. It is strategy development carried out by leadership [p. 53].

Dan Petersen’s definition of worker-focused behavior-based safety as shown in the *Proceedings* of the ASSE 1998 Seminar will be used here.
Perhaps the definitions we hear most about today are those that define behavior-based safety as a process of involving workers in defining the ways they are most likely to get hurt, thus getting their involvement and thus some buy-in, asking the workers to observe other workers to determine progress in the reduction of unsafe behaviors etc. [p. 2].

How many companies adopted a form of behavioral safety? Estimates go from 30% to 40%. How many succeeded and how many failed? No one knows. Practitioners in the field continue to rave about their successes: Seldom do they talk about their failures. Current views of the status of behavioral safety cover an immense spectrum: From “it’s the best that’s ever happened in the practice of safety” to “it never was soundly based and it’s on the way out.”

In the October 2001 issue of *Professional Safety* there is an article titled “Projecting the Next Decade in Safety Management: A Delphi Technique Study.” Shawn Adams reported that one of the observations made by the ASSE chapter presidents who took part in the delphi-modeled survey was that:

The current emphasis on behavioral safety techniques will be discredited due to the inability to effect long-term change in behavior [p. 28].

In the August 2001 issue of *Industrial Safety & Hygiene News*, the Editor and Publisher, Dave Johnson, wrote an editorial titled “Beyond Behavior—New Labels for Old Medicine.” Excerpts from that editorial follow.

Bottom line pressures, management turnover and good old human nature just about guarantee a steady stream of safety issues to deal with. So the hunt never ends for the next new thing to cure, or at least arrest, those chronic challenges. Behavior-based safety has been the medicine of choice in recent years. But interest shows signs of waning, and the field’s experts now prescribe a cocktail mix of behavioral, systems and motivational remedies.

As the experts make substantive changes in what they prescribe, will reflection after the passage of time result in the conclusion that what they proposed in the beginning was just another fad? The critics are right when they say that behavior modification and psychology of safety approaches inappropriately focus on employee performance, rather than on management’s responsibility to provide a safe operating system. Also, whether the subject is productivity, cost efficiency, quality, or safety,
the methods applied to achieve acceptable employee behavior are the same.

**BASICS OF FINANCIAL MANAGEMENT**

I recommend that, as early as practicable, safety practitioners take a course in financial management as a career enhancement measure. To introduce this subject, I borrow from the chapter titled “A Short Course on Financial Management” in the book *Innovations in Safety Management: Addressing Career Knowledge Needs*.

Why does that book contain a chapter on financial management basics, and what is it to accomplish? The idea for it originated in a study initiated by this author to identify emerging knowledge needs in the practice of safety.

A part of the study included interviews with senior-level safety professionals to obtain their comments on the subjects they believed to be significant in maintaining professional performance and for career enhancement. This scenario was presented to 17 divisional and corporate safety practitioners and two university professors to produce the discussions desired.

You are to have a gathering of safety practitioners for educational purposes, and you want to have workshops on those topics for which you believe additional knowledge is required, considering current needs as well as looking ahead three to five years. What topics would you choose?

This survey became a fascinating and surprising experience. When the data were summarized and a list was produced of the seminars and workshops that interviewees thought were necessary, first priority was given to their recognizing the need for a better understanding of financial management basics.

The safety directors interviewed had management positions. They had become aware that they could be more effective in assisting their companies attain established goals if they had a better understanding of financial management basics. They said that they would be more comfortable in their jobs and in business meetings if they had knowledge of basics such as

- The language of finance, and financial management principles
- How corporate budgets are prepared and managed
- The impact of adequate or inadequate cash flows
- The performance measures applied to managers
- The primary elements in a financial report
• How executives make decisions when resources are limited and they have to evaluate multiple expenditure requests

With this knowledge, safety directors say they can more effectively draft their hazard prevention and control proposals, emphasizing their favorable financial impact on overall operations, including applicable aspects of productivity and cost efficiency, as well as risk reduction.

Comments made by safety directors prompted the research for this chapter. Its purpose is to address their expressed needs (p. 1).

Finance is the language of management. Safety practitioners who strive for management positions would do themselves well if they understood that language.

CONCLUSION

Transitions will surely continue in business practices and in the practice of safety. Change is a constant. That should be accepted. To the astute practitioner, those transitions can be perceived as opportunities if they develop and maintain a solid career base.

And the astute observer will be attentive to the emergence of what has been referred to as the safety through design movement. Safety through design is defined in Innovations in Safety Management: Addressing Career Knowledge Needs as the integration of hazard analysis and risk assessment methods early in the design and engineering stages and the taking of the actions necessary so that the risks of injury and illness are at an acceptable level (p. 218).

Safety professionals should be aware that more recently issued safety standards and guidelines require hazard analysis and risk assessment. Adoption of safety through design concepts is slow-moving, but certain. In time, many more safety professionals will need to become skilled in making hazards analyses and risk assessments. That spells career opportunity.

REFERENCES


INTRODUCTION

A highly regarded professor in industrial engineering observed, after participating with safety practitioners in what he considered a baffling discussion of concepts, that what we who call ourselves safety professionals actually do will never be accepted as a profession by those outside our field until we agree on a clear definition of our practice. I agree with that premise, and I will explore in this chapter the scope and function of the professional safety position and will define the practice of safety in terms of a societal responsibility.

It is a basic requirement of a profession to develop a precise and commonly accepted language that clearly presents an image of the profession. And the terminology used by safety professionals also should convey an immediate perception of their practice.

In his book *General Insurance*, David L. Bickelhaupt made a significant statement about the need for clear communications that speaks to the purpose of this treatise:

Terminology becomes important in the serious study of any subject. It is the basis of communication and understanding. Terms that are loosely used in a general or colloquial sense can lead only to misunderstanding in a specialized study area such as insurance [p. 28].
Similarly, clear terminology and avoiding terms that lead to misunderstanding is necessary in the practice of safety, which surely requires highly specialized study. We have not yet agreed on universally accepted definitions of the terms we use, but progress is being made in that direction.

DEFINING SAFETY

We must agree on what we mean when we use the word safety, as in the practice of safety. If we cannot, how can we assume that we are communicating with each other when we use the term or with those outside our profession?

Dictionary definitions of safety are commonly given in safety literature, and the use of them indicates a lack of understanding of safety, as well as hazards and risk. Since the dictionary terms relate to absolutes, such definitions are of little value to us. One dictionary defines safety as: “the quality of being safe; freedom from danger or injury.” And safe is defined as: “free from or not liable to danger; involving no danger, risk or error.” As you will see, being completely “free from danger” is not possible.

In the book Introduction to Safety Engineering, Gloss and Wardle give this definition of safety:

Safety is the measure of the relative freedom from risks or dangers. Safety is the degree of freedom from risks and hazards in any environment [p. 3].

Also, in answering the question “How safe is safe?” Gloss and Wardle say:

Safety is relative—nothing is 100% safe under all conditions [p. 3].

In Occupational Safety Management and Engineering, Willie Hammer wrote this:

Safety—frequently defined as free from hazards. However, it is practically impossible to completely eliminate all hazards. Safety is therefore a matter of relative protection from exposure to hazards; the antonym to danger [p. 142].

Lowrance stated in Of Acceptable Risk: Science and the Determination of Safety that:

We will define safety as a judgment of the acceptability of risk. A thing is safe if its risks are judged to be acceptable [p. 8].
None of the authors cited defined safety in the absolute terms of dictionary definitions, which indicate that to be safe one must be “free from or not liable to danger; involving no danger, risk or error.” Attaining a state in which there is no danger or risk that would qualify for dictionary definitions of safety is not possible. No environment can be absolutely safe.

For several years, I have proposed the following definition of safety as being applicable to the work in which all safety professionals are engaged. It cleared editorial review and appears in the 12th edition of National Safety Council’s Accident Prevention Manual—Engineering & Technology in the chapter written by this author titled “Safety Through Design” (p. 6). It is also credible in dealing with decision makers.

Safety is defined as that state for which the risks are judged to be acceptable.

In recent years, there has been activity to achieve universally accepted definitions of the terms used in the practice of safety. The leadership has come from the Europeans. A second edition was issued in 1999 of ISO/IEC Guide 51. Its title is Safety aspects—Guidelines for Their Inclusion in Standards. Although brief—there are only nine pages of guidelines—this is an important document. It lists definitions of terms that have been agreed to by the guideline writing committee. Furthermore, it is issued by the International Organization for Standardization, a recognized international body.

In Guide 51, this definition is given: Safety — freedom from unacceptable risk (3.1). It is exchangeable with the definition I have used: Safety is defined as that state for which the risks are judged to be acceptable.

Safety professionals must be aware that implementing all that they propose may reduce risk significantly, but that risk cannot be eliminated entirely. No matter how effective the preventive measures taken, there will always be a residual risk if an operation continues. It is unrealistic to assume that an environment could exist in which the probability is zero of an injurious or damaging event occurring.

Determining whether a thing, an activity, or an environment is safe requires making a judgmental decision. People are risk takers. They make countless decisions to participate in activities for which they judge the risks to be tolerable (driving an auto, skiing, boating, et cetera). Deciding that a thing is safe or not safe requires judgments of whether the probability of an undesired incident occurring and the severity of its outcome are acceptable. On a macro basis, those decisions are societal and made by politicians or bureaucrats.

Lowrance made the point that risk assessments made as a result of studies undertaken by scientists do not determine whether a thing is safe.
Results of their studies will establish the probability of undesirable events occurring under given circumstances and the severity of their outcomes. Whether that probability and severity is acceptable or not is a societal judgment (p. 9).

In the definitions of safety previously quoted, the terms *risk* and *hazards* are used. In establishing what the practice of safety is all about, clear understanding is also necessary of those two terms.

**DEFINING RISK**

Arriving at a definition of risk applicable to the practice of safety that could be used convincingly in discussions with decision makers was not easy. Risk is a word that has too many meanings. Executives with whom safety professionals deal may hear the word used in several contexts in a given day.

Taking a business risk, a speculative risk, offers the possibility of gain or loss. That implies a meaning of risk different from that to which the practice of safety applies. Risks with which safety professionals are involved can only have adverse outcomes.

Definitions of risk in risk management and insurance literature were reviewed with the expectation that they would be helpful. In summary, they emphasize the uncertainty or the lack of predictability concerning loss. It is a fundamental actuarial concept that risk implies uncertainty. But definitions of risk based on uncertainty do not communicate entirely the nature of risk for which safety professionals give counsel. I cannot conceive of safety professionals presenting themselves as consultants in uncertainty reduction.

Also, the definitions of risk given in risk management and insurance literature seldom mention the severity of an event’s consequences — even by implication. Giving advice to reduce the severity of results of an incident is a significant part of the work of safety professionals.

Other authors include concepts of both incident probability and severity of consequences in their definitions of risk. In *Of Acceptable Risk: Science and the Determination of Safety*, Lowrance wrote that:

Risk is a measure of the probability and severity of adverse effects [p. 94].

Rowe, in *An Anatomy of Risk*, gave this definition of risk, which supports Lowrance’s definition:

Risk is the potential for realization of unwanted, negative consequences of an event [p. 464].
Expanding on Lowrance and Rowe, this definition of risk relates more precisely to the work of safety professionals.

Risk is defined as a measure of the probability of a hazards-related incident occurring and the severity of harm or damage that could result.

That definition is close to two almost identical definitions appearing in recently issued documents. For example:


Risk: Combination of the probability of occurrence of harm and the severity of that harm, as in ISO/IEC Guide 51 (3.2), a 1999 publication.

Consensus is being reached on a very broad base among those involved in safety that to address risk, a determination of both the probability of an incident occurring and the severity of its adverse results must be made. This promotes a thought process that asks

- Can it happen?
- What is exposed to harm or damage?
- What is the frequency of endangerment?
- What will be the consequences if it does happen?
- How often can it happen?

Thus, professional safety practice requires addressing those two distinct aspects of risk:

- Avoiding, eliminating, or reducing the probability of a hazards-related incident occurring
- Minimizing the severity of adverse results, if an incident occurs

DEFINING HAZARDS

Having defined risk, these questions should then be asked. What is the source of risk? What presents the probability of incidents occurring that could result in harm or damage? The source of risks is hazards. Hazards are the justification for the existence of the practice of safety.
In the previously cited documents — ANSI B11.TR3-2000 and ISO/IEC Guide 51 — very simple, identical, and generally applicable definitions of a hazard appear. This is the definition.

Hazard: a potential source of harm (3.4 in TR3, and 3.5 in Guide 51).

Note what is occurring, internationally. It is accepted that a hazard is defined as the potential for harm. For the work of safety professionals and the practice of safety as I know it to be, I offer the following definition of hazards:

Hazards are defined as the potential for harm or damage to people, property, or the environment; hazards include the characteristics of things and the actions or inactions of people.

And it should be understood: All risks with which safety professionals are involved derive from hazards; there are no exceptions. How do safety professionals deal with hazards? Consider the following view.

**WHAT IS A SAFETY PROFESSIONAL? WHAT DO THEY DO WITH RESPECT TO HAZARDS?**

Those who obtain certification as safety professionals through the Board of Certified Safety Professionals represent a broad range of safety practice. Similarly, the members of its Board of Directors come from several organizations and hold a variety of technical and management positions. Nevertheless, they have agreed on and published their response to the question, What is a safety professional? You can find it at www.bcsp.org. It’s downloadable, and it follows. Note that throughout the document, safety professionals identify and evaluate hazards as a prelude to all other aspects of their work.

**What is a Safety Professional?**

A safety professional is a person engaged in the prevention of accidents, incidents, and events that harm people, property, or the environment. They use qualitative and quantitative analysis of simple and complex products, systems, operations, and activities to identify hazards. They evaluate the hazards to identify what events can occur and the likelihood of occurrence, severity of results, risk (a combination of probability and severity), and cost.

They identify what controls are appropriate and their cost and effectiveness. Safety professionals make recommendations to managers, designers, employers, government agencies, and others.
Controls may involve administrative controls (such as plans, policies, procedures, training, etc.) and engineering controls (such as safety features and systems, fail-safe features, barriers, and other forms of protection). Safety professionals may manage and implement controls.

Beside knowledge of a wide range of hazards, controls, and safety assessment methods, safety professionals must have knowledge of physical, chemical, biological and behavioral sciences, mathematics, business, training and educational techniques, engineering concepts, and particular kinds of operations (construction, manufacturing, transportation, etc.).

This is a purposely brief description of what a safety professional does. Following the response to its question — What is a Safety Professional? — the instruction on the BCSP website is to click on “Standards of the Safety Profession” for a formal definition of the professional safety position. That will take you to a more detailed position description of the scope of what safety professionals do. You will come to an American Society of Safety Engineers’ document titled as in the next caption.

SCOPE AND FUNCTIONS OF THE PROFESSIONAL SAFETY POSITION

Mention is made in more than one place in this book of the “Scope and Functions of the Professional Safety Position.” As a position description, it is exceptionally well done. Because of its thoroughness and accuracy, I recommend it as a knowledge source and as reference. With the permission of ASSE, the entirety of the document appears as the Addendum to this chapter. ASSE has requested that I state that the Scope and Functions paper may become an American National Standard.

My belief is that the definition I give here of the practice of safety is in concert with the “Scope and Functions of the Professional Safety Position.”

OUR BAFFLING AND NONDESCRIPTIVE TITLES

Unfortunately, safety personnel use many job titles, and that may be a hindrance in their achieving an understanding of the practice of safety by those outside the profession. Safety practitioners call themselves by too many names, some of which do not communicate a favorable image of what they do.

An informal and unscientific study was conducted to assess how management personnel perceived some of the titles used by safety practitioners. Risk managers were approached who had on their staffs people with
titles like Director of Loss Control, Director of Loss Prevention, Industrial Hygienist, Safety Manager, Director of Safety, and Fire Protection Engineer. They arranged communications for me to have discussions with their bosses or their bosses’ bosses so that I could determine whether they understood what the people did who had the titles previously cited.

For the title Fire Protection Engineer, there was very good recognition as to function and purpose. The work of those who had the titles Director of Safety and Safety Manager was quite well understood, but not as well as Fire Protection Engineer.

Unfortunately, the title Industrial Hygienist got the least recognition and was often equated with sanitation. As a part of a title, Occupational Health frequently was well understood as to role and purpose.

Loss Control and Loss Prevention as titles did not convey clear images of purpose, and recognition of the function of those having such titles was poor. Loss Control was often believed to represent the security function of inventory control. On several occasions, Loss Prevention was assumed to be a part of claims management.

Loss Control and Loss Prevention as functional designations have their origins in the insurance business. Within the insurance fraternity and among some other safety practitioners, the terms are understood. But, those terms do not convey clear messages of purpose and function to people outside that group.

If I had a magic wand with which I could eliminate the use of the titles Loss Control, Loss Prevention, and Industrial Hygienist, I would do so. And I would believe that I had performed a highly beneficial service. If the names safety professionals give themselves baffle people, can what safety professionals do ever be considered a profession?

DEFINING THE PRACTICE OF SAFETY

With the dissertation from BCSP on What Is a Safety Professional? and with a good position description in ASSE’s “Scope and Functions of the Professional Safety Position,” why go further to define the practice of safety? For this reason: If the practice of safety is to be recognized as a profession, it must:

- Serve a declared and understood societal purpose.
- Clearly establish what the outcome of applying the practice should be.

And its description should be an example of simplicity and clarity. As a reference to develop a definition of the practice of safety, I first go to
Roger L. Brauer’s definition of safety engineering, in his book *Safety and Health for Engineers*.

Safety engineering is the application of engineering principles to the recognition and control of hazards [p. 12].

A compatible definition appears in *Introduction to Safety Engineering* by Gloss and Wardle:

Safety engineering is the discipline that attempts to reduce the risks by eliminating or controlling the hazards [p. 3].

At a meeting of the Board of Certified Safety Professionals, a definition of safety practice was written during discussions of a project to validate that examinations given properly measure what safety professionals actually do. It is as follows.

Safety practice is the identification, evaluation, and control of hazards to prevent or mitigate harm or damage to people, property, or the environment. That practice is based on knowledge and skill as respects Applied Engineering, Applied Sciences, Applied Management, and Legal/Regulatory and Professional Affairs.

Dr. Thomas A. Selders, CSP, CIH, P.E., has said that the practice of safety should be anticipatory and proactive. That idea is easily supported. Reflecting on all of the foregoing, I propose adoption of this definition of the practice of safety.

**The Practice of Safety**

- Serves the societal need to prevent or mitigate harm or damage to people, property, and the environment, which may derive from hazards.
- Is based on knowledge and skill with respect to safety, health, and environmental:
  - engineering
  - management
  - information and communications
  - legal and regulatory affairs
- Is accomplished through
• anticipating, identifying, and evaluating hazards and assessing the risks that derive from them; and
• taking actions to avoid, eliminate, or control those hazards.
• Has as its ultimate purpose attaining a state for which the risks are judged to be acceptable.

Whatever the particular field of endeavor and the name it is given, the entirety of the practice of safety is represented in this definition. It applies to all occupational fields for which the generic base is hazards—occupational safety, occupational health, environmental affairs, product safety, all aspects of transportation safety, safety of the public, health physics, system safety, fire protection engineering, and so on.

While safety professionals may undertake many tasks in their work, the underlying purpose of each task is to have the attendant risks at an acceptable level. Every element of a safety initiative should relate to hazards and the risks that derive from them.

To all for whom the generic base of their existence is hazards, a previously made statement applies. If there are no hazards, there is no need for their existence.

MAJOR ELEMENTS IN THE PRACTICE OF SAFETY

There are three major elements in the applied practice of safety, all hazards focused:

• In the design processes, preoperational — where the opportunities are greatest for identifying and analyzing hazards and for their avoidance, elimination, or control.
• In the operational mode — where, integrated within a continuous improvement process, hazards are identified and evaluated and eliminated or controlled, before their potentials are realized and hazards-related incidents occur.
• Post incident — through investigation of hazards-related incidents to determine and eliminate or control their causal factors.

For all three of these major elements, the fundamentals in the description of the practice of safety apply: to identify and evaluate hazards; and to propose what is necessary to have the risks deriving from those hazards at an acceptable level.
KNOWLEDGE AND SKILL REQUIREMENTS

The knowledge and skill requirements to enter the practice of safety and to fulfill the requirements of professional safety practice are discussed in Chapter 5, “Academic and Skill Requirements for the Practice of Safety.” Those knowledge and skill requirements are, of necessity, exceptionally broad.

CONCLUSION

If a mission statement was written to establish the purpose of the practice of safety within an organization’s goals, the following premise will serve well as a reference.

The entirety of purpose of those responsible for safety, in fulfilling their societal responsibilities, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are at an acceptable level.

It is the intent of this chapter to define the practice of safety in a logical and precise manner. All safety professionals who would like their practices to be thought of as representing a profession are invited to move this discussion forward.

REFERENCES


ADDENDUM: SCOPE AND FUNCTIONS OF THE PROFESSIONAL SAFETY POSITION

To perform their professional functions, safety professionals must have education, training, and experience in a common body of knowledge. Safety professionals need to have a fundamental knowledge of physics, chemistry, biology, physiology, statistics, computer science, engineering mechanics, industrial processes, business, communication, and psychology. Professional safety studies include the following.

- Design of engineering hazard controls
- Fire protection
- Ergonomics
- Industrial hygiene and toxicology
- System and process safety
- Safety and health program management
- Accident investigation and analysis
- Product safety
- Construction safety
- Education and training methods
- Measurement of safety performance
- Human behavior
- Environmental safety and health
- Safety, health, and environmental laws, regulations and standards

Many safety professionals have backgrounds or advanced study in other disciplines, such as management and business administration, engineering, education, physical and social sciences, and other fields. Others have advanced study in safety. This extends their expertise beyond the basics of the safety profession.

Because safety is an element in all human endeavors, safety professionals perform their functions in a variety of contexts in both public and private sectors, often employing specialized knowledge and skills. Typical settings are manufacturing, insurance, risk management, health care,
engineering and design, waste management, petroleum, facilities management, retail, transportation, and utilities. Within these contexts, safety professionals must adapt their functions to fit the mission, operations, and climate of their employers.

Not only must safety professionals acquire the knowledge and skill to perform their functions effectively in their employment context, through continuing education and training they stay current with new technologies, changes in laws and regulations, and changes in the work force, workplace, and world business, political, and social climate.

As part of their positions, safety professionals must plan for and manage resources and funds related to their functions. They may be responsible for supervising a diverse staff of professionals.

By acquiring the knowledge and skills of the profession, developing the mind-set and wisdom to act responsibly in their employment context, and keeping up with changes that affect the safety profession, the safety professional is able to perform required safety professional functions with confidence, competence, and respected authority.

**Functions of the Professional Safety Position**

The major areas relating to the protection of people, property, and the environment are as follows:

- Anticipate, identify and evaluate hazardous conditions and practices.
- Develop hazard control designs, methods, procedures, and programs.
- Implement, administer, and advise others on hazard controls and hazard control programs.
- Measure, audit, and evaluate the effectiveness of hazard controls and hazard control programs.

A. Anticipate, identify, and evaluate hazardous conditions and practices. This function involves

   1. Developing methods for
      a. anticipating and predicting hazards from experience, historical data, and other information sources;
      b. identifying and recognizing hazards in existing or future systems, equipment, products, software, facilities, processes, operations and procedures during their expected life; and
      c. evaluating and assessing the probability and severity of loss events and accidents which may result from actual or potential hazards.
2. Applying these methods and conducting hazard analyses and interpreting results.

3. Reviewing (with assistance of specialists where needed) entire systems, processes, and operations for failure modes, causes and effects of the entire system, process or operation and any sub-system, or components due to
   a. system, subsystem, or component failures;
   b. human error;
   c. incomplete or faulty decision-making, judgments, or administrative actions; and
   d. weakness in proposes or existing policies, directives, objectives or practices.

4. Reviewing, compiling, analyzing, and interpreting data from accident and loss event reports and other sources regarding injuries, illnesses, property damage, environmental effects, or public image impacts to
   a. identify causes, trends, and relationships;
   b. evaluate the effectiveness of classification schemes and data collection methods; and
   c. initiate investigations.

5. Providing advice and counsel about compliance with safety, health, and environmental laws, codes, regulations, and standards.

6. Conducting research studies of existing or potential safety and health problems and issues.

7. Determining the need for surveys and appraisals that help identify conditions or practices affecting safety and health, including those which require the services of specialists, such as physicians, health physicists, industrial hygienists, fire protection engineers, design and process engineers, ergonomists, risk managers, environmental professionals, psychologists and others.

8. Assessing environments, tasks and other elements to assure that physiological and psychological capabilities, capacities and limits of humans are not exceeded.

B. Develop hazard control designs, methods, procedures, and programs. This function involves

1. Formulating and prescribing engineering or administrative controls, preferably before exposures, accidents, and loss events occur, to
a. eliminate hazards and causes of exposures, accidents and loss events.
b. reduce the probability or severity of injuries, illnesses, losses or environmental damage from potential exposures, accidents, loss events when hazards cannot be eliminated.

2. Developing methods that integrate safety performance into the goals, operations, and productivity of organizations and their management and into systems, processes, and operations or their components.

3. Developing safety, health, and environmental policies, procedures, codes, and standards for integration into operational policies of organizations, unit operations, purchasing, and contracting.

4. Consulting with and advising individuals and participating on teams
   a. engaged in planning, design, development and installation or implementation of systems or programs involving hazard controls; and
   b. engaged in planning, design, development, fabrication, testing, packaging, and distribution of products or services regarding safety requirements and application of safety principles which will maximize product safety.

5. Advising and assisting human resources specialists when applying hazard analysis results or dealing with the capabilities and limitations of personnel.

6. Staying current with technological developments, laws, regulations, standards, codes, products, methods, and practices related to hazard controls.

C. Implement, administer, and advise others on hazard controls and hazard control programs. This function involves

1. Preparing reports that communicate valid and comprehensive recommendations for hazard controls that are based on analysis and interpretation of accident, exposure, loss event, and other data.

2. Using written and graphic materials, presentations, and other communication media to recommend hazard controls and programs to decision-making personnel.

3. Directing or assisting in planning and developing educational and training materials or courses. Conducting or assisting with courses related to designs, policies, procedures, and programs involving hazard recognition and control.
4. Advising others about hazards, hazard controls, relative risk, and related safety matters when they are communicating with the media, community, and public.

5. Managing and implementing hazard controls and hazard control programs that are within the duties of the individual’s professional safety position.

D. Measure, audit, and evaluate the effectiveness of hazard controls and hazard control program programs. This function involves

1. Establishing and implementing techniques that involve risk analysis, cost, cost–benefit analysis, work sampling, loss rate, and similar methodologies, for periodic and systematic evaluation of hazard control and hazard control program effectiveness.

2. Developing methods to evaluate the costs and effectiveness of hazard controls and programs and measure the contribution of components of systems, organizations, processes, and operations toward the overall effectiveness.

3. Providing results of evaluation assessments, including recommended adjustments and changes to hazard controls or hazard control programs, to individuals or organizations responsible for their management and implementation.

4. Directing, developing, or helping to develop management accountability and audit programs that assess safety performance of entire systems, organizations, processes, and operations or their components and involve both deterrents and incentives.
INTRODUCTION
For the practice of safety to be recognized as a profession, it must have a sound theoretical and practical base. Application of that knowledge base will be effective in attaining hazard avoidance, elimination, or control and, thereby, achieving a state in which the risks deriving from those hazards are at an acceptable level. My belief is that there is a generic base for the work of safety professionals that must be understood and applied if we are to be effective.

But, safety professionals have not yet agreed on those fundamentals. We take a variety of approaches to achieving safety, each based on substantively different premises. They can’t all be right or equally effective. To promote a discussion toward establishing a sound theoretical and practical base for the practice of safety, I offer a listing of general principles, statements, and definitions that I believe to be rational. The list is a beginning: It is not complete.

I hope that this listing will encourage dialogue by those who have an interest in moving the state of the art forward.

A. Hazards are the Generic Base of, the Justification for the Existence of, and the Practice of Safety

1. A hazard is defined as the potential source of harm (ISO/IEC Guide 51, 3.5). Hazards include the characteristics of things and the actions or
inactions of persons that have the potential to harm or damage people, property, or the environment.

2. Hazards encompass any aspect of technology or activity that produces risk (Fischhoff, p. 217).

3. Hazards are the generic base of, as well as the justification for the existence of, the entirety of the practice of safety. If there were no hazards, safety professionals need not exist.

4. If a hazard is not avoided, eliminated, or controlled, its potential may be realized, and a hazards-related incident may occur that will or will not result in harm or damage, depending on exposures.

5. A hazard-related incident, a HAZRIN, is an unplanned, unexpected process of multiple and interacting events, deriving from the realization of uncontrolled hazards and occurring in sequence or in parallel, that is likely to result in harm or damage.

6. Hazards-related incidents, even the ordinary and frequent, are complex and have multiple and interacting causal factors.

7. Hazard analysis is the most important safety process in that, if that fails, all other processes are likely to be ineffective (Johnson, p. 245).

8. If hazard identification and analysis do not relate to actual causal factors, corrective actions will be misdirected and ineffective.

**B. Defining Risk and Safety, and their Relationship**

1. Risk is defined as a combination of the probability of occurrence of harm and the severity of that harm (*ISO/IEC Guide 51*, 3.2).

2. Probability is defined as the likelihood of a hazard being realized and initiating an event or series of events that could result in harm or damage—for the selected unit of time, events, population, items or activity being considered.

3. Severity considerations include injury and illness to people, damage to property and the environment, business downtime, loss of business, and so on.

4. Safety is defined as freedom from unacceptable risk (*ISO/IEC Guide 51*, 3.1). Or, safety is defined as that state for which the risks are judged to be acceptable.

5. All risks to which the practice of safety applies derive from hazards: There are no exceptions.

6. Setting a goal to achieve a zero risk environment may seem laudable, but doing so requires chasing a myth.
7. It is impossible to attain a risk-free environment. Even in the most desirable situations, there will still be residual risk after application of the best practical prevention methods.

8. Residual risk is defined as the risk remaining after protective measures have been taken (ISO/IEC Guide 51, 3.9).

9. For an operation to proceed, its risks must be judged to be acceptable.

C. Defining the Practice of Safety

1. The entirety of purpose of those accountable for safety, in fulfilling their societal responsibilities, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are at an acceptable level.

2. The practice of safety

   - Serves the societal need to prevent or mitigate harm or damage to people, property, and the environment, which may derive from hazards;
   - Is based on knowledge and skill with respect to safety, health, and environmental:
     - engineering;
     - management;
     - information and communications; and
     - legal and regulatory affairs;
   - Is accomplished through
     - anticipating, identifying, and evaluating hazards and assessing the risks that derive from them; and
     - taking actions to avoid, eliminate, or control those hazards; and
   - Has as its ultimate purpose attaining a state for which the risks are judged to be acceptable.

3. While safety professionals may undertake many tasks in their work, the underlying purpose of each task is to have the attendant risks at an acceptable level. Every element of a safety initiative should relate to hazards and the risks that derive from them.

4. Professional safety practice requires consideration of two distinct aspects of risk:

   - avoiding, eliminating, or reducing the *probability* of a hazard-related incident occurring; and
   - minimizing the *severity* of harm or damage, if an incident occurs.
5. There are three major elements in the practice of safety:

- in the design processes, preoperational — where the opportunities are greatest for identifying and analyzing hazards and risks for their avoidance, elimination, or control;
- in the operational mode — where, integrated within a continuous improvement process, hazards and risks are identified and evaluated and eliminated or controlled, before their potentials are realized and hazards-related incidents occur; and
- post incident — through investigation of hazards-related incidents to determine and eliminate or control their causal factors.

D. On Achieving the Theoretical Ideal for Safety

1. The theoretical ideal for safety is achieved when all risks deriving from hazards are at an acceptable level.

2. That definition serves, generally, as a mission statement for the work of safety professionals, and as a reference against which each of the many activities in which they engage can be measured.

3. A statement in Why TQM Fails and What to Do About It by Brown, Hitchcock, and Willard, with minimum modification, provides a basis for review to determine how near operations are to achieving the theoretical ideal for safety. In the following quotation, the word safety appears twice. In the first instance, it replaces TQM; in the second, it replaces quality:

   When safety is seamlessly integrated into the way an organization operates on a daily basis, safety becomes not a separate activity for committees and teams, but the way every employee performs job responsibilities [Brown et al., p. 79].

4. That statement implies that a system of expected behavior is in place, as a reflection of an organization’s culture: a system of expected behavior that requires a superior level of safety performance.

5. When safety is seamlessly integrated into the way an organization functions on a daily basis, a separately identified safety program is not needed since all actions required to achieve safety would be blended into operations.

6. Thus, the theoretical ideal for a safety program is nothing. (Program: a plan or schedule to be followed.)
E. On Organizational Culture

1. An organization’s culture determines the level of safety to be attained. What the board of directors or senior management decides is acceptable for the prevention and control of hazards is a reflection of its culture.

2. An organization’s culture consists of its values, beliefs, legends, rituals, mission, goals, performance measures, and sense of its responsibility to its employees, to its customers, and to its community, all of which are translated into a system of expected behavior.

3. Management obtains, as a derivation of its culture — as an extension of its system of expected behavior — the hazards-related incident experience that it establishes as tolerable. For personnel in the organization, “tolerable” is their interpretation of what management does.

4. An organization’s culture, translated into a system of expected behavior, determines management’s commitment or noncommitment to safety; involvement and direction; accountability system; safety policy; safety organization; standards for workplace and work methods design; requirements for continuous improvement; and the behavioral climate that is to prevail concerning management and personnel factors (leadership, training, communication, adherence to safe work practices, et cetera).

5. Management commitment is questionable if the accountability system does not include safety performance measures that impact on the well-being of those responsible for results.

6. What management does, rather than what management says, defines the actuality of commitment or noncommitment to safety.

7. Principal evidence of an organization’s culture with respect to hazards management is demonstrated through the design decisions that determine what the facilities, hardware, equipment, tooling, materials, configuration and layout, the work environment, and the work methods are to be.

8. If the design of a system (the facilities, equipment, work methods, etc.) does not achieve minimum risk, superior results with respect to safety cannot be attained, even if personnel and management factors approach the ideal.

9. Where the culture, the system of expected behavior, demands superior safety performance, the design and engineering, management and operations, and task performance aspects of safety are well-balanced.

10. Major improvements in safety will be achieved only if a culture change takes place — only if major changes occur in the system of expected behavior.
F. Concerning Leadership, Training, and Behavior Modification

1. Effective leadership, training, communication, persuasion, behavior modification, and discipline are vital aspects of hazards management, without which superior results cannot be achieved.

2. But, training and behavior modification, among other things, are often erroneously applied as solutions to problems, with unrealistic expectations. Such personnel actions have limited effectiveness when causal factors derive from workplace and work methods design decisions. (It is recognized that, in certain situations, behavioral and personnel actions are the only preventive actions that can be taken.)

3. Heath and Ferry wrote this in *Training in the Workplace: Strategies for Improved Safety and Performance*:

   Employers should not look to training as the primary method for preventing workplace incidents that result in death, injury, illness, property damage or other down grading incidents. They should see if engineering revisions can eliminate the physical safety and health hazards entirely [p. 6].

4. As an idea, the substance of, but not the precise numbers of, Deming’s 85–15 Rule applies to all aspects of the practice of safety. This is from *The Deming Management Method* by Mary Walton:

   Deming’s 85–15 Rule holds that 85 percent of the problems in any operation are within the system and are the responsibility of management, while only 15 percent lie with the worker [p. 242].

5. In *Out of the Crisis*, by W. Edwards Deming, this is how the subject just previously mentioned is treated:

   I should estimate in my experience most troubles and most possibilities for improvement add up to proportions something like this: 94% belong to the system (responsibility of management); 6% special [p. 315].

6. The premise is valid — that a large majority of the problems in any operation are systemic, deriving from the workplace and the work methods created by management, and can be resolved only by management: responsibility for only the relatively small remainder lies with the worker.

7. Extrapolating from Deming, a large majority of the causal factors for hazards-related incidents are systemic, and a small minority will be principally employee-focused.

8. Problems that are in the system can only be corrected by a redesign of the system. If system design and work methods design are the problems, the capability of employees to help is principally that of problem identification.
9. This is from *Out of the Crisis* in which W. Edwards Deming, referencing Juran, speaks of workers being “handicapped by the system”:

The supposition is prevalent the world over that there would be no problems in production or in service if only our production workers would do their jobs in the way that they were taught. Pleasant dreams. The workers are handicapped by the system, and the system belongs to management. It was Dr. Joseph M. Juran who pointed out long ago that most of the possibilities for improvement lie in action on the system, and that contributions of production workers are severely limited [Deming, p. 134].

10. While employees should be trained and empowered up to their capabilities and encouraged to make contributions to safety, they should not be expected to do what they cannot do.

11. While safety is a line responsibility, it should be understood that achievements by management at an operating level are limited by the previously made workplace and work methods design decisions. If the design of the system presents excessive operational risks for which the cost of retrofitting is prohibitive, then administrative controls, which perhaps may be the only actions that can be taken, will achieve less than superior results.

G. Significance of Design and Engineering

1. W. Edwards Deming got it right: A large majority of the problems in an operation are systemic, deriving from the workplace and work methods created by management, and responsibility for only the relatively small remainder lies with the workers.

2. Thus, the greatest strides forward with respect to safety, health, and the environment are being made through the design and redesign processes.

3. For the practice of safety, the term *design process* applies to:

   - facilities, hardware, equipment, tooling, selection of materials, operations layout and configuration; and

   - work methods and procedures, personnel selection standards, training content, management of change procedures, maintenance requirements, personal protective equipment needs, et cetera.

4. Design and engineering applications that determine the workplace and work methods are the preferred measures of prevention since they are more effective in avoiding, eliminating, and controlling risks.
5. Over time, the level of safety achieved will relate directly to the caliber of the initial design of the workplace and work methods, and their subsequent redesign in a continuous improvement endeavor.

6. A fundamental design goal is to have processes that are error proof. Juran and Gryna, in *Quality Planning and Analysis*, speak appropriately of “Error Proofing the Process,” in these quotations:

   An important element of prevention is the concept of designing the process to be error free through “error proofing” (the Japanese call it pokayoke or bakayoke). A widely used form of error proofing is the design (or redesign) of the machines and tools (the “hardware”) so as to make human error improbable or even impossible [p. 347].

7. Requirements to achieve an acceptable risk level in the design process can usually be met without great cost if the decision-making takes place sufficiently upstream. When that does not occur, and retrofitting to eliminate or control hazards is proposed, the cost may be so great as to be prohibitive.

**H. On System Safety**

1. The “Scope and Functions of the Professional Safety Position” issued by the American Society of Safety Engineers says that the safety professional is to anticipate, identify, and evaluate hazardous conditions and practices, and develop hazard control designs, methods, procedures and programs. Those are valid statements.

2. If safety professionals are to anticipate hazards, they must participate in the design process. To be involved in the design process effectively, they must be skilled in hazard analysis and risk assessment techniques. Being a participant in the design process and using hazard analysis and risk assessment techniques are the basics of system safety.

3. Applied system safety requires a conscientious, planned, disciplined, and systematic use of special engineering and management tools *on an anticipatory and forward-looking basis*.

4. Browning’s premise, as stated in *The Loss Rate Concept in Safety Engineering*, is sound:

   As every loss event results from the interactions of elements in a system, it follows that all safety is system safety [p. 12].

5. A significant premise of system safety is that hazards are most effectively and economically anticipated, avoided, or controlled in the initial design process.
6. For workplace design, management and operations, and task performance aspects of safety, application of hazard analysis and risk assessment methods are vital to achieving an acceptable risk level.

7. Joe Stephenson, in *System Safety 2000*, expressed this view, which is sensible:

The safety of an operation is determined long before the people, procedures, and plant and hardware come together at the work site to perform a given task [p. 10].

I. Significance of Ergonomics

1. Ergonomics is the art and science of designing the work to fit the worker — to achieve optimum productivity and cost efficiency, and minimum risk of injury.

2. Estimates frequently appear indicating that as many as 50% of work injuries and illnesses and 60% of total claims costs are ergonomics-related.

3. Assume that estimate to be close to reality. Then, to be effective, a safety generalist giving counsel for workplace safety and health must be deeply engaged in ergonomics.

4. Effective application of ergonomics principles requires that workplace and work methods analyses properly identify the possible stresses to employees — the hazards — and that they be addressed in the design or redesign of the work place and work methods.

5. Ergonomics developed out of the need to make work less stressful and more comfortable. Those are laudable goals that can be more effectively achieved if managements are convinced that the application of ergonomics principles also serves their productivity and cost efficiency goals.

6. It should be the exception when an ergonomics analysis is made only for safety purposes. Rather, the analysis should address the aspects of productivity, cost efficiency, and risk reduction — all in one study.

J. Setting Priorities and Utilizing Resources Effectively

1. These principles are postulated.

   • All hazards do not present equal potential for harm or damage.

   • All incidents that may result in injury, illness, or damage do not have equal probability of occurrence, nor will their adverse outcomes be equal.

   • Some risks are more significant than others.
• Resources are always limited. Staffing and money are never adequate to attend to all risks.

• The greatest good to employees, to employers, and to society is attained if available resources are effectively and economically applied to avoid, eliminate, or control hazards and the risks that derive from them.

2. Since resources are always limited, and since some risks are more significant than others, safety professionals must be capable of distinguishing the more significant from the lesser significant.

3. Professional safety practice requires that the potentials for the greatest harm or damage be identified for the decision makers and that a ranking system be applied to proposals made to avoid, eliminate, or control hazards.

4. Safety professionals must, therefore, be capable of using hazard analysis and risk assessment methods.

5. Causal factors for low-frequency incidents resulting in severe harm or damage may be different from the causal factors for more frequently occurring incidents. Such low-frequency incidents often involve unusual or nonroutine work, nonproduction activities, sources of high energy, and certain construction situations.

6. Thus, safety professionals must undertake a separate and distinct activity to seek those hazards that present the most severe injury or damage potential so that they can be given priority consideration.

K. On Incident Causation

1. For most all hazards-related incidents, even those that seem to present the least complexity, there are multiple causal factors that derive from less than adequate: workplace and work methods design engineering, management and operations, and personnel task performance practices.

2. In MORT Safety Assurance Systems, Johnson wrote succinctly about the multifactorial aspect of incident causation, as in the following:

   Accidents are usually multifactorial and develop through relatively lengthy sequences of changes and errors. Even in a relatively well-controlled work environment, the most serious events involve numerous error and change sequences, in series and parallel [p. 74].

3. In the hazards-related incident process, deriving from those multiple causal factors:
there are unwanted energy flows or exposures to harmful environments;

• a person or thing in the system, or both, are stressed beyond the limits of tolerance or recoverability;

• the incident process begins with an initiating event in a series of events; and

• multiple interacting events occur, sequentially or in parallel, over time and influence each other, to a conclusion that may or may not result in injury or damage.

4. Severity potential should determine whether hazards-related incidents should be considered significant, even though serious harm or damage did not occur.

5. H. W. Heinrich has had more influence on the practice of safety than any other author. Even if a safety practitioner has never heard of him, Heinrich’s influence may still be felt in what the safety practitioner does since Heinrich’s premises have been adopted by many as certainty. They permeate the safety literature. Four editions of his book Industrial Accident Prevention were printed, the last being in 1959. Many of the Heinrich premises are questionable, as follows:

a. Heinrich’s 88:10:2 ratios indicate that among the direct and proximate accident causes, 88% are unsafe acts, 10% are unsafe mechanical or physical conditions, and 2% are unpreventable (p. 174).

• The methodology used in arriving at those ratios cannot be supported.

• Current causation knowledge indicates the premise to be invalid.

• This premise conflicts with the work of others, such as W. Edwards Deming, whose research finds root causes to derive from shortcomings in the management systems.

• Among all the Heinrich premises, application of these ratios has had the greatest impact on the practice of safety and has also done the most harm—since it promotes preventive efforts being focused on the worker, rather on the operating system.

• Those who continue to promote the idea that 88% of all industrial accidents are caused primarily by the unsafe acts of persons do the world a disservice.

b. The Foundation of a Major Injury, the 300:29:1 ratios (Heinrich’s triangle) is the least tenable of his premises (p. 27).
• It is impossible to conceive of incident data being gathered through the usual reporting methods in 1926 (when his postulation was made) in which 10 out of 11 reports would pertain to accidents that resulted in no injury.

• Conclusions pertaining to the 300:29:1 ratios were revised from edition to edition, without explanation, thus presenting questions about which version is valid.

c. Heinrich’s often-stated belief that the predominant causes of no-injury accidents are identical with the predominant causes of accidents resulting in major injuries is not supported by convincing evidence and is questioned by several authors. Application of the premise results in misdirection since those who apply it may presume, inappropriately, that if they concentrate their efforts on the types of accidents that occur frequently, the potential for severe injury will also be addressed (p. 33).

• Investigation of numerous accidents resulting in fatality or serious injury by modern-day safety professionals leads to the conclusion that their causal factors are not linked to accidents that occur frequently and result in minor injury.

d. No documentation exists to support Heinrich’s 4:1 ratio of indirect injury costs to direct costs. Furthermore, arriving at a ratio that is applicable universally is implausible (p. 40).

e. In Heinrich’s Principles of Accident Prevention, an inordinate emphasis is placed on the unsafe acts of individuals as causal factors, and insignificant attention is given to causal factors deriving from operating systems. It is my belief that many safety practitioners would not agree with Heinrich’s premise that “man failure is the heart of the problem and the methods of control must be directed toward man failure” (p. 4).

f. In Heinrich’s Accident Factors, prominence is given to causal factors deriving from ancestry and environment and to the faults of persons that allegedly derive from inherited or acquired faults: that is inappropriate with respect to current societal mores (p. 15).

6. Incident investigation, initially, should address the work system, applying a concept that

• commences with inquiries to determine whether causal factors derive from workplace design decisions; and
• promotes ascertaining whether the design of the work methods was overly stressful or error-provocative, or whether the immediate work situation encouraged riskier actions than the prescribed work methods.

L. Performance Measures

1. If the practice of safety professionals is based on sound science, engineering, and management principles, it follows that they should be able to provide measures of performance that reflect with some degree of accuracy the outcomes of the hazards management initiatives they propose.

2. Understanding the validity and shortcomings of our performance measures is an indication of the maturity of the practice of safety as a profession.

3. Safety professionals must understand that the quality of the management decisions made to avoid, eliminate, or control hazards and risks are impacted directly by the validity of the information they provide through their performance measurement systems. Their ability to provide accurate information to be used in the decision-making is a measure of their effectiveness.

4. Since safety achievements in an organization are a direct reflection of its culture, and since it takes a long time to change a culture, short-term performance measures should be examined cautiously as to validity.

5. Except for low probability–high consequence incidents, as the exposure base represented by the number of hours worked increases, the historical incident record has an increasing degree of confidence as

• a measure of the quality of safety in place; and

• a general, but not hazard-specific, predictor of the experience that will develop in the future.

6. But, no statistical, historical performance measurement system can assess the quality of safety in place that encompasses low probability–high consequence incidents since such events seldom appear in the statistical history. (Example: A risk assessment concludes that a defined catastrophic event, one that has not happened and is not represented in the statistical base, has an occurrence probability of once in 200 plant operating years.)

7. Even for the large organization with significant annual hours worked, in addition to historical data, hazard-specific and qualitative performance measures (safety audits, perception surveys, the incident
recall technique) are also necessary, particularly to identify low probability/severe consequence risks.

8. Statistical process controls (cause-and-effect diagrams, control charts, etc.), as applied in quality management, can serve as performance measures for safety, if they are used prudently and with caution.

9. Incidents resulting in severe injury or damage seldom occur and would rarely be included in the plottings on a statistical process control chart. Although such a chart may indicate that a system is in control, it could be deluding if it was presumed that the likelihood of low-probability incidents occurring that could result in severe harm or damage was encompassed in the plottings.

10. Since the language of management is finance, safety practitioners must be able to communicate incident experience in financial terms (see “Establishing Your Value: Communicating Incident Statistics in Financial Terms,” in Innovations in Safety Management: Addressing Career Knowledge Needs).

11. Much interest has developed in what are being called leading indicators for the measurement of safety. Those who promote the development of leading indicators as a performance measure call the statistics traditionally gathered trailing indicators. Leading indicators would be, for example, training programs conducted, inspections made, hazard communication sessions held, and so on. In the long term, management will still want to know whether application of the leading indicators has been successful, and the success will be measured largely by the trending in the trailing indicators (the incident experience) and the costs.

M. On Safety Audits

1. Safety audits must meet this definition to be effective: A safety audit is a structured approach to provide a detailed evaluation of safety effectiveness, a diagnosis of safety problems, a description of where and when to expect trouble, and guidelines concerning what should be done about the problems.

2. The paramount goal of a safety audit is to influence favorably the organization’s culture. Kase and Wiese concluded properly in Safety Auditing: A Management Tool that:

   Success of a safety auditing program can only be measured in the terms of the change it effects on the overall culture of the operation, and enterprise that it audits [p. 36].

3. Since evidence of an organization’s culture and its management commitment to safety is first demonstrated through its upstream design and
engineering practices, safety audits that do not evaluate the design processes are incomplete and fall short of the definition of an audit.

4. Safety audits must also properly measure management commitment, primary evidence of which is a results-oriented accountability system. If such an accountability system does not exist, management commitment is questionable.

CONCLUSION

Early on, it was said that this chapter would not contain a complete listing of the principles for the practice of safety, knowing that others would add to it. But, the intent is to produce a document that would encourage dialogue. To some extent, that has occurred and continues.

REFERENCES


ACADEMIC AND SKILL REQUIREMENTS FOR THE PRACTICE OF SAFETY

INTRODUCTION

Having defined the Practice of Safety in Chapter 3, these two subjects will now be addressed:

- The academic knowledge and skills that would prepare one to enter the practice of safety
- The knowledge and skill requirements that describe the applied practice of safety, using the term broadly

Fortunately, the work of many others with regard to the knowledge and skill required for the practice of safety, done under the auspices of the American Society of Safety Engineers (ASSE) and the Board of Certified Safety Professionals (BCSP), serves as valuable resources for the purposes of this chapter. A review of the history of that highly significant work is given here.

EVOLUTION OF JOINT ASSE AND BCSP BACCALAUREATE CURRICULUM STANDARDS

For many years, ASSE accredited college and university safety degree programs that met its standards. Over time, members of the ASSE Board
of Directors and others contributed to the development of the “Suggested Core Curriculum for the Occupational Safety and Health Professional” that was used in the accreditation process.

In April of 1980, BCSP issued Technical Report No. 1 titled *Curricula Development and Examination Study Guidelines*. Ralph J. Vernon, Ph.D., CSP, was the author. That Report was issued in response to a “perceived need to compile and publish data that would provide insight into the academic preparation and experience” required by those who chose to attain certification as a safety professional and would take what was then a single-level BCSP examination.

Dr. Vernon reviewed the education and experience of the 4400 applicants who had, up to that time, been examined by BCSP. He also had available two research papers that were developed for the National Institute for Occupational Safety and Health. One was *A Nationwide Survey of the Occupational Safety and Health Work Force*. The other was *Development and Validation of Career Development Guideline by Task/Activity Analysis of Occupational Safety and Health Professions: Industrial Hygiene and Safety Profession*.

As a part of his work, Dr. Vernon prepared and included in BCSP Technical Report No. 1 a “Suggested Baccalaureate Curriculum for the Safety Professional.” In August of 1981, BCSP published an extension of the original curriculum guideline in Technical Report No. 2. Its title is *Curricula Guidelines for Baccalaureate Degree Programs in Safety*. That report was prepared by The BCSP Ad Hoc Committee on Academic Guidelines. Both of these Reports are still valuable resources.

Distribution of those reports by BCSP had a broad impact on many safety professionals, including me. At the time of their publication, I was a member of the board of directors of ASSE. Working with other board members, modifications were proposed and made in the ASSE curriculum guidelines that moved them closer to those of the BCSP.

*Curriculum Standards for Baccalaureate Degrees in Safety* were published in August of 1991 by ASSE and BCSP as Joint Report No. 1. Subsequently, ASSE arranged with the Accreditation Board for Engineering and Technology (ABET) to have ABET’s Related Accreditation Commission (RAC) be the accrediting entity for college and university safety degree programs. That continues to be the arrangement. The ASSE/BCSP *Curriculum Standards for Baccalaureate Degrees in Safety* form the basis for accreditation by ABET/RAC.
DO ASSE/BCSP CURRICULUM STANDARDS MATCH EDUCATIONAL NEEDS?

Just how well would graduates be prepared to enter the practice of safety if they fulfilled the course requirements of the ASSE/BCSP Curriculum Standards? In making that judgment, one would have to consider the recent transitions in the responsibilities of safety professionals, the diversity of their roles, and the many specialties within the practice of safety.

As an indication of those transitions, the responsibilities of many safety professionals have been extended and now include occupational safety, occupational health, and environmental affairs. Some are also engaged in other hazards-related functions such as fire protection, product safety, and transportation safety. In BCSP’s “Overview of CSP Examinations,” this appears:

Recent data indicate about 13 percent of CSPs deal solely with safety as a job function. Eighty percent deal with some combination of other topics and 40 percent have responsibility for safety, health, and environmental matters [p. 3].

Transitions in the practice of safety have extended the functions performed by safety practitioners considerably. Thus, no college curriculum could include in a baccalaureate safety degree program all the courses that one would like students to take in preparation for entry into the practice of safety. So, at a baccalaureate level the course work should be basic and preparatory and provide broad opportunities in anticipation of current and evolving professional needs.

(When theorizing on the ideal outline of courses to be taken by a student preparing for the practice of safety, it was easy for me to get the course load up to 180 hours. And that’s absurd.)

I have made a thorough re-study of the Curriculum Standards for Baccalaureate Degrees in Safety in light of the added responsibilities many safety practitioners now have. Because of the soundness of the basic requirements and the flexibility they provide for electives, they still provide an excellent foundation for the diverse needs of those entering the safety profession. The Standards are foundational and their content is very broad. They recognize the need to have several electives available in specialty fields, and they also recognize that individual universities will have particular course requirements.

Several outstanding safety professionals contributed to the development of the Curriculum Standards for Baccalaureate Degrees in Safety, and they
should be commended for their work. Both ASSE and BCSP should be
proud of their accomplishments.

A REVIEW OF THE CURRICULUM STANDARDS

The purpose of the curriculum standards is to define the minimum aca-
demic requirements for entering the safety profession. To meet the ASSE/-
BCSP accreditation requirements for a baccalaureate degree in safety, a
college or university program must require not less than 120 semester
hours (or equivalent) of study and meet a broad range of prescribed stud-
ies. They are briefly reviewed here.

Minimum requirements for lower-level courses are listed under the
caption “University Studies.” Those subjects usually exist in a variety of
departments. Six foundational course categories are considered essential
for the safety professional. They are listed here, along with specific course
requirements.

- **Mathematics, Statistics, and Computer Science.** Courses required:
  Calculus, Statistics, and Computer and Information Processing.

- **Physical, Chemical, and Life Sciences.** Courses required: Physics
  (with laboratory), Chemistry (with laboratory), and Life Science (a
  laboratory component is recommended). An Organic Chemistry cour-
  se is strongly recommended.

- **Behavioral Science, Social Science, and Humanities.** Courses re-
  quired: Psychology, and other Social Science and Humanities courses,
totaling at least 15 semester hours.

- **Management and Organizational Science.** Course strongly recom-
  mended: Introduction to Business or Management. Course recom-
  mended: Business Law or Engineering Law.

- **Communication and Language Arts.** Courses required: Rhetoric and
  Composition, and Speech. A course in technical writing is strongly
  recommended.

- **Basic Technology and Industrial Processes.** Courses required: App-
  lied Mechanics, or its equivalent, and Industrial or Manufacturing
  Processes.

A program would be considered deficient if it did not contain a “strongly
recommended” course, unless its absence could be well-supported.

Next in the Curriculum Standards is a listing of “Professional Core”
courses that are to develop the basic knowledge and skills required in the
practice of safety. All of the following are required courses.
• Introduction to Safety and Health
• Safety and Health Program Management
• Design of Engineering Hazard Control
• Industrial Hygiene and Technology
• Fire Protection
• Ergonomics
• Environmental Safety and Health
• System Safety and Other Analytical Methods for Safety
• Experiential Education — there shall be either an internship or COOP course

“Required Professional Subjects” are next listed, and they follow. However, it is not necessary that a full course be devoted to each subject, although a school has that option.

• Measurement of Safety Performance
• Accident/Incident Investigation and Analysis
• Behavioral Aspects of Safety
• Product Safety
• Construction Safety
• Educational and Training Methods for Safety

Then, the captions “Professional Electives” and “General Electives” follow in the Curriculum Standards. Thirty-one possible elective subjects are listed as examples, with the indication that the courses a school offers need not be limited to the listing. General electives are to fulfill the additional course hours required.

Considering the recent transitions in the practice of safety and the breadth of present and probable future requirements, I believe that the Curriculum Standards for the Baccalaureate Degrees in Safety represent a sound course of study through which the needed academic knowledge can be acquired to prepare those who are to enter the practice of safety.

But, because of the emergence of what has been called the safety through design movement and the recent publication of safety guidelines and standards that propose or require hazard analysis and risk assessment, special courses need to be crafted to address these additional knowledge need.
RELATIONSHIP BETWEEN THE ASSE/BCSP BACCALAUREATE CURRICULUM STANDARDS AND THE BCSP CERTIFICATION EXAMINATIONS

BCSP is an examination and certifying body. Candidates who pass a Safety Fundamentals Examination receive the Associate Safety Professional (ASP) title; those who pass the Comprehensive Practice Examination receive the Certified Safety Professional (CSP) title. Also, BCSP gives specialty examinations in subjects such as system safety and ergonomics.

If an entity that examines and certifies professionals chooses to attain stature, credibility, and recognition, it will meet the requirements of nationally recognized accrediting organizations with respect to its standards, procedures, and examinations systems. Yes, there are accrediting agencies that accredit accrediting and certifying organizations. The BCSP program is accredited by the National Commission for Certifying Agencies (NCCA) and the Council of Engineering and Scientific Specialty Boards (CESB).

One of the requirements of such accrediting bodies is that the certifying entity periodically validate that its examinations properly reflect the work done by those being examined and certified. BCSP completed such a validation study in 1999, and it reported on the results and the changes to be made in its examinations in a 2001 bulletin titled “Updating the CSP for the 21st Century.” These are highlights from that bulletin.

- This is the purpose given for making a validation study: A validation study intends to assess what people in an area of professional practice do in their jobs.
- The validation study involved nearly 1500 practitioners.
- Subject content for the Safety Fundamentals Examination and the Comprehensive Practice Examination will be the same, but the examinations differ greatly in what is tested.
- For the Safety Fundamentals examination, it is assumed that the candidate has no safety job experience, and tests are subject matter based. For the Comprehensive examination, it is assumed that the candidate has at least four years of experience, and the test presents problems that are based on work content.
- More emphasis is placed in both the Safety Fundamentals and the Comprehensive Practice examinations on information management and communications.
- There are four knowledge skill categories, called domains. They are: Safety, Health, and Environmental Management; Safety, Health, and
Environmental Engineering; Safety, Health, and Environmental Information Management and Communications; and Professional Conduct and Ethics. Influenced by the transitions that have taken place in the practice of safety, health and environmental affairs now have added emphasis in the examinations.

- In relation to previous BCSP publications about its examinations, these terms now appear more prominently: environmental controls; safety through design; design of hazard control systems; risk management; and risk assessment techniques.
- There is now a greater emphasis on the needed communications skills.

My purpose here is to determine whether what people are taught in the ASSE/BCSP sanctioned baccalaureate programs matches what safety professionals do and the content of the examinations they take to obtain professional certification. In the BCSP bulletin “Updating the CSP for the 21st Century,” both the knowledge and skill fields for each responsibility category are shown. A listing of the four domains, the responsibility categories, and the relevant knowledge fields follows. Skills as shown in the BCSP bulletin relate directly to the application of the knowledge fields listed.

The intent here is to make a review of responsibility categories and knowledge fields. The skill descriptions will not be shown. (For a listing of the skill descriptions, you can go to www.bcsp.org and locate “Appendix B. Safety Fundamentals and Comprehensive Examination Blueprints” in the downloadables.)

In the following listing, you will find that some subjects appear in more than one knowledge field. The reason for that in relation to the responsibility category will be understandable. As you review the knowledge fields, keep in mind the material given earlier in this chapter on the ASSE/BCSP curriculum requirements. There is a very good, but not exact, match.

**Domain 1. Safety, Health, and Environmental Management**

**Responsibility 1.** Design comprehensive management systems by defining requirements and developing policies, procedures and programs to protect people, property, and the environment.

**Knowledge Fields**

1. Statutory and case law regulating safety, health, and the environment
2. Operational process to design/develop safe work practices
3. Material flow process
4. Safety, health, and environmental sciences
5. Design of hazard control systems (i.e., fall protection, scaffolding)
6. Design of record keeping systems that allow for collection, storage, interpretation, and dissemination
7. Mathematics and statistics
8. Methods and techniques for achieving safety through design
9. Methods and techniques for accident investigation
10. Property protection (physical and intellectual) and security

Responsibility 2. Implement policies, procedures, and programs through management systems to protect people, property, and the environment.

Knowledge Fields
1. Organizational theory and behavioral science
2. Education and training methods
3. Basic sciences: chemistry, biology, physics, physiology, and anatomy
4. Safety, health, and environmental sciences

Responsibility 3. Determine the effectiveness of management systems by measuring and evaluating performance indicators to ensure continuous improvement in the protection of people, property, and the environment.

Knowledge Fields
1. Quantitative and qualitative performance indicators
2. Mathematics and statistics
3. Basic sciences: chemistry, biology, physics, physiology, and anatomy
4. Safety, health, and environmental issues
5. Management and behavioral sciences
6. Laws, standards, and regulations
7. Safety management systems
8. Education and training methods
9. Auditing techniques and management system reviews

Responsibility 4. Implement risk management strategies by using the results of hazard identification and risk analyses to eliminate/or reduce harmful exposures to people, property, and the environment.
Knowledge Fields

1. Laws, standards, and regulations
2. Process operations (e.g., critical inputs, assessments, and inventory)
3. Mathematics and statistics
4. Insurance practices (types, and premium calculations)
5. Industrial hygiene including chemical, physical, and biological agents
6. Safety engineering
7. Safety management
8. Fire prevention and protection including life safety
9. Construction safety
10. Education and training methods
11. Ergonomics program management
12. Transportation fleet safety management
13. Workers’ compensation and case management
14. Risk management concepts
15. Crisis management
16. Post-incident and loss mitigation
17. Behavior modification
18. Safety through design process

Responsibility 5. Apply sound business practices and economic principles for efficient use of resources to increase the value of the safety processes.

Knowledge Fields

1. Business regulations and laws
2. Economics, accounting, and statistics
3. Process management, material flow, and procurement
4. Personnel development techniques
5. Insurance practices (types, and premium calculation)
6. Drug/alcohol programs, including Employee Assistance Programs
7. Capital budgeting and long-range planning

Responsibility 6. Encourage participation through communication and other methods to ensure that all stakeholders (e.g., employees, managers, vendors, contractors) have an understanding and an active role in the formulation and implementation of safety processes.
Knowledge Fields

1. Communication and presentation techniques
2. Organizational theory and behavioral science
3. Laws, standards, and regulations that require employee participation
4. Economics and budgeting
5. Management principles
6. Employee participation committees
7. Labor relations, including union/management committees

Domain 2. Safety, Health, and Environmental Engineering

Responsibility 1. Evaluate facilities, products, systems, equipment, workstations, and processes by applying qualitative and quantitative techniques to identify the hazards and assess the associated risks.

Knowledge Fields

1. Methods and techniques for evaluation of facilities, products, systems, equipment, workstations, and processes
2. Methods and techniques for measurement, sampling, and analysis
3. Specifications and drawings
4. Laws, standards, and regulations
5. Risk assessment techniques
6. Characteristics and hazards of materials
7. Basic sciences: chemistry, biology, physics, physiology, and anatomy
9. Industrial hygiene, including chemical, physical, and biological agents
10. Fire protection and prevention, including life safety
11. Environmental protection and pollution prevention
12. Construction safety
13. System safety
14. Product safety
15. Behavioral sciences
16. Education and training methods
17. Ergonomics and human factors
18. Process safety
19. Physical and chemical characteristics of hazardous materials
20. Equipment and facility safety requirements

Responsibility 2. Recommend controls through design, engineering, and specification to eliminate or reduce the risks posed by safety, health, and environmental hazards.

Knowledge Fields
1. Laws, standards, and regulations
2. Risk management
3. Record keeping, data collection, and retrieval systems
4. Materials
5. Basic sciences: chemistry, biology, physics, physiology, and anatomy
6. Applied engineering sciences: electronics, mechanics, thermodynamics, materials, structures, plant layout, etc.
7. Industrial hygiene, including chemical, physical, and biological agents
8. Fire protection and prevention, including life safety
9. Environmental protection and pollution prevention
10. Construction safety
11. System safety
12. Product safety
13. Behavioral sciences
14. Education and training methods
15. Ergonomics and human factors
16. Process safety
17. Ventilation systems
18. Procurement

Responsibility 3. Evaluate controls by analyzing feasibility, effectiveness, reliability, and cost to achieve the optimal solution.

Knowledge Fields
1. Laws, standards, and regulations
2. Methods and techniques for evaluating feasibility, effectiveness, reliability, and cost–benefit
3. Risk assessment
4. Specifications and drawings
5. Data management
6. Industrial hygiene, including chemical, physical, and biological agents
7. Fire protection and protection, including life safety
8. Environmental protection and pollution prevention
9. Construction technology
10. Inspection and auditing techniques
11. System and occupational safety

Responsibility 4. Obtain compliance certifications, listings, approvals, or authorizations by identifying and meeting applicable national and international laws, regulations, and standards in order to ensure product, process, and facility safety.

Knowledge Fields
1. Laws, standards, and regulations
2. Data management
3. Quality assurance and control
4. Documentation protocol
5. Certification requirements
6. Appropriate entities to contact for forms, approval, and certification

Domain 3. Safety, Health and Environmental Information Management and Communications

Responsibility 1. Develop effective training programs by establishing learning objectives to impart knowledge and facilitate an understanding of hazards and controls.

Knowledge Fields
1. Adult learning
2. Group dynamics
3. Technical content
4. Needs analysis
5. Testing and measurement
6. Presentation media and technologies
7. Graphic design

Responsibility 2. Deliver effective training programs by using media and methods appropriate to the audience to maximize understanding of the subject matter.

Knowledge Fields
1. Presentation media
2. Adult learning
3. Target audience background and informational needs
4. Group dynamics
5. Active learning techniques
6. Conflict resolution techniques

Responsibility 3. Evaluate training programs through performance assessments and various forms of feedback in order to assure training that is effective.

Knowledge Fields
1. Testing and measurement
2. Sampling techniques
3. Statistical analysis
4. Item writing and test construction
5. Methods for obtaining feedback

Responsibility 4. Present technical information, both verbally and in writing, to effectively communicate with employees, management, customers, contractors, public relations officials, vendors, and the public.

Knowledge Fields
1. Graphic design
2. Group dynamics
3. English and grammar
4. Format for various types of media
5. Protocols for public announcements
6. Risk assessment techniques
7. Legal aspects of communication
Responsibility 5. Communicate hazards, risks, and control measures to employees, management, customers, contractors, vendors, and the public by preparing and delivering appropriate information to educate an organization or the community.

**Knowledge Fields**
1. Legal aspects of communication
2. Labeling requirements for products, materials, and equipment
3. International symbols
4. Symbology (colors, wording, format, presentation)
5. Cultural norms and their relationship to communication

Responsibility 6. Develop ongoing relationships with the community by interacting with outside organizations to foster a mutual understanding of the profession and community needs with regard to safety issues.

**Knowledge Fields**
1. Governmental entities and responsibilities
2. Mutual aid agreements
3. Emergency response planning and communication
4. Standards development
5. Sphere of influence

Responsibility 7. Maintain a record keeping and data capture and retrieval system by using appropriate data management systems to acquire, analyze and distribute accurate data.

**Knowledge Fields**
1. Record keeping and recording requirements (e.g., OSHA, EPA, workers’ compensation, hazardous waste permitting and manifesting requirements, DOT)
2. Statistical analysis
3. Computers, data transfer, and storage hardware options
4. Data logging and monitoring equipment
5. Business software (e.g., database software)
6. Report development (e.g., training records, accident report forms, inspection forms)
7. Record retention requirements and management protocols (confidentiality, etc.)
8. Data analysis and presentation
9. Chain of custody regard to incident investigation

Responsibility 8. Develop and maintain proficiency in professional communication through continuing personal education in the use of business technology.

Knowledge Fields
1. Computer software concepts (databases, spreadsheets, word processing)
2. Internet resources
3. Information transfer
4. Information acquisition (data logging) technologies
5. Telecommunications technology

Domain 4. Professional Conduct and Ethics

Responsibility 1. Hold paramount the protection of people, property, and the environment by persistently working with management and governmental agencies until the identified hazard has been eliminated or minimized.

Knowledge Fields
1. BCSP Code of Professional Conduct
2. Organizational protocol
3. Conflict resolution techniques
4. Formal and informal presentation techniques
5. Negotiation procedures
6. Laws, standards, and regulations

Responsibility 2. Adhere to standards of professional conduct by limiting practice to areas of competence and avoiding conflicts of interest to minimize the potential for harm.

Knowledge Fields
1. BCSP Code of Professional Ethics
2. General business ethics
3. Conflict resolution techniques
4. Personal and professional limitations
5. Methods of facilitating teamwork
6. Competencies of other technical professionals with whom the safety professional interacts
7. Consequences of professional errors or omissions
8. Elements of a conflict and interest policy
9. Laws relating to conflict of interest

Responsibility 3. Accept responsibility to promote safety by providing technical counsel and advice on issues related to the safety profession to protect people, property, and the environment.

Knowledge Fields
1. BCSP Code of Professional Conduct
2. Sources safety, health and environmental literature and other information
3. Job authority, responsibility, and accountability
4. Professional liability issues
5. Conflict resolution

Responsibility 4. Conduct professional activities by following organizational protocol to assist in making positive, balanced and effective decisions.

Knowledge Fields
1. BCSP Code of Professional Conduct
2. General business ethics
3. Organizational protocol
4. Management principles of accountability and responsibility

Responsibility 5. Improve technical competency through continuing professional and self-development in order to increase knowledge and skills.

Knowledge Fields
1. BCSP code of Professional Conduct
2. Recent technical issues and advances in the safety, health, and environmental profession
3. Continuing education sources in the safety, health, and environmental profession (e.g., conferences, professional seminars, networking, textbooks, magazines, professional journals)
4. Specialty certification opportunities
Responsibility 6. Foster accurate accountability for injuries/illnesses and other types of occurrences by identifying root and contributing causes in order to ensure that proper controls are implemented.

Knowledge Fields

1. BCSP Code of Professional Conduct
2. Conflict resolution techniques
3. Methods of identifying accident causation
4. Management principles of authority, responsibility, and accountability

The validation exercise undertaken by BCSP established the breadth of knowledge and skill required in the practice of safety, and it is extensive. The BCSP Safety Fundamentals Examination is a knowledge examination: It is presumed that applicants taking the examination have no safety job experience. Comparing the knowledge requirement for this examination to the Curriculum Standards for Baccalaureate Degrees in Safety results in this conclusion: The curriculum standards are both specific and broad enough to provide students with an excellent grounding in safety knowledge, provided that professors find means to accommodate the knowledge transitions and extensions that have taken place.

It is assumed that applicants taking the BCSP Comprehensive Practice Examination have at least four years of safety work experience. This examination represents a great breadth of “applied” knowledge and skill. And, it is my opinion that it realistically relates to the professional practice of safety.

CONCLUSION

Every recognized profession has developed a body of knowledge and skill that is unique to that profession. It is to the advantage of safety professionals, in seeking professional recognition, to promote a course of study representing the appropriate body of knowledge for those entering the practice of safety and to establish broadly the knowledge and skill standards for applied safety practice. For those purposes, the work done by ASSE and BCSP is commendable.

POSTSCRIPT

ASSE and BCSP have also developed and published Curriculum Standards for Master’s Degrees. A March 1994 publication, Joint Report No. 2, is
titled *Curriculum Standards for Master’s Degrees in Safety*. Accreditation has been given by ABET/RAC to several Master’s Degree Programs.

ASSE and BCSP issued Joint Report No. 3 in November of 1994. Its title is *Curriculum Standards for Safety Engineering Master’s Degrees and Safety Engineering Options in Other Engineering Master’s Degrees*. A baccalaureate degree from an ABET accredited engineering program is one of the prerequisites for this master’s degree. No such degree program has yet been accredited by ABET/RAC, although several schools are active candidates.

REFERENCES


INTRODUCTION

Safety practitioners continue to strive for recognition as a profession. They seek that recognition within society, by other professions, by their employers, and from each other. They will attain recognition as a profession only when the practice of safety meets the regimens of a profession, and only when the content and quality of their performance earn professional and societal respect.

We who are engaged in the practice of safety use the word professional quite freely as a form of self-identification. For those who want to be considered safety professionals and who want the practice of safety recognized as a profession, a serious introspection concerning the perception others have of what they do would serve their purposes well. This chapter will present

- The requirements for the practice of safety to be recognized as a profession
- Comments on each of those requirements
- A listing of actions that, if undertaken, would move the practice of safety toward recognition as a profession

Insightful readers could, understandably, debate what I present here, and that could produce a positive outcome.
Obviously, we must recognize with gratitude the accomplishments over several decades by those who have been successful in promoting a higher level of preparation for, and accomplishment in, the practice of safety. Many have contributed to that progress. A challenge remains for continued gains.

A LIMITED LITERATURE REVIEW

Only a few authors have written about the practice of safety being recognized as a profession. Most safety texts do not address the subject at all. Two such articles on professional practice have appeared in *Professional Safety*, the magazine of the American Society of Safety Engineers (ASSE). In June 1981, Richard J. Finegan wrote, “Is the loss control effort a profession?” Dan Petersen’s article titled “Professionalism — A Fourth Step” was published in 1982.

Petersen’s article began with this statement: “Safety is working very hard to become a profession.” Petersen suggested that we should examine our theoretical base by asking whether it’s fact or opinion. Many of the questions he posed in 1982 are still pertinent.

In *Techniques of Safety Management*, Petersen made these comments on the need for introspection.

In the safety profession, we started with certain principles that were well explained in Heinrich’s early works. We have built a profession around them, and we have succeeded in progressing tremendously with them. And yet in recent years we find that we have come almost to a standstill. Some believe that this is because the principles on which our profession is built no longer offer us a solid foundation. Others believe they remain solid but that some additions may be needed. Anyone in safety today at least ought to look at that foundation — and question it. Perhaps the principles discussed here can lead to further improvements in our approach and further reductions in our record [p. 27].

In *Analyzing Safety Performance*, also written by Dan Petersen and published in 1980, Chapter 1 is titled “The Professional Safety Task.” It opens with a duplication of the then-available issue of the *Scope and Functions of the Professional Safety Position*, which is published by the American Society of Safety Engineers (ASSE).

ASSE’s Scope and Functions of the Professional Safety Position is a widely quoted document. It has served its purpose well. It is a good
position description. Those who developed the 1998 revision deserve commendation for the improvements they made.

Ted S. Ferry made this brief mention of the requirements of a profession in Safety Program Administration for Engineers and Managers.

A profession is an occupation generally involving a relatively long and specialized preparation on the level of higher education and is usually governed by its own code of ethics. Nearly every profession has some safety and health aspects, some of them with distinct safety and health sub-disciplines [p. 14].

In MORT Safety Assurance Systems by William G. Johnson, the chapter on “The Safety Function” also quotes the ASSE Scope and Functions of the Professional Safety Position (p. 463). Introduction to Safety Engineering by David S. Gloss and Miriam Gayle Wardle contains the only reference I found in a safety-related text that speaks of the requirements of a profession. This is what they wrote.

**Hallmarks of a Profession**

If safety engineering is to be considered a profession, then it must meet the criteria for professionalization. Greenwood proposed that professions have specific characteristics.

1. A well-defined theoretical base
2. Recognition as a profession by the clientele
3. Community sanction for professionalization
4. A code of ethics, which regulates the professional’s relationships with peers, clients, and the world at large
5. A professional organization [p. 13].

Dr. Roger L. Brauer, Executive Director of the Board of Certified Safety Professionals, says that you can tell that a profession has been recognized when

- Other professions seek it out.
- Laws, regulations, and standards cite it.
- There is public awareness of whom to contact for assistance to resolve a problem in the field addressed by the profession.

**REQUIREMENTS FOR THE PRACTICE OF SAFETY TO BE RECOGNIZED AS A PROFESSION, AND DISCUSSION**

The previously cited references are helpful in producing (a) the following outline of the requirements for the practice of safety to be recognized as a profession and (b) the discussion that follows each requirement element.
Requirements for the Practice of Safety to Be Recognized as a Profession

A. Establish a Well-Defined Theoretical and Practical Base, to Include:

- A definition of the practice of safety
- The societal purpose of the practice of safety
- A recognized body of knowledge
- The methodology of the practice of safety

Discussion

"Defining the Practice of Safety," Chapter 3, was written to move the discussion forward concerning the societal purposes of the practice of safety; to establish that there is a recognized body of knowledge for the practice; to speak of the rigor of education that would prepare one to enter safety practice; and to outline its methodology. A work in progress relates to the second of those purposes. At the American Society of Safety engineers, a Body of Knowledge Task Force is gathering data — to outline the body of knowledge applicable in the practice of Safety.

In Chapter 19, “Applied Ergonomics: Significance and Opportunity,” I refer to an article by Alphonse Chapanis titled “To Communicate the Human Factors Message, You Have to Know What the Message Is and How to Communicate It.” One of his themes is that human factors engineering has to be defined and its practitioners must know what it is to be able to communicate about it successfully. Safety professionals have the same need.

The practice of safety, as defined, includes all fields of endeavor for which the generic base is hazards: occupational safety, occupational health, environmental affairs, product safety, transportation safety, safety of the public, health physics, system safety, fire protection engineering, et cetera.

If the practice of safety is to be recognized as a profession, it must

- Serve a declared and understood societal purpose.
- Clearly establish what the outcome of applying the practice is to be.

The definition I developed of the practice of safety is also being given here as a reference for the discussion that follows.

The Practice of Safety

- Serves the societal need to prevent or mitigate harm or damage to people, property, and the environment, which may derive from hazards.
Is based on knowledge and skill as respects safety, health, and environmental
Engineering
Management
Information and communications
Legal and regulatory affairs
Is accomplished through
Anticipating, identifying, and evaluating hazards
Taking actions taken to avoid, eliminate, or control those hazards
Has as its ultimate purpose attaining a state for which the risks are judged to be acceptable.

In ASSE’s *Scope and Functions of the Professional Safety Position,* these comments are made about the education, training, and experience needs of safety professionals.

To perform their professional functions, safety professionals must have education, training, and experience in a common body of knowledge. Safety professionals need to have a fundamental knowledge of physics, chemistry, biology, physiology, statistics, mathematics, computer science, engineering mechanics, industrial processes, business, communications, and psychology.

Note the term “a common body of knowledge.” In the process of researching and writing Chapter 5, “Academic and skill Requirements for the Practice of Safety,” I concluded that the *Curriculum Standards for Baccalaureate Degrees in Safety,* jointly published by the Academic Accreditation Council of the American Society of Safety Engineers and the Board of Certified Safety Professionals, establish a rigor of education that adequately prepares one to enter the safety profession.

Furthermore, I observed that the domains and responsibilities and the knowledge and skill categories for the Comprehensive Practice Examination given by the Board of Certified Safety Professionals defines the breadth of knowledge and skill required in applied safety practice.

Serious questions about our “recognized body of knowledge” continue to arise, since some safety practitioners still hold dearly to far too many myths. In *Safety Program Administration for Engineers and Managers,* Ted S. Ferry devoted a chapter to “Those Cherished and Hallowed Old Safety Clichés and Truisms” (p. 24). He commented on 19 such clichés and truisms.

We should take a professional approach to examining those safety clichés and, where appropriate, educate concerning them. Comments will
be made here about only a few of those myths. Others can surely add to this list.

1. At ASSE Professional Development Conferences, always, one or more speakers inform attendees that 90% of accidents are principally caused by unsafe acts of employees. How pitifully unprofessional! Heinrich’s 88:10:2 ratios were the conventional wisdom years ago. They have been found to be untenable.

2. Many still offer as truth Heinrich’s Foundation of a Major Injury—the 1:29:300 premise, which stated that: “. . . in a unit group of 330 similar accidents occurring to the same person, 300 will result in no injury, 29 will produce minor injuries, and 1 will cause a serious injury. Think about that—330 similar accidents occurring to the same person. Would that include a fall off a 50-story building?

Bird and Loftus propose a different ratio: “. . . 1 disabling injury for every 100 minor injuries and 500 property damage incidents.”

Use of these statistical bases gives support to the principle that if we give adequate attention to the incidents that occur frequently, we will also be taking care of severity potential. That may or not be so, depending on whether the severity potential is also represented in the more frequent incidents.

It has not been possible to locate a body of research that supports the validity of either the Heinrich or the Bird and Loftus postulations. They are mythical. Yet, safety professionals continue to offer them as truths.

(For further discussion on items 1 and 2, see Chapter 7, “Heinrich Revisited: Truisms or Myths.” Furthermore, I am a member of the Editorial Advisory Board for the magazine Professional Safety. The number of articles submitted for publication that commence with one of the Heinrich myths is disturbing.)

3. Does the well-used axiom “garbage in, garbage out” apply to our incident analysis systems? Do we hold to information gathering systems that produce misinformation?

4. Is the occupational health exposure really as significant as many profess? For well over 40 years, we have been hearing about the latency period after which occupational illnesses would appear in great numbers in workers compensation experience. That has not happened. Yes, there are many real occupational health exposures. But, has the time come to wonder about their actual extent? Some scientists now question previous decisions and the validity of models used in arriving at health risks.
The United States Department of Labor—Bureaus of Labor Statistics April 10, 2002 report USDL 02–196 is designated as “Lost-Worktime Injuries: Characteristics and Resulting Time Away from Work, 2000.” Table 4 is titled “Number of nonfatal occupational injuries and illnesses involving days away from work by selected injury and illness characteristics and industry division, 2000.” One of the categories in the listing of “Event(s) or exposure(s) leading to injury or illness” is “Exposure to harmful substances.” Of the 1,477,800 injuries and illnesses covered in Table 4, 69,100 are in the “Exposure to harmful substances” category. That’s 4.7% of the total.

My first study of the magnitude of the occupational health exposure was made over 25 years ago. I found that occupational illness cases represented about 5% of the total injuries and illnesses in the summaries I reviewed. That percentage has not changed much over the years. Yet, proponents in the occupational health field continue to say, “Each day an average of 137 individuals die from work-related diseases” (National Occupational Research Agenda, 1996). That works out to 50,005 deaths per year. That’s absurd.

Has the time arrived for safety practitioners to stop reciting clichés, repeating the literature—without requiring substantiation? Should we cease docilely adopting published premises, without promoting scientific inquiry as to their validity?

In no way is it intended that the preceding comments on clichés be considered inclusive, especially coming from but one source.

B. Developing a Common Language Within Safety Practice, with a Realization that:

- A “hallmark” of a profession is to define itself.
- The public does not know who we are or what we do.
- We confuse others with our multitude of titles.

Discussion

Try this experiment. Have your associates assume that a member of the public asks them: What is your job? What do you do? I asked those questions of a group of safety professionals, and the answers were embarrassing. We have not established a common understanding of our practice, nor do we use a common language to define what we do. If we are to be recognized as a profession, we must be able to identify what is unique about it, and its societal purposes.

One of the objectives of Chapter 3, “Defining the Practice of Safety,” is to emphasize the significance of our not having yet defined our practice. And, we must do so to attain professional recognition.
Names of other professions — law, medicine, accounting — immediately bring to mind a mental image of that field of endeavor, and the requirements to be a member of the profession. We must follow that lead and define who we are. What we call ourselves and the language we use in communications both with our clients and in the community at large should convey an appropriate image of our discipline. The great variations in terms and titles we use may confuse those with whom we try to communicate. There is no question that we baffle decision makers, as well as the public, with the multitude of titles we give ourselves.

A brief and unscientific study was made of the understanding that decision makers have of the titles we use, about which comment is made in Chapter 3, “Defining the Practice of Safety.” I wrote that if I had a magic wand with which I could eliminate the use the titles Loss Prevention, Loss Control, and Industrial Hygiene, I would do so and believe that I had done a great service for those engaged in the practice of safety.

In addition, I said that the generic base of the practice of safety is hazards, and that if there are no hazards, there would be no reason for safety professionals to exist. In time, we will more than likely be considering an umbrella term that encompasses all aspects of safety practice. Hazards Management would serve very well for that purpose.

C. Achieving Recognition as a Profession by the Clientele to Whom We Give Advice, Considering:

- The content, the substance, of the advice we give
- Whether the advice we give achieves expected results
- The nature of our communication

Discussion

It’s possible that the substance of the communications of too many safety professionals to decision makers is perceived as shallow, superficial, and not pertinent to an entity’s real hazards management needs. Much of our language developed years ago. It is time to evaluate the real substance of it. As an example, are the terms unsafe act and unsafe condition obsolete? Ergonomists and industrial hygienists — closely related practitioners — don’t use those terms. They speak of risk factors or causal factors.

Too many safety professionals are perceived as having established a culture of separateness, and of having purposes that do not directly help management attain their goals. Safety professionals should strive to be perceived as part of the management team and as cognizant of the goals of, and the constraints on, the organizations for which they provide a consultancy.
Our literature frequently indicates that the causes for all incidents resulting in injury or illness derive from something being wrong in the management system. And we promote the idea, over and over. As we do so, are we being overly critical of a group of which we want to be a part? Do we gain more or lose more by its never-ending repetition?

Yes, it can be theorized that there was a management shortcoming for the existence of every hazard, the realization of which resulted in injury or damage. And it’s necessary to identify those shortcomings in causal studies. But acceptance by our clientele can be obtained more effectively through language that demonstrates participation toward achieving goals we share.

At our professional conferences, we often discuss “how to obtain management support.” Speakers address effective communication methods, and they are important. But, I suggest that we will gain from an examination of the content of our practice and the substance of our communications. If a practice is not perceived as being professional and having import, the world’s best communicator will still not get the management support and involvement necessary.

To determine what others have written about the content of our practice and what we need to do to move it to a professional level, a review was made of all articles published in Professional Safety in the years 1995 through 2001.

- Dan Petersen. “Safety Management: Our Strengths and Weaknesses.” Professional Safety, January 2000. Petersen addresses, as the title says, the strengths and weaknesses in the practice of safety; he also addresses studies he has made of shortcomings, particularly with respect to measurement systems.

- Ronald E. Fitzgerald. “Call to Action: We Need a New Safety Engineering Discipline.” Professional Safety, June 1997. Fitzgerald says “Human factors engineering has historically focused on the reduction of human-related error, while system safety engineering has emphasized the elimination of system design error. Now is the time to bring the disciplines together.”

- Larry L. Hansen. “Re-Braining Corporate Safety and Health: It’s Time to Think Again” Professional Safety, October 1995. Hansen says, ”Re-braining safety requires a major shift in current beliefs about what drives safety performance. The challenge is set forth, and 12 guiding principles that will drive the process are discussed.”

March 1995. They say, “New challenges require new thinking, especially when current methods maintain the status quo or produce higher incident rates. The innovative approach presented here is based on a combination of “strategic” and “systems” thinking.

**D. Promoting and Supporting Research, Recognizing that:**

- Knowledge requirements concerning hazards and the methodologies to anticipate, avoid, eliminate, or control those hazards will continue to expand.
- It is typical of a profession to continuously examine the effectiveness and outcomes of the solutions proposed, and seek to innovate.

*Discussion*

How much needs to be said about the expanded knowledge needs of safety professionals, especially in the past 10 years? It should concern us that safety research is most often done by people who would not consider themselves to be safety professionals. We are almost entirely excluded from determining what the research needs are and from assessing the results.

This is a subject for which, with rare exceptions, activity by safety practitioners will be an original undertaking. As a beginning, research is needed to evaluate the premises that have accumulated in the practice of safety in the past 75 years. If we are to be recognized as a profession, we must have established that we are promoters and supporters of research.

**E. Maintaining Rigid Certification Requirements, Promoting the Significance of Certification, And Giving Additional Status to Certification**

*Discussion*

Much thanks should be given to those visionaries on the Board of Directors of the American Society of Safety Engineers in the 1960s who conceived of and established the Board of Certified Safety Professionals (BCSP). As a result of their work, a sound and proven certification program exists for safety professionals, for which recognition continues to grow. The CSP — the Certified Safety Professional designation — has become the mark of the professional within the safety field.

Little will be said here about the BCSP program. Initiated in 1969, it has stood the test of time. The number of those seeking examinations and certification has steadily increased. To have examinations that relate to the actuality of the practice of safety, which is constantly in transition, BCSP undertakes a validation study about once every five years to ensure that
its examinations properly examine what safety professionals actually do. Each such validation results in revisions in examination content, reflecting on the results of the validation exercise.

All involved—individual safety professionals, the BCSP, ASSE—could do a better job of promoting the significance of certification and of giving it a higher status. Individuals who employ safety professionals can especially give greater significance to the CSP designation.

**F. Adhering to an Accepted Standard of Conduct, Which Is an Absolute Requirement of a Socially Recognized Profession**

**Discussion**

How can anyone presume to be a professional without being willing to meet high standards of performance and to insist that others in the profession do the same? A prescribed statement of professional conduct would cover the content of an individual’s practice and the relationships expected with one’s clients, peers, and the community at large.

The Board of Certified Safety Professionals and the American Society of Safety Engineers have issued Codes of Professional Conduct that deserve publicity and promotion. Currently applicable codes of ethics and professional conduct issued by BCSP and ASSE are Addenda A and B in this chapter.

**G. Having a Professional Society, Participating in It, and Supporting It**

**Discussion**

Several related societies exist that safety professionals can well support. Low levels of participation in such societies lead to the observation that more safety practitioners call themselves safety professionals than should. Just being a member of such a society doesn’t really qualify for professional status.

Those who seek professional status and would like their practices to be recognized as a profession must be more prominent participants in the societies of which they are members.

**H. Obtaining Societal Sanction for Professionalization**

**Discussion**

This is a futuristic goal. It will have been achieved when the public perceives that the practice of those who designate themselves as safety professionals has a distinct value to society. Safety professionals will earn that respect and recognition only through their performance. When that occurs, it will be expected that a person with a prescribed professional education, experience, and certification will fulfill safety responsibilities.
We’ve come a long way and yet have a long way to go, especially with respect to recognition by the general public.

At least in employment, the value of professional certification—the CSP designation—has achieved greater recognition. That is a form of societal sanction. There has been a continual increase in the percentage of job advertisements for safety positions that mention the desirability of being a Certified Safety Professional.

**CONCLUSION**

This chapter is intended to promote individual and collective introspection. Accomplishment for each of the action subjects discussed in this chapter will serve to achieve professional status for those engaged in the practice of safety, which is an ultimate ideal. A summary pertaining to those action subjects follows.

**Action Subjects**

1. Agreeing on and promoting an understanding of a definition of the practice of safety and its basic methodology.

2. Determining that the Curriculum Standards for Baccalaureate Degrees in Safety jointly published by ASSE and BCSP represent sound preparation for one to enter the safety profession, and strongly promoting their extended adoption.

3. Establishing that the domains and responsibilities and the knowledge and skill categories for the BCSP Comprehensive Practice Examination represents the breadth of knowledge and skill required for safety practice and communicating that to the public and to safety practitioners.

4. Examining safety literature to identify what is patently unprofessional, with the intent of arranging exposition and debate on those subjects.

5. Promoting adoption by safety professionals of methods of scientific inquiry, as well as encouraging peer review and verification of that which is published.

6. Establishing a system to review the knowledge fields for which additional information is needed to maintain professional practice, and arranging development and dissemination of that information.

7. Undertaking to develop a commonly accepted language that clearly presents an image of the practice of safety.
8. Arranging for a study of the public understanding of the titles we use, and promoting the use of those which best convey the image of a profession.

9. Promoting exploration of incident causation theory, knowledge of which is both fundamental and vitally needed for the practice of safety.

10. Taking the initiative in arranging, promoting and supporting research projects.

11. Promoting the significance of the CSP designation by individual safety professionals, BCSP and ASSE.

12. Publicizing the ASSE and BCSP standards of professional conduct and encouraging safety professionals to consider them as foundational in their own practices.

13. Convincing safety professionals who want recognition as a professional that they should be active participants in their professional societies.

REFERENCES

*Body of Knowledge Task Force*. Des Plaines, IL: American Society of Safety Engineers, a work in progress.


Fitzgerald, R. E. “Call To Action: We Need a New Safety Engineering Discipline.” *Professional Safety*, June 1977.


ADDENDUM A

American Society of Safety Engineers Code of Professional Conduct

Fundamental Principles. As a member of the American Society of Safety Engineers, I recognize that my work has an impact on the protection of people, property and the environment.

In order to assume professional responsibility, I shall uphold and advance the integrity, honor, and dignity of the safety, health, and environmental profession by:

Enhancing protection of people, property and the environment through knowledge and skill;
Being honest, impartial, and serving the public, employers and clients with fidelity;
Striving to increase my competence in and the prestige of the safety profession; and
Avoiding circumstances where compromise of the professional conduct or conflict of interest may arise.

Fundamental Canons. In the fulfillment of my duties as a safety professional, I shall:
Hold paramount the protection of people and property and the environment;
Advise employers, clients, employees, or appropriate authorities when my professional judgment indicates that the protection of people, property, or the environment is unacceptably at risk;
Strive for continuous self-development while participating in the safety profession;
Perform professional services only in the areas of my competence;
Issue public statements only in an objective and truthful manner and in accordance with the authority bestowed on me;
Act in professional matters as faithful agent or trustee and avoid conflict of interest;
Build my professional reputation on merit of service; and
Assure equal opportunities for individuals under my supervision.

As a member of ASSE, I shall comply with these provisions of the “Code of Professional Conduct.”
Approved by ASSE Board of Directors February 26, 1993.
Adopted by the ASSE Assembly June 20, 1993.

ADDENDUM B

Board of Certified Safety Professionals Code of Ethics and Professional Conduct

This code sets forth the code of ethics and professional standards to be observed by holders of documents of certification conferred by the Board of Certified Safety Professionals. Certificants shall, in their professional safety activities, sustain and advance the integrity, honor, and prestige of the safety profession by adherence to these standards.

Standards

1. Hold paramount the safety and health of people, the protection of the environment, and protection of property in the performance of professional duties and exercise their obligation to advise employers, clients, employees, the public, and appropriate authorities of danger and unacceptable risks to people, the environment, or property.

2. Be honest, fair, and impartial; act with responsibility and integrity. Adhere to high standards of ethical conduct with balanced care for the interests of the public, employers, clients, employees, colleagues,
and the profession. Avoid all conduct or practice which is likely to discredit the profession or deceive the public.

3. Issue public statements only in an objective and truthful manner and only when founded upon knowledge of the facts and competence in the subject matter.

4. Undertake assignments only when qualified by education or experience in the specific technical fields involved. Accept responsibility for their continued professional development by acquiring and maintaining competence through continuing education, experience, and professional training.

5. Avoid deceptive acts which falsify or misrepresent their academic or professional qualifications. Do not misrepresent or exaggerate their degree of responsibility in or for the subject matter of prior assignments. Presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, or past accomplishments with the intent and purpose of enhancing their qualifications and their work.

6. Conduct their professional relations by the highest standards of integrity and avoid compromise of their professional judgment by conflicts of interest.

7. Act in a manner free of bias with regard to religion, ethnicity, gender, age, national origin, or disability.

8. Seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health, and well-being of their community and their profession by sharing their knowledge and skills.
INTRODUCTION

During a discussion with a colleague, who fervently attempts to move the state of the art forward, we explored the continuing evolution of the concepts applied in the practice of safety and what safety practitioners must do to establish their practice as a profession. Among several things, we agreed on the importance of eliminating from our practice any age-old but continued-in-use premises that, upon examination, would be judged invalid.

Several of the premises about which validity was questioned in our discussions are found in the work of H. W. Heinrich as expressed in the four editions of his book *Industrial Accident Prevention: A Scientific Approach*. My colleague suggested that I review the origin of those premises, how they changed over time, and their validity. Findings of that review are set forth in this chapter.

Both the methods used by Heinrich to establish some of his premises and the premises themselves are questionable. Also, significant changes were made from edition to edition, without explanation. Hoping to achieve a better understanding of Heinrich’s research, I attempted to locate his original files: They no longer exist. Thus, only the data contained in Heinrich’s books are available. His information-gathering methods, the
quality of the information, or the analytical systems used cannot be examined.

Who was H. W. Heinrich? He was one of the foremost pioneers in the field of accident prevention. Give him his due. My view is that, from the 1930s until today, he has had more influence than any other individual on the work of occupational safety practitioners. In my early years, I was influenced considerably by his writings. I still have a set of dominoes representing Heinrich’s Accident Sequence.

Herbert William Heinrich was born in Bennington, Vermont in 1881. He began working as an apprentice in the machinist trade at age 16. At age 23, he became a Third Assistant Engineer. In 1918, he joined the U.S. Naval Reserve as a Lieutenant Junior Grade, was called to active duty as an Engineering Officer, and was discharged in 1919 with the rank of Senior Lieutenant.

At the age of 32, he joined the Travelers Insurance Company at Hartford, Connecticut where (except for the period of active duty during World War I) he served until his retirement in 1956 at age 74. In 1925, he was promoted to assistant superintendent of the Engineering and Inspection Division. Heinrich conducted safety courses for students at New York University for more than 20 years, beginning in 1938. In 1942, he was appointed chairman of the War Advisory Board, Safety Section, providing assistance to the U.S. Army safety effort. In 1956, he was appointed chairman and president of the Uniform Boiler and Pressure Vessels Laws Society, an organization promoting the uniformity of laws governing the safety of steam boilers and pressure vessels in the United States and Canada. Heinrich died in 1962.

As I commenced a review of the Heinrich premises, a basis for thinking and analysis was adopted related to the opening paragraphs in the Preface of his first edition.

The use of the word “scientific” in the subtitle of this book indicates the author’s belief that science may be applied practically and successfully to the prevention of accidents.

The term “science” is commonly defined as knowledge of principles and facts. Consequently, if accident prevention work is to be conducted scientifically, it must be founded upon well-established principles or facts that have been proved by application. [Citation 1]

Thus, I sought to analyze Heinrich’s principles and facts and determine whether they have been proven by application. Readers are also asked to apply logical and critical thinking to this chapter.
SUBSTANCE OF THE REVIEW

Material will be found in this chapter under the following captions, each of which relates to Heinrich’s work.

- Transitions in the Work World Over 70 years
- Psychology and Safety
- Accident Cause Analysis: The 88:10:2 Ratios
- The Foundation of a Major Injury: The 300:29:1 Ratios
- Causal Factors: And Resource Misdirection
- Incidental Costs of Accidents: The 4:1 Ratio

EDITORIAL NOTES

1. To assist readers who may have one of the four editions of Heinrich’s book, a listing is provided in the reference section, giving the citation number and page numbers on which the excerpt appears in the several editions. For references from publications by other authors, the author’s name and the page number in the publication are given.

2. In today’s social climate, some of Heinrich’s terminology would be considered sexist. He uses terms such as man failure, the foreman, and he is responsible. But consider the times in which he did his writing. The latest of the four editions of his book was published in 1959. Also, women readers should take heart: only men failed; women did not fail.

TRANSITIONS IN THE WORK WORLD OVER 70 YEARS

The publication dates for the four editions of Heinrich’s Industrial Accident Prevention: A Scientific Approach covered a period of nearly 30 years: 1931, 1941, 1950, 1959. In each edition, Heinrich recorded his estimates of the “annual industrial accident toll in the United States.” Table 7.1 gives excerpts from those recordings (Citation 2).

Table 7.2 shows data taken from the National Safety Council publication Injury Facts, 2000 Edition (p. 44). What’s the point of all this? Fatal accident experience in the work world has changed substantially since Heinrich’s studies were made. In the National Safety Council publication, 1933 is the first year for which a death rate per 100,000 workers is shown.
Table 7.1. Heinrich’s recordings on occupational deaths

<table>
<thead>
<tr>
<th>Edition</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931</td>
<td>24,000</td>
</tr>
<tr>
<td>1959</td>
<td>14,300</td>
</tr>
</tbody>
</table>

Table 7.2. Data from injury facts, 2000 edition — NSC

<table>
<thead>
<tr>
<th>Year</th>
<th>Deaths</th>
<th>Death Rate per 100,000 Workers</th>
<th>Number of Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933</td>
<td>14,500</td>
<td>37.0</td>
<td>39,000,000</td>
</tr>
<tr>
<td>1999</td>
<td>5,100</td>
<td>3.8</td>
<td>134,688,000</td>
</tr>
</tbody>
</table>

From 1933 to 1999, the death rate dropped 90%. It is recognized that fatality rates are not the only measure of safety performance. Nevertheless, these numbers are significant.

Reliable data indicating trends for nonfatal injuries is virtually unattainable. Heinrich gives an estimate of 3,000,000 lost-time injuries annually in his first edition, without citing a source or defining the term *lost time* (Citation 2). In *Injury Facts, 2000*, disabling injuries for the year 1999 are shown as 3,800,000 (National Safety Council, p. 44). From 1933 to 1999, as shown in Table 7.2, there was a 245% increase in the number of workers.

Making assumptions from these numbers is speculative and iffy. But, assuming that Heinrich’s estimate was reasonably accurate and that there is a correlation between a lost-time injury and a disabling injury, the downward trend for disabling injuries in relation to the size of the employment base is also significant.

Heinrich’s studies, from which his accident prevention philosophy originated, were done in the 1920s. And the workplace has been impacted since then by mechanization, automation, more stringent safety standards, human factors engineering, improved knowledge of and more effective control of occupational diseases, the electronic age, the communication age, the transition in the United States from a manufacturing-based to a service-based industry, et cetera.

Thus, I pose this general question: Could workplace studies made in the 1920s be valid in relation to the workplace as it now exists? I don’t think so.
PSYCHOLOGY AND SAFETY

To understand Heinrich’s work as a whole, one must appreciate the significance he gave to psychology, which dominated his approach to accident prevention. How extensively did psychology impact on Heinrich’s accident prevention philosophy? Consider the following:

1. Heinrich’s expressed belief that “psychology in accident prevention is a fundamental of great importance” (Citation 3)
2. His premise that “psychology lies at root of sequence of accident causes” (Citation 4)
3. His insistence that “a total of 88 percent of all industrial accidents are caused by the unsafe acts of persons” (Citation 5)
4. His oft-repeated statement that “man failure causes the most accidents” (Citation 6)
5. The emphasis given in his accident causation model, called the accident sequence, to the faults of persons and to ancestry and environment, which identified the traits of individuals as the principal causative elements (Citation 7)

In the fourth edition, Heinrich envisions “the more general acceptance by management of the idea that an industrial psychologist be included as a member of the plant staff as a physician is already so included” (Citation 8).

As you will note in the following quotation, Heinrich believed that employers have the primary responsibility for safety. Having said that, he took a rather unusual position, saying:

Indeed, safety psychology is as fairly applicable to the employer as to the employee. The initiative and the chief burden of activity in accident prevention rest upon the employer; however, the practical field of effort for prevention through psychology is confined to the employee, but through management and supervision. [Citation 9]

Who was to apply the psychology? Since the application of practical psychology is confined to the employee, who reports to a foreman, the psychology applier is the foreman. With all due respect to foremen, it’s doubtful that many could apply psychology “as a fundamental of great importance” in their accident prevention efforts.

To establish the relation between psychology and accident prevention, Heinrich stated that accident prevention had developed along distinct lines. In the earlier edition, there were three such lines of development. In
the later editions, the number was extended to five. The later version appears here.

Note that Step 3 in the following says “This procedure involving rule-of-thumb psychology is featured in the text” and that Step 5 proposes the “Selection of remedies based on psychological analysis.”

**Relation of Psychology to Accident Prevention**

Accident prevention may be said to have developed along five distinct lines:

*Step 1.* Guarding and elimination of machine and physical or material hazards without the use of cause analysis.

*Step 2.* Selection of remedies based on practical cause analysis that stops at the selection of direct and proximate causes, including personal unsafe acts, when results are not produced by simpler methods.

*Step 3.* Selection of remedies based on knowledge of personal subcauses or reasons for the commission of unsafe acts and which considers underlying causes only when the problem does not yield to direct attack. (This procedure involving rule-of-thumb psychology is featured in the text.)

*Step 4.* Selection of remedies based on analysis of underlying causes.

*Step 5.* Selection of remedies based on psychological analysis. (Citation 10)

Heinrich recognized that safety psychology was not widely applied, and he pleaded for recognition of the great value he perceived it to have.

In any event, there is no gainsaying the fact that psychology in accident prevention is of great importance. By means of its application, the ideal may more rapidly be approached. Psychology has already proved its value in enough cases to establish it as a factor in the field of approved practice. Some of the more advanced research in accident prevention psychology has been done in the areas of both industrial and motor-vehicle operations. [Citation 11]

In the second and third editions, Heinrich seemed to be encouraged. He stated that the point of view of the psychologist was gradually being introduced into the field of practical accident prevention, that in certain cases it had influenced active participants in safety work sufficiently to cause them to direct their efforts into psychological channels. In the fourth edition, he spoke of opportunities existing “for professional psychology to be introduced much more completely into the field of practical accident prevention” (Citation 12) In this latter edition he offers this caution:
It is advisable to make clear that reference is made here to trained professional psychology. The successful accident preventionist, although untrained and inexperienced professionally, already applies psychological methods in his work. Knowing that the unsafe actions of persons predominate in accident causation he endeavors to sell safe methods. Specific effort is made, when simple and direct remedies such as instruction fail, to find out why the unsafe action persists and then to apply a remedy based on what he finds. [Citation 13]

As was previously noted, Heinrich said that for the selection of remedies based on knowledge of personal subcauses, “The procedure involving rule-of-thumb psychology is featured in the text” (Citation 14).

As readers proceed, it is suggested that they keep in mind Heinrich’s emphasis on psychology as a root causal factor and as a means of problem resolution. Also, safety practitioners could profitably reflect on the bases upon which behavioral safety is founded. Some critics have said that behavioral safety is Heinrich repackaged, and they can present an arguable case.

**ACCIDENT CAUSE ANALYSIS: THE 88:10:2 RATIOS**

As a prelude to my comments on Heinrich’s accident causation theory, I would like readers to understand this: I believe that those who proclaim that unsafe acts are the principal causes of accidents do the world a disservice.

Heinrich professed that among the direct and proximate accident causes for industrial accidents, 88% are unsafe acts of persons, 10% are unsafe mechanical or physical conditions, and 2% of accidents are unpreventable. According to Heinrich, man failure is the problem, and psychology is an important element in correcting it (Citation 16).

Previously, I quoted the following phrase, which is at the beginning of a paragraph in all of Heinrich’s editions: Psychology lies at root of sequence of accident causes. In that paragraph, Heinrich said that:

All accident causes must, if traced to their origin, emanate from the faults of employee or employer; indeed safety psychology is as fairly applicable to the employer as to the employee. [Citation 17]

In his discussion of the relation of psychology to accident prevention, Heinrich advocated identifying the first proximate and most easily prevented cause in the selection of remedies, to which psychology would
be applied when simpler methods did not produce results. As I previously cited in the discussion of psychology and safety, Heinrich proposed the following.

Selection of remedies based on practical cause-analysis that stops at the selection of the first proximate and most easily prevented cause (such procedure is advocated in this book) and considers psychology when results are not produced by simpler analysis. [Citation 18]

Note that the first proximate and most easily prevented cause is to be selected. That concept permeates Heinrich’s work. It does not encompass what has been learned subsequently about the complexity of accident causation or that other causal factors may be more significant than the first proximate cause.

A great many safety practitioners have adopted the premises on which the 88:10:2 ratios are based, and they apply them to this day. Of all the Heinrich concepts, his thoughts pertaining to accident causation, expressed as the 88:10:2 ratios, have had the greatest impact on the practice of safety and have done the most harm. Why harm? Because when basing safety efforts on the premise that man failure causes the most accidents, the preventive efforts are directed at the worker rather than on the operating system in which the work is done.

Certainly, operator errors may be causal factors in accident occurrences. But, consider Ted Ferry’s comments on this subject as expressed in Modern Accident Investigation and Analysis: An Executive Guide.

We cannot argue with the thought that when an operator commits an unsafe act, leading to a mishap, there is an element of human or operator error. We are, however, decades past the place where we once stopped in our search for causes. Whenever an act is considered unsafe we must ask why. Why was the unsafe act committed? When this question is answered in depth it will lead us on a trail seldom of the operator’s own conscious choosing [Ferry, p. 56].

If during an accident investigation a professional search is made for causal factors beyond an unsafe act, it will often be found that the causal factors built into the work systems may be of greater importance. Fortunately, a body of literature has emerged that pleads for recognition of the significance of causal factors deriving from the design of the workplace and the work methods.

W. Edwards Deming was world renowned in quality management. The principle embodied in his 85–15 rule also applies to safety. This is the rule, as cited in Mary Walton’s book The Deming Management Method:
The Rule holds that 85 percent of the problems in any operation are within the system and are the responsibility of management, while only 15 percent lie with the worker [Walton, p. 242].

Since the majority of the problems in an operation are systemic, the safety efforts should be directed toward improving the system. Unfortunately, the use of the terms unsafe acts and unsafe conditions focuses attention on the worker or a condition and diverts attention from the root causal factors that are built into an operation.

The practice of safety can be moved forward if safety practitioners discard the terms unsafe acts and unsafe conditions and replace them with terms such as causal factors or risk factors (terms commonly used by ergonomists, human factors engineers, and industrial hygienists) and concentrate on the sources of the causal factors, most of which are systemic.

Allied to Deming’s view is the work of Alphonse Chapanis, who was prominent in the field of ergonomics and human factors engineering. Representative of Chapanis’ writings is “The Error-Provocative Situation,” a chapter in The Measurement of Safety Performance, by William E. Tarrants (Tarrants, p. 119).

Chapanis’ message is this: If the design of the work is error-provocative, you can be certain that errors will occur, in the form of accident causal factors.

It is illogical to conclude in an incident investigation that the principal causal factor is the unsafe act of the worker if the design of the workplace or the work methods is error-provocative. In such cases, the error-provocative aspects of the work should be considered primary. (A few organizations are giving courses on “Preventing Human Error” which focus on how to identify and prevent what they are calling error-likely work situations. This is a recent development.)

A last reference here is the Guide to Use of the Management Oversight and Risk Tree (MORT). In the abstract for that publication, MORT is described as a “comprehensive analytical procedure that provides a disciplined method for determining the systemic causes and contributing factors of accidents.” This reference to “performance errors” is of particular interest.

It should be pointed out that the kinds of questions raised by MORT are directed at systemic and procedural problems. The experience, to date, shows there are a few “unsafe acts” in the sense of blameworthy work level employee failures. Assignment of “unsafe act” responsibility to a work level employee should not be made unless or until the preventive steps of: (1) hazard analysis, (2) management or supervisory direction, and (3) procedures safety review have been shown to be adequate [DOE, p. 19].
So, as knowledge has evolved about how accidents occur and their causal factors, the emphasis in some of the literature is now properly placed on the work system, rather than on the worker. That’s just the opposite of what Heinrich proposed.

From the very beginning, Heinrich chose to assign only one accident cause in his cause determining process, and 88% of the time he chose an unsafe act. For example, in his first edition, the terminology following the caption “Method of Assigning Causes” is singular: “the person who is to select the cause” (Citation 19); “having assigned a tentative cause” (Citation 20); and “the real cause was determined” (Citation 21).

Heinrich recognized that other studies on accident causation identified both unsafe acts and unsafe conditions as causal factors with almost equal frequency. Those studies produced results different from his 88:10:2 ratios, and Heinrich commented on those differences. For example, he cited the National Safety Council as a resource on such studies (Citation 22).

In the eighth edition of the National Safety Council’s Accident Prevention Manual for Industrial Operations: Administration and Programs, these comments were made about studies of accident causation.

Two historical studies are usually cited to pinpoint the contributing factor(s) to an accident. Both emphasize that most accidents have multiple causes.

- A study of 91,773 cases reported in Pennsylvania in 1953 showed 92% of all nonfatal injuries and 94% of all fatal injuries were due to hazardous mechanical or physical conditions. In turn, unsafe acts reported in work injury accidents accounted for 93% of the nonfatal injuries and 97% of the fatalities.
- In almost 80,000 work injuries reported in that same state in 1960, unsafe condition(s) was identified as a contributing factor in 98.4% of the nonfatal manufacturing cases, and unsafe act(s) was identified as a contributing factor in 98.2% of the nonfatal cases (National Safety Council, p. 141).

Although aware that others studying accident causation had recognized the multifactorial nature of causal factors, Heinrich continued to justify his choosing of a single causal factor in his analytical process. The following paragraph is in the second through the fourth editions. It follows an explanation of the study resulting in the formulation of the 88:10:2 ratios.

In this research major responsibility for each accident was assigned either to the unsafe act of a person or to an unsafe mechanical condition but in no case were both personal and mechanical causes charged. [Citation 23]
Recall that the study resulting in 88:10:2 ratios was made in the 1920s. The relationship between a study made then and the work world as it now exists is questionable and unknown, as are the methods used in producing it. As to the study methods, consider the following paragraph: It appears in the first edition. Some minor revisions were made in later editions.

Twelve thousand cases were taken at random from closed-claim-file insurance records. They covered a wide spread of territory and a great variety of industrial classifications. Sixty-three thousand other cases were taken from the records of plant owners. [Citation 24]

The source of the data—insurance claims files and records of plant owners—cannot provide reliable accident causal data. From personal experience, I can say that insurance claims reports rarely include causal data. And my studies of incident investigation reports completed by supervisors require the conclusion that they are not a reliable source for valid causal data.

When I provided counsel to clients in the early stages of development of computer-based incident analysis systems, insurance claims reports and supervisors investigation reports were examined as possible sources of data. Having found those sources to be inadequate as respects causal factors, and not having found other reliable sources, I advised clients not to include causal data in their computer-based analytical systems. For analytical purposes, such systems were reasonably accurate for injury and illness types, for parts of body injured, and for identification data such as location, time of occurrence, department, and so on.

In three exercises, I collected a total of 905 incident investigation reports completed by supervisors for an analysis of the quality of incident investigation. With emphasis, I state that the study I made would not meet the modeling and methods requirements of scientific inquiry. Nevertheless, some interesting observations were made.

Causal factor determination varied greatly as to quality: In some of companies, it is poorly done. How poorly? It was necessary to report to some of the safety directors who provided investigation forms that on a scale of 10, their incident investigation systems scored a 2. (See Chapter 11, Incident Investigation: Studies of Quality.)

In preparation for presentations I was to make early in 2002 to representatives of one of the world’s companies, I again asked that randomly selected incident reports completed by supervisors be sent to me. Using the same scoring system, with 10 being best, the quality of causal factor determination in each instance was given a 5.5 rating.
The point to be made is this: If accurate causal data are not represented in the resource base, the validity of the study has to be questioned, and the resource base for the Heinrich study is questionable.

THE FOUNDATION OF A MAJOR INJURY: THE 300:29:1 RATIOS

In the same way in all four editions, Heinrich presented his concepts on “The Foundation of a Major Injury.” He originally stated that in a unit group of 330 accidents, 300 result in no injury, 29 result in minor injury, and 1 results in a major or lost time case (Citation 27).

To this day, safety practitioners use Heinrich’s 300:29:1 ratios, known as the Heinrich triangle, as soundly based premises. But, a review of the Heinrich texts and the lack of documentation require that serious questions be asked as to their validity. In each of the editions following the first edition, the premise to which the ratios apply changed, with no explanation.

Taken from Heinrich’s first edition, this paragraph sets the stage for the discussion that follows.

Analysis proves that for every mishap resulting in an injury there are many other accidents in industry that cause no injuries whatever. From data now available concerning the frequency of potential injury accidents, it is estimated that in a unit group of 330 accidents, 300 resulted in no injuries, 29 in minor injuries, and 1 in a major or lost-time case. [Citation 28]

Note the simplicity of the phraseology: In a unit group of 330 accidents, 300 resulted in no injuries, 29 in minor injuries, and 1 in a major or lost time case.

Also, in the first edition, it is said “The total of 330 accidents all have the same cause.” (Citation 29) Note that “cause” is singular.

As you read the following, keep in mind that in accident analysis, causes are a distinct and separate category from kinds of accidents, usually referred to as accident types. In the second edition, three significant changes are made in the text:

- The statement that the 330 accidents all have the same cause was eliminated, without explanation.
- The word “similar” has been inserted between “other” and “accidents.”
- Also without explanation, the 330 accidents are now “of the same kind.” (Citation 30)
In the third edition, one additional language change is made, also significant. Now, the 330 accidents are to involve the same person.

... in a unit group of 330 accidents of the same kind and involving the same person.

This is how the text reads in the third and fourth editions, encompassing the changes noted above:

Analysis proves that for every mishap resulting in an injury there are many other similar accidents that cause no injuries whatever. From data now available concerning the frequency of potential-injury accidents, it is estimated that in a unit group of 330 accidents of the same kind and involving the same person, 300 result in no injuries, 29 result in minor injuries, and 1 in a major or lost-time injury. [Citation 31]

If the original data was valid, how does one explain the substantive revisions in the conclusions drawn from it? How does one support using the ratios without having explanations of the differing interpretations Heinrich gave to the data in each edition?

Thinking about the changes made in the second and third editions and carried over into the fourth edition, the 300:29:1 ratios present serious conceptual problems. To which types of accidents does “In a unit group of 330 accidents of the same kind and occurring to the same person” apply? Certainly, it does not apply to some commonly cited accident types: falling to a lower level, struck by objects, and so on. Keep this point in mind as you get to understand how Heinrich defined the 300, the 29, and the 1 — discussion of which follows.

Not only have many safety practitioners used the 300:29:1 ratios in their statistical presentations, but they have also misconstrued what Heinrich intended with respect to the terms “major injury,” “minor injury,” and “no-injury accidents.” In each edition, Heinrich gave nearly identical definitions of the accident categories to which the 300:29:1 ratios apply. This is how the definition reads in the fourth edition.

In the accident group (330 cases), a major injury is any case that is reported to insurance carriers or to the state compensation commissioner. A minor injury is a scratch, bruise, or laceration such as is commonly termed a first-aid case. A no-injury accident is an unplanned event involving the movement of a person or an object, ray, or substance (slip, fall, flying object, inhalation, etc.), having the probability of causing personal injury or property damage. The great majority of reported or major injuries are not fatalities of fractures or dismemberments; they are not all lost-time cases,
and even those that are do not necessarily involve payment of compensation. [Citation 32]

A safety director recently said that in the previous year his company sustained one fatality and 30 OSHA lost workday incidents, and, therefore, Heinrich’s progression was validated. Not so. That is just one example of how Heinrich’s ratios are misused: There have been thousands of such misuses.

Think about what Heinrich intended for the major injury category. His definition compels the conclusion that any injury requiring more than first aid is a major injury. Then, is it not so that, according to Heinrich’s definition, every OSHA recordable injury is a major injury? When Heinrich developed his definitions, very few companies were self-insured for workers compensation. Having insurance companies pay for medical-only claims was typical. Almost all such claims would be considered major injuries.

It should be understood that ratios could be produced from most statistical gatherings on incident occurrences. And, they may have value in their own settings. However, in a constantly changing world, those ratios may not have permanency, nor are they universally applicable in all work environments.

There are contradictions in Heinrich’s texts about when a major injury would occur and the relationship between the occurrences of unsafe acts and a major injury. In the first edition, he states:

For each accident producing a personal injury of any kind (regardless of severity) there are at least ten other accidents; furthermore, because of the relative infrequency of serious injuries, it requires 330 accidents to produce only 1 major injury and 29 injuries. [Citation 33]

In the paragraph above, 330 accidents are required to produce 1 major injury. Note the term required. In later editions it is recognized that a major injury can result from the first accident. For example, in the fourth edition, in the text beneath a chart showing The Foundation of a Major Injury, Heinrich says:

The major injury may result from the very first accident or from any other accident in the group. [Citation 34]

Elsewhere, in all editions, reference is made to 330 careless acts or several hundred unsafe acts occurring before a major injury occurs, as in the following examples taken from the first and third editions.
Keep in mind that a careless act occurs approximately three hundred times before a serious injury results and that there is, therefore, an excellent opportunity to detect and correct unsafe practices before injury occurs. [Citation 35]

Keep in mind that an unsafe act occurs several hundred times before a serious injury results. [Citation 36]

While a particular type of unsafe act may be performed many times before a particular type of accident occurs resulting in serious injury, it should not be assumed that such is always the case. Particularly, it is not the case in a very large majority of the incidents resulting in death or serious injury. Also, recall that for Heinrich, a serious injury — the 1 in his 300:29:1 ratios — is any injury that requires more than first aid.

After all of the foregoing, Heinrich set fourth, in his fourth edition, this view of the relationship that unsafe acts or exposures to mechanical hazards had to the occurrence of accidents.

If it were practicable to carry on appropriate research, still another base therefore could be established showing that from 500 to 1,000 or more unsafe acts or exposures to mechanical hazards existed in the average case before even one of the 300 narrow escapes from injury (events-accidents) occurred. [Citation 37]

There is a real problem here: All of those unsafe acts or exposures to mechanical hazards take place before even one accident occurs. As a concept, that is not acceptable.

As a summation on the 300:29:1 ratios, I present a more serious conceptual problem: It is impossible to conceive of incident reporting data being gathered in 1926, or even now, in which 10 out of 11 reports would pertain to accidents that resulted in no injury.

**CAUSAL FACTORS: AND RESOURCE MISDIRECTION**

Heinrich often stated his belief that the predominant causes of no-injury accidents are identical to the predominant causes of accidents resulting in major injuries. That led many safety practitioners to believe that if efforts were concentrated on the types of accidents that occur frequently, the potential for severe injury would also be addressed. I submit that this premise is not valid.

This is a subject to be taken seriously since the efforts of many safety practitioners are still misdirected because of their reliance on this Heinrich premise. Quotations indicating how Heinrich expressed his view are taken from the first and fourth editions.
The predominant causes of no-injury accidents are, in average cases, identical with the predominant causes of major injuries — and incidentally of minor injuries as well. [Citation 38]

The repetition of no-injury accidents eventually leads to explosions, fires and resultant panics, wrecks, and other catastrophes that cause tremendous loss of life. The foregoing statements and figures justify the conclusion that in the largest injury group — minor injuries — lie the more valuable clues to accident causes. [Citation 39]

Adoption of the Heinrich premise leads to misdirection in resource application, as well as ineffectiveness with respect to serious harm potentials. My experience has been that many incidents resulting in fatality or severe injury are singular and unique events, that their causal factors are multifaceted and complex, and that descriptions of similar incidents are seldom found in the historical body of incident data.

Furthermore, all hazards do not have equal potential for harm. Similarly, some risks are more significant than others. The quality requirements of DaimlerChrysler, Ford Motor Company, and General Motors assist in making the case for giving priority to risks that have a high potential for serious injury.

Suppliers to those auto companies must meet the requirements set forth in a reference manual titled Potential Failure Mode and Effects Analysis — FMEA and must do what the title implies. They make failure mode and effects analyses of the equipment they supply. In that process, a risk priority number (RPN) is developed, giving consideration to occurrence likelihood, severity of effect, and detection ability.

A defective cup holder for which several minor injuries are reported would receive a much lower RPN than would the potential for a seldom occurring vehicle rollover for which injury potential is severe. Surely, the design of the defective cup holder would be given suitable attention. But it cannot be said that “the more valuable clues to accident causes” lie in the causal factors pertaining to the defective cup holder because of the frequency of minor injuries, as Heinrich postulated.

As an additional example, a frequency of minor injuries from paper cuts will not provide clues with respect to the causal factors for the type of accident categorized as “fall to lower level.” Heinrich’s premise deflates the importance of severity potential, to the disadvantage of workers and employers.

The following comment is made in the FMEA text concerning RPN numbers and priority setting:

In general practice, regardless of the resultant RPN, special attention should be given when severity is high. [Automotive Industry Action Group, p. 43]
When the potential for severe injury is high, prevention of the event should be given high priority, even though the event probability is low. In the real world, resources are always limited, and staffing and money are never adequate to attend to all risks. Thus priorities must be set for the application of safety-related resources so that the greatest good derives to employees and to employers from their expenditure. That requires giving special attention to hazards presenting severity potential.

Other authors have proposed that events that could result in severe injury deserve a special place in the safety process. In Safety Management, 2nd edition, under the caption “The Causes of Frequency and of Severity,” Dan Petersen wrote this:

Safety professionals for years have been attacking frequency rates in the belief that severity would be reduced as a by-product. As a result, our frequency rates nationwide have been reduced much more than our severity rates have.

If we study the mass data, we can readily see that the types of accidents resulting in temporary total disabilities are different from the types of accidents resulting in permanent partial disabilities or in permanent total disabilities or fatalities. [Petersen, p. 11]

Petersen then listed “The Ten Basic Principles of Safety,” the second being as follows:

Certain sets of circumstances can be predicted to produce severe injuries. These circumstances can be identified and controlled:

- unusual, non-routine work;
- non-production activities;
- sources of high energy; and
- certain construction situations. [Petersen, p. 15]

Furthermore, Petersen wrote, “Principle 2 states that we can attack severity directly instead of merely hoping our attack on frequency will also effect severity” (Petersen, p. 16).

In Profitable Risk Control, William W. Allison also writes of the need to address severity potential.

A basic problem has been the need of a method to enable each facility to identify those severe risks which can result in loss of life, limb, material resources and profitability in that specific facility or in a new operation. [Allison, p. 45]
A colleague of long standing, Mr. Pat Clemens of Sverdrup Technology, Inc., had discussion of the improbability of finding a positive relation between accidents resulting in minor injuries and those resulting in major injury or fatality. This is taken from a letter he wrote to me after reflecting on his experiences:

Subject: Does attention to trivia lead to catastrophe prevention? Not very danged often!

Recently, I had occasion to review the circumstances of nine fatalities that occurred over a 35-year period in a facility having a work force numbering approximately 4000 employees. My purpose was to identify those cases in which recognizing and reacting to a pattern of minor precursory mishaps at the facility might have led to anticipating and preventing the proximate cause of the fatality that was suffered later. Of the nine cases, only one fell in that category. The one exception was a case in which improved standards of general housekeeping or a more effective safe-work permit system might have been expected to serve as an adequate preventive measure.

Since resources are always limited, and since some risks are more significant than others, safety practitioners must be capable of distinguishing the more important from the less important. They would then allocate the necessary time to those risks that present the greatest potential for severe harm. Such an undertaking requires discounting the Heinrich premise that the causal factors for no-injury accidents are the same as those for accidents resulting in severe injuries.

INCIDENTAL COSTS OF ACCIDENTS: THE 4:1 RATIO

For years, safety practitioners have sought soundly based methods to communicate to management on the reality of hazards-related incident costs. That would be great to have.

Absent a more reliable system, many safety practitioners accepted as universally applicable Heinrich’s undocumented premise that the “incidental cost of accidents has been found by analysis to be four times as great as compensation and medical costs” (Citation 40).

There is a great deal of literature on the subject of indirect accident costs and their relationship to direct costs. Bird and Davies say in Safety & The Bottom Line, a 1996 publication, that a literature search indicated that well over 90 published articles or books have been written discussing accident costs since Heinrich went to press in 1931 (Bird and Davies, p. 272).
This subject was researched in 1999–2000 for a chapter titled “Establishing Your Value: Communicating Incident Statistics In Financial Terms” which appears in the book Innovations in Safety Management (Manuele, p. 29). The following observation is made in that text: A single ratio of direct to indirect costs of incidents that is universally applicable to all industries cannot be developed.

As to Heinrich’s ratio, consider the following explanatory comment; it appeared in the third and fourth editions:

The original research resulting in the 4-to-1 ratios was made in 1926. No similar extensive study known to the author has since been made. However, sampling checks have been undertaken and these confirm the first findings. Increases in the cost of equipment and other factors on the side of hidden costs seem to be well balanced by increases in compensation and medical costs. [Citation 41]

To introduce the 4-to-1 ratio, wording similar to the following appeared in all four editions; this is taken from the 1959 text:

**Hidden Costs.** To industrial executives is offered the incidental or, more correctly, the hidden or indirect, but nonetheless real, employer costs of accidents, as indisputable evidence of the need for recognizing accident prevention as an essential of sound business management.

The many and varying estimates of the annual cost of industrial accidents are stated in terms of millions of dollars and are usually based on the lost time of the injured worker and medical expense. This is largely an employer loss, inasmuch as the employee is partially compensated; but it is far from being all of the cost to the employer. The remaining additional, and so-called “incidental,” cost has been found by research to be four times as great as compensation and medical payments. Expressed in another way, compensation and medical payments constitute only one-fifth of the total employer accident cost. The accuracy of this estimate has been demonstrated by application to scores of specific plants. [Citation 42]

Safety practitioners have wanted a way to express the financial impact of accidents, and for many of them, the 4-to-1 ratio was sufficiently reliable for their use.

What have others written about direct and indirect incident costs? A brief review will be given of the Rollin H. Simonds method; the Frank E. Bird, Jr. studies; an analysis made by Stanford University’s Department of Civil Engineering; and OSHA’s Safety Pays Program.

In a doctoral dissertation at Northwestern University in 1948, Simonds stated that the ratio of insured to uninsured costs was probably close to
1:1. For many years, the National Safety Council applied that ratio in its *Accident Facts* publication.

In the 1974 book titled *Management Guide to Loss Control*, Frank E. Bird, Jr. presented what he called the iceberg theory of incident costs. In an exhibit having the appearance of an iceberg and captioned “The Real Costs Of Accidents Can Be Measured and Controlled,” Bird gave these ratios:

*The Bird Ratios*

- $1 Insured costs (medical and compensation)
- $5 to $50 Uninsured property damage costs (building damage, tool and equipment damage, product and material damage, production delays and interruptions)
- $1 to $3 Uninsured miscellaneous costs (items such as hiring and training, replacements, investigation time, etc.) (Bird, p. 25)

In 1982, under contract to The Business Round Table, Stanford University’s Department of Civil Engineering issued “Improving Construction Safety Performance, Technical Report #269.” This study was made to provide guidance in reducing accident frequency and severity in the construction industry, as well as reducing the attendant costs. At the Business Round Table, the report is identified as “Improving Construction Safety Performance, Report A-3.”

**Excerpts from Table 3 in the report “Improving Construction Safety Performance”**

<table>
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<th>Number of Cases</th>
<th>Average Ratio Indirect Costs/Benefits Paid</th>
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<td>3000 to 4999</td>
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<td>1.2</td>
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<tr>
<td>10,000 plus</td>
<td>4</td>
<td>1.1</td>
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</table>
Direct and indirect costs are addressed in that report. Its Table 3 is titled “Analysis of Accident Costs.” Excerpts follow. Note that the ratio of indirect to direct costs diminishes as the cost of the benefits paid increases. Also, keep in mind that money numbers are in 1982 dollars.

Statisticians may say they would like a larger sample from which to draw conclusions. Nevertheless, the data are significant. An excerpt from the report follows. Its substance is pertinent to the improbability of arriving at a universally applicable indirect-to-direct accident cost ratio.

So many variables are involved that it is not possible to provide a single multiplier for all construction industry accidents.

How significant is this study? OSHA developed a costing system based on it. In 1998, OSHA published the “Safety Pays” program. It can be accessed through OSHA’s world wide web at www.osha.gov — Outreach — OSHA/Software Advisors. This is what the literature says the program does.

OSHA’s “SAFETY PAYS” program is interactive software developed by OSHA to assist employers in assessing the impact of occupational injuries and illnesses (with Lost Work Days) on their profitability. It uses a company’s profit margin, the AVERAGE costs of an injury or illness, and an indirect cost multiplier to project the amount of sales a company would need to generate in order to cover those costs.

In the OSHA program, the ratios used of indirect costs to direct costs are almost identical to those in the construction industry study. The OSHA system adds to the body of knowledge on direct and indirect costs and should be seriously considered by those who choose to produce cost data.

Obviously, the literature on direct and indirect costs of worker injuries and illnesses does not present a uniformly accepted computation method. Systems developed by authors vary considerably. One reason is that they do not measure the same things, and their outcomes will logically vary. Nevertheless, reasonably well-researched financial exhibits of costs can be impressive and convincing, especially in the prevailing economic climate in which there is so much pressure on managers for financial results.

Thus, I suggest that safety practitioners adopt from the systems discussed here and develop tailored approaches to determining the incident costs in the operations for which they have responsibility. Their systems should encompass as many categories of hazard-related occurrences as feasible (worker injuries, auto accidents, environmental incidents, fires, boiler and machinery loss events, etc.).

To sum up, Heinrich’s attempt at developing a method to discover the total costs of accidents was noteworthy. But, the 4-to-1 ratio cannot
be used universally. Yet, authors in safety often cite the 4-to-1 ratio as a valid premise from which to begin their dissertations. A researched, valid, variable system would be beneficial.

CONCLUSION

The intent of this chapter is to present a review of the origin of certain of Heinrich’s premises that became accepted as truisms, describe how they evolved and changed over time, and determine their validity. A summary of the observations made in this chapter follows.

1. Files pertaining to Heinrich’s research do not exist. Thus, there is no material to review as to (a) the quality of his research or (b) the analytical system used to arrive at his premises and their validity.

2. Heinrich’s studies were made of accidents that occurred in the 1920s. Safety at work and the workplace itself have changed substantively since then, as evidenced by noteworthy reductions in accident experience in the past 70 plus years. Therefore, the current value and applicability of his conclusions should be questioned and researched.

3. While psychology has a place in safety management, the emphasis Heinrich gave to it as being “a fundamental of great importance in accident causation” was disproportionate, and that overemphasis influenced his work considerably, and that of many safety practitioners.

4. Heinrich’s 88:10:2 ratios indicate that among the direct and proximate accident causes, 88% are unsafe acts, 10% are unsafe mechanical or physical conditions, and 2% are unpreventable.
   - The methodology used in arriving at those ratios cannot be supported.
   - Current causation knowledge indicates the premise to be invalid.
   - This premise conflicts with the work of others, such as W. Edwards Deming, whose research finds root causes to derive from shortcomings in the management systems.
   - Among all the Heinrich premises, application of these ratios has had the greatest impact on the practice of safety, and has also done the most harm — since they promote preventive efforts being focused on the worker, rather than the operating system.

5. The Foundation of a Major Injury, the 300:29:1 ratios (Heinrich’s triangle), is the least tenable of his premises.
• It is impossible to conceive of incident reporting data being gathered in 1926, or even now, in which 10 out of 11 reports would pertain to accidents that resulted in no injury.

• Conclusions pertaining to the 300:29:1 ratios were revised from edition to edition, without explanation, thus presenting questions about which version is valid.

6. Heinrich’s often-stated belief that the predominant causes of no-injury accidents are identical with the predominant causes of accidents resulting in major injuries is not supported by convincing evidence, and is questioned by several authors. Application of the premise results in misdirection since those who apply it may presume, inappropriately, that if they concentrate their efforts on the types of accidents that occur frequently, the potential for severe injury will also be addressed.

• Investigation of numerous accidents resulting in fatality or serious injury by modern-day safety professionals leads to the conclusion that their causal factors are seldom linked to accidents that occur frequently and result in minor injury.

7. No documentation exists to support Heinrich’s 4-to-1 ratio of indirect injury costs to direct costs. Furthermore, arriving at a ratio that is applicable universally is implausible.

If we are to be recognized as a profession, our practice must be based on soundly established premises. Questioning and examining premises that we have accepted as truisms for many years is not easy to do. Resistance to such inquiry is to be expected. Yet, we must be capable of discarding those premises that scrutiny reveals to be unsustainable.

For several of the subjects discussed here, it is evident that soundly based research, capable of standing the test of good science, is needed to move forward the state of the art in the practice of safety.

(A version of Heinrich Revisited: Truisms or Myths was published by the National Safety Council in 2002. This variation is included here in accord with an agreement with the National Safety Council.)

REFERENCES

## Editions and page numbers

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ADDRESSING SEVERE INJURY POTENTIAL

INTRODUCTION

In Chapter 7, “Heinrich Revisited: Truisms or Myths,” comments are made on Heinrich’s often expressed premise that the predominant causes of no-injury accidents are identical to the predominant causes of accidents resulting in major injuries. I said that I found the premise to be invalid. Furthermore, I made the case that a large proportion of the incidents resulting in serious injuries are singular and unique events, that their causal factors are multifaceted and complex, and that descriptions of similar accidents are seldom found in the historical body of incident data.

Some safety practitioners presume that efforts concentrated on the types of accidents that occur frequently will also encompass the types of accidents that result in severe injury or damage. That often results in the severity potential being overlooked, along with a misdirection in the application of resources.

D. Kriebel, in “Occupational Injuries: Factors Associated with Frequency and Severity,” makes these interesting observations about the relation between injury frequency and severity.

A Model of Injury Severity: Safety researchers have generally ignored severity, perhaps because for many years it was believed that the seriousness of the consequences of an accident was essentially randomly determined
ADDRESSING SEVERE INJURY POTENTIAL

(Heinrich 1959). However, the analysis of the data from 89 industries (studied)... shows that the frequency and average severity of the injuries in an industry are poorly correlated one to the other, and are essentially independently determined [p. 212].

William G. Johnson, in MORT Safety Assurance Systems, also implies that severity potential needs greater emphasis. He writes:

Some safety professionals are overly concerned with winning awards for reductions in minor injuries and under emphasize sources of serious accidents and disasters. Such a tendency can mislead management [p. 19].

To encourage safety practitioners to adopt measures specifically directed to preventing accidents that have the potential to result in severe injury, this chapter will:

• Elaborate further on the premise that a large proportion of the accidents resulting in severe injury are unique and singular and that their causal factors are multifactorial and complex
• Review selected literature that discusses the cascading of events in accidents resulting in severe injury
• Discuss real-world accidents that resulted in fatalities, which are illustrative of the multiplicity and complexity of causal factors, acting in sequence
• Present methods to identify and act on hazards before they become the causal factors for accidents resulting in severe injuries

MOST ACCIDENTS RESULTING IN SEVERE INJURY ARE UNIQUE EVENTS

Can we identify serious injury potential? To a considerable extent, the answer to that question is yes. We can identify the types of work out of which many accidents occur that result in serious injury and address the relevant hazards in that work on an anticipatory basis. Although the data in support of that premise are limited, it is persuasive. As was indicated in the chapter on “Heinrich Revisited,” Dan Petersen said in his book Safety Management, 2nd edition:

If we study any mass data, we can readily see that the types of accidents that result in temporary total disabilities are different from the types of accidents resulting in permanent partial disabilities or in permanent total disabilities or fatalities. The causes are different. There are different sets
of circumstances surrounding severity. Thus if we want to control serious injuries, we should try to predict where they will happen. Today we can often do just that.

Studies in recent years suggest that severe injuries are fairly predictable in certain situations. Some of those situations involve:

- Unusual, non-routine work;
- Non-production activities;
- Sources of high energy; and
- Certain construction situations.

These are just a beginning point. A long list could be made which would more extensively specify the areas where severity is predictable [p. 11].

Data, not yet published, provided by Dr. Franklin Mirer, who is Director of the Health and Safety Department at the International Union — UAW, are in concert with Petersen’s observations. The data indicate that severe injury accidents occur disproportionately in unusual and nonroutine work, in nonproduction activities, and where there are high sources of energy. During the 18 years previous to January 1, 2001, the data show that skilled trades people, who represent about 20% of the UAW work population of about 700,000, have 40–50% of the fatalities. Skilled trades people, such as maintenance personnel, millwrights, electricians, steamfitters, pipefitters, and tinsmiths, are seldom engaged in repetitive and routine work. They are not engaged in production work. Total hours worked by the UAW population in this period is in the billions, and that represents a sound statistical base. These statistics have significance.

And these observations are pertinent, and the points made apply to other industries. In discussions with a safety director in a chemical company, he said that: when the system is running, the risks are lower; when we have to open up the system for maintenance or have an equipment failure or a chemical release, severity potential is greatly increased. A safety director for a heavy electrical equipment manufacturer said that severe injuries in his worldwide company seldom occur in routine production operations.

But, it is recognized that severe injury or damage potential exists in routing production work, and that this potential can also be identified through methods to be described later. Furthermore, it is not the purpose here to suggest diminishing the efforts to prevent accidents resulting in less than severe injuries. It is the intent to encourage adoption of those additional efforts needed to prevent accidents resulting in severe injury.
CASCADING EVENTS: ACCIDENTS RESULTING IN SERIOUS INJURY

What have others said about the nature of those incidents that result in serious injury? In his book *The Psychology of Everyday Things*, Donald A. Norman makes the case that “It is spectacularly easy to find examples of false assessment in industrial accidents.” He is Professor and Director of the Institute for Cognitive Sciences at the University of California, San Diego, and teaches undergraduate and graduate classes at UCSD entitled “Cognitive Engineering.” He wrote this:

> Explaining away errors is a common problem in commercial accidents. Most major accidents follow a series of breakdowns and errors, problem after problem, each making the next more likely. Seldom does a major accident occur without numerous failures: equipment malfunctions, unusual events, a series of apparently unrelated breakdowns and errors that culminate in major disaster; yet no single step has appeared to be serious. In many of these cases, the people involved noted the problem but explained it away, finding a logical explanation for the otherwise deviant observation [p. 128].

Note the terminology “numerous failures,” and “a series of apparently unrelated breakdowns and errors.” An aspect of many incidents that result in severe injury is the cascading effect of multiple causal factors acting in sequence — sometimes in multiple and parallel sequences — toward an undesirable end.

Kingsley Hendrick and Ludwig Benner, Jr. make similar comments about the cascading effect of events in accident occurrences in *Investigating Accidents with Step*.

Because accidents are composed of sets of individual events, all of which are interrelated, each event affects one or more actors and what they do next, changing their state. The first event in the accident process is a perturbation or an undesired or unplanned change in someone or something within the planned process. That first disruptive event initiates a sort of cascading effect, culminating in some harm or loss [p. 31].

The term “actor” is used to identify the people or things who or which directly influenced the flow of events constructing the accident sequence [p. 69].

STEP is an acronym for “sequentially timed events plotting.” STEP is an events-analysis-based approach in which the events are plotted, sequentially — and in parallel, if appropriate — showing the cascading effect as each event impacts on others. It is built on the management system
embodied in MORT (the management oversight and risk tree) and system safety technology.

I have been involved in many incident investigations and have reviewed over a thousand incident investigation reports for an assessment of the quality of their content. My experience compels the observation that many accidents resulting in severe injury are unique and singularly occurring events in which a series of breakdowns occur in a cascading effect. This phenomenon pleads for creating and implementing methods that identify serious injury potentials and mitigating against their occurrence.

CASE STUDIES

Descriptions follow of two incidents resulting in fatalities. One occurred while routine work was being performed in a manufacturing operation; the other occurred in a distribution center while unusual, nonroutine work was being done.

As you review these incidents, try to determine the causal factors and how the first hazard, hazardous event, or decision led to other causal factors, in a sequential and cascading manner. The purpose here is to encourage thinking about the complexity and uniqueness of the incident process that resulted in fatality.

Causal factors include all of the elements—the hazards (the characteristics of things, and the actions and inactions of people) and the events deriving from them—that contribute to the incident process.

Case Study 1

**Background.** Company X produces a wide variety of die-cut foam parts for component suppliers to several industries. For this operation, sheets of foam are manually inserted into a press by an operator and placed against locating blocks on the platen. The die is located in a stationary surface that is set at an angle of approximately 20 degrees from the perpendicular. The platen is almost parallel to the floor and raises the material to be cut to meet the die as the machine cycles. Figure 8.1 shows a diagram of the machine. A two-person team operates the press: (1) an operator who feeds the press and removes the parts after they are cut and (2) a packer who inspects the parts for quality and places them in boxes. After the pieces are cut, the machine lowers the platen, the operator removes the part—typically with the left hand—and stacks it on a table while simultaneously inserting another part with the right hand. The packer inspects the parts for quality and places them in boxes.
Operating Conditions. Presses can be operated in one of three modes: single stroke, which requires the operating control to be actuated on each cycle; a timed mode, which causes the press to operate continuously with an operator-set time delay between each cycle; and continuous without a delay between cycles. Most of the experienced operators run the presses in the continuous mode or the timed mode. At the time this incident occurred, the press was being operated in a continuous mode. In any of the three modes, operators have their hands and arms inside the platen area during the cycle.

There is a speed control that allows the speed to be set from “0” to “10,” with “10” being the highest speed. At the highest speed, the press cycles approximately every 3 to 4 seconds. At the time the incident occurred, the speed control was set at “10.”
The Incident. Parts coming off the press were of good quality and the press was operating normally. To rearrange the stack of material to be cut and to spray water on it, which was done to eliminate static electricity, the operator stopped the press, by pushing the bottom safety bar at the platen location—what should have been a prohibitive practice except in an emergency. The circuitry did not require a resetting of the safety device to restart the press.

The operator was turned 90 degrees from the front of the press, facing the table on which the material was stacked. Her back was to the packer. The machine control panel was on a stand along side of the table about 18 inches away from the press. The packer had noticed a large piece of scrap foam material in the back of the press and said to the operator, “maybe they should clean back there once in a while.”

Moments before the operator restarted the press by pushing the start button on the control panel, the packer had stepped to the side of the press and leaned into the platen area to remove the debris from the back of the press. As the operator turned toward the press, she saw the packer trapped between the platen and the fixed die mounted surface. The packer died as a result of a fractured skull.
Findings. Operators were trained and experienced. Job instructions intended to address quality and safety issues were posted near the press. They did not contain any specific instructions related to removal of debris from the press.

ANSI Standard B65.5–1996 “Safety Standard-Stand Alone Platen Presses” applies to this press, which was manufactured in 1969. The standard requires that its provisions be applied immediately upon relocation of older equipment. This press was moved to this facility about one year prior to this incident. It had not been upgraded.

The lower safety trip bar located at the front of the platen is spring-loaded. After it is pushed downward to stop the press, it returns to its original position. Resetting the safety trip is not necessary: Pushing the start button can restart the press.

Wire mesh guarding had been installed around the back and sides of the press, but it did not extend far enough to prevent access to the area to the side of the platen. The distance from the end of the fixed wire mesh guarding to the edge of the press, the place where the packer was standing to remove the scrap, was about 24 inches.

Subsequently. The press was brought up-to-date with respect to ANSI B65.5; wire mesh guarding was extended to prevent access to the side of press from the operations area (the wire mesh guarding has an electronically interlocked entry door in the rear); the control panel was moved to the front of the press to ensure clear and unobstructed vision of the entire platen area; the safety control circuit was upgraded to require specific resetting, once the stop switch on the safety bar on the platen had been actuated; the press was adjusted to operate in the “timed mode” with a minimum cycle limit of 10 seconds; the job description was revised to include instructions on removing debris; safety mats were installed to prevent access to the platen area from the sides of the platen; and training was improved.

(Safety mats are commonly used in industry and were used elsewhere at this location. A safety mat contains a normally open electrical switch that is integrated into a safety circuit. It contains an upper and a lower conductive plate. When a weight that exceeds a specified minimum is placed on top of the mat, the upper conductive plate makes contact with the mat’s lower conductive plate. That completes an electrical circuit that actuates the machine’s primary controller to stop the machine.)

Case Study 2

Background. A distribution center for electronic components occupies an old mill building built in 1922. Several powered trucks are used to
move the cartons in which the components are received, and subsequently reshipped, often after some repackaging. Overhead guards on the powered trucks were removed so that operators could take a shortcut through a basement area where the ceiling clearance is too low to accommodate trucks having overhead protection.

Removal of the overhead protection took place about a year prior to the date of this incident. That was done to save time in that the alternative to removing the overhead protection in some instances was to follow a route that would require 5 minutes longer per trip.

**The Incident.** A semi-trailer had arrived at the premise to unload a large quantity of electronic components. The semi-trailer’s access to the loading ramp was blocked by a number of large storage racks. Each of these steel racks is 3.5 feet high and weighs about 800 pounds. They were stacked five high for a total of 17.5 feet high. This exceeded the orally established provision whereby racks were not to be stacked more than three high.

The racks were to have been removed by workers on the previous shift. The forklift truck operator, using a large forklift with a 6000-pound capacity, picked up a stack of racks and commenced moving them across the yard to a storage area.

Because of the height of the stack, forward visibility was obstructed. The stack of racks struck an electrical cable that was strung 14 feet 9 inches above ground level. The top rack fell toward the forklift operator, causing severe injuries to his head and chest. He did not survive.

**Findings.** Operating forklift trucks without overhead protection in place violates OSHA standard 1910.178, Powered Industrial Trucks; as well as ANSI/ASME B56.1–1992, Safety Standards for Low Lift and High Lift Trucks.

Operating a forklift truck was not a part of the job of the person assigned by a supervisor to move the stack of racks. He had not been trained for the work and had only occasionally operated a forklift truck. Stacking racks 17.5 feet high was known to be risky because at that level they were unstable.

The supervisor on the previous shift could not give an adequate explanation for the racks being stacked as high as they were. Nor could he explain why the racks were still in the area blocking access to the loading dock by the semi-trailer, except that it just didn’t get done before his shift ended.

The best that the supervisor who assigned the moving of the racks to an inexperienced operator could say was that “he was right here and
available.” The supervisor instructed the forklift driver on the route he was to take and where he was to place the racks, but he did not advise him of the existence of the overhead cable. He did not have the height of the racks reduced before they were moved.

If the overhead protection had not been removed from the forklift trucks, the falling racks would have been diverted from the operator and injury would not have resulted.

**Subsequently.** Overhead protection was reinstalled on all forklift trucks. Using the time-saving shortcut was prohibited. Training and licensing of forklift truck operators was brought up-to-date. The provision of not storing racks more than three high was enforced. Supervisory responsibility was clarified and strengthened, particularly about the risks involved in out-of-the-ordinary work. Overhead obstructions in the yard areas were relocated.

**PREVENTING ACCIDENTS HAVING SERIOUS INJURY POTENTIAL**

Not only do the foregoing case studies indicate that accidents resulting in serious injury are unique and singular events, but also their causal factors are often identifiable before the incidents occur. Preventing such accidents requires adopting a mind-set that specifically addresses serious injury potential in every aspect of safety management — from the initial design process through to dismantling and disposition. For both of the cases cited, there were significant workplace and work methods design problems.

**RISK AVOIDANCE AND CONTROL IN THE DESIGN PROCESS**

Avoiding serious injury potential is most effectively accomplished in the original system and work methods design process. But redesign opportunities, applying the same safety-through-design principles, present similar opportunities when retrofitting takes place. Several chapters in this text relate to designing, originally and in retrofitting, to achieve acceptable risk levels. They are: Chapter 14, “Hazard Analysis and Risk Assessment”; Chapter 16, “Safety Professionals and the Design Process”; Chapter 17, “Guidelines: Designing for Safety”; Chapter 18, “System Safety: The Concept”; and Chapter 19, “Applied Ergonomics: Significance and Opportunity.”

In the book *Innovations in Safety Management: Addressing Career Knowledge Needs*, Chapter 7 is titled “How to Avoid Bringing Hazards
into the Workplace.” In that chapter a composite is provided of (a) the procedures in place at several companies to achieve hazard avoidance and control on an anticipatory basis and (b) the systems to be followed before new or modified equipment is released for operation. Some of those procedures apply to initial designing and subsequent redesigning of systems; others pertain to operational procedures and work methods, both routine and unusual.

An example is given in the previously cited Chapter 7 pertaining to an auto company, whereby its contract with the auto union requires that “As early as possible and preferably in the zero phase of the planning in the design process, the parties agree to perform Task Based Risk Assessments on new equipment and manufacturing systems, and on existing equipment and manufacturing systems where locally agreed to.”

A “General Industry Guide: Safety Design and Operational Requirements” sets forth the requirements for equipment and process design safety reviews. That is followed by (a) a “General Design Safety Checklist” and (b) the procedures in place in a large company to integrate consideration of environmental, health, and safety needs in the tool development cycle, starting at the design concept phase.

Also, there is a chapter in Innovations in Safety Management titled “The Safety Decision Hierarchy.” It sets forth a decision-making process for risk elimination and control within the context of the principles of good problem techniques.

A RELEVANT EUROPEAN GUIDELINE: IMPACTING DESIGN AND OPERATIONS CONSIDERATIONS

With respect to guidelines and standards that include provisions applicable to the prevention of accidents resulting in severe injuries or fatalities, it is my view that the Europeans are the world’s leaders. Very little safety literature applies specifically to preventing serious injuries. But, at http://mahbsrv.jrc.it/NewProducts-SafetyManagementSystems.html, you will find “Guidelines on a Major Accident Prevention Policy and Safety Management System as Required by Council Directive 96/82/EC (Seveso II).” This document was issued by the European Commission—Joint Research Centre, Institute for Systems Information and Safety, Major Accident Hazards Bureau in Luxemburg.

These Guidelines reflect the intent of Council Directive 96/82/EC (SEVESO II) which “is aimed at the prevention of major accidents involving dangerous substances, and the limitation of their consequences.” There are four major sections in the document: Introduction to Safety
Management systems; Development of Major Accident Prevention Policy (MAPP); Elements of Safety Management Systems; and Bibliography.

The section on Elements of Safety Management Systems speaks particularly to the purposes of this chapter. It contains these subsections:

- Organization and personnel
- Hazard identification and evaluation
- Operational control
- Management of change
- Planning for emergencies
- Monitoring performance
- Audit and review

While all of these Elements of Safety Management Systems are significant in avoiding accidents resulting in severe consequences, the section titled “Hazard Identification and Evaluation” is principally relevant here. It requires hazard identification and avoidance or mitigation, both on an anticipatory basis in the design process and during all phases of operations. That encompasses both routine and unusual operations. This is how the directive reads:

The following issues shall be addressed by the safety management system (SMS): identification and evaluation of major hazards — adoption and implementation of procedures for systematically identifying major hazards arising out of normal and abnormal operation and the assessment of their likelihood and severity.

The following excerpts, taken from the text that follows the citation above, specify the actions to be taken with respect to major hazards.

Hazard identification and evaluation procedures should be applied to all relevant stages from project conception through to decommissioning, including:

- potential hazards arising from or identified in the course of planning, design, engineering, construction, commissioning, and development activities; and

- the normal range of process operating conditions, hazards of routine operations and non-routine situations, in particular start-up, maintenance, and shut-down.
Thus, the requirements encompass identifying hazards both on an antici-
patory basis in the design process and in the entire spectrum of operations.
That’s exceptionally important in minimizing severe injury potential. If
there are no hazards, no potential for harm, no accidents can occur.

A companion piece to the above referenced Guidelines is the book *Pre-
vention of Major Industrial Accidents*. It is an International Labour Office
“Code of Practice.” The content of the book parallels the Guidelines, but
the text is more extensive.

While the Guidelines pertain to the prevention of major accidents
involving dangerous substances, it is important to understand that the
principles embodied are suitable for all operations. I do not know of
a comparable document having been issued in the United States that
addresses the prevention of major accidents as broadly and specifically.

Although the OSHA and EPA regulations cited here could be considered
as addressing severe injury potential, the terminology contained in them
is not specifically so directed. OSHA’s rule 1910.119, which pertains to
“Process Safety Management of Highly Hazardous Chemicals,” contains
provisions such as process hazard analysis, operating procedures, pre-
startup safety review, management of change, and emergency planning
and response.

OSHA’s regulatory authority pertains to on-site consequences. The con-
cerns of the Environmental Protection Agency (EPA) center on offsite
consequences. EPA Rule 40 CFR Part 68 is titled “Risk Management Pro-
gams for Chemical Accidental Release Prevention.” Similarly, it contains
provisions for hazard reviews and control, with considerable overlap-
ning with the OSHA requirements. But the language in the OSHA and
EPA rules does not include language comparable to that quoted from the
“Guidelines on major accident prevention . . . ” with respect to “poten-
tial hazards arising from or identified in the course of planning, design,
engineering, construction, commissioning, and development activities.”
(Emphasis added.)

**OTHER PREVENTION TECHNIQUES**

In addition to the previously described methods to avoid serious injury,
other preventive techniques are also available. Although it is suggested
that safety practitioners make adaptations from the following techniques as
specific measures to identify hazards that present serious injury potential,
these methods can encompass all types of incidents. Those adaptations
should suit the culture and need of a particular operation.
• The critical incident technique (also referred to as incident recall and the significant incident technique)
• Safety sampling
• Pre-job planning and safety reviews for nonroutine work

The Critical Incident Technique

The purpose of the critical incident technique is to identify and take action on the hazards in an operation that have serious injury potential, utilizing the knowledge of skilled safety practitioners and of the work staff. In applying the technique, skilled observers interview a sampling of persons, eliciting their recall of “critical” incidents that have occurred that exposed them to operational or physical hazards that gave them cause to be concerned, whether the incidents did or did not result in injury.

For this process to succeed, it must be recognized that the people doing the work are a valuable resource in identifying hazards and risks because of their extensive knowledge of how the work gets done.

Critical incidents identified are analyzed and classified with respect to the significance of the risks presented by the hazards noted, with priorities being set for remedial action.


William G. Johnson, in MORT Safety Assurance Systems, refers to a similar process known as Incident Recall. This is what he says about it.

Incident recall is an information gathering technique whereby employees (participants) describe situations they have personally witnessed involving good and bad practices and safe and unsafe conditions. Such studies, whether by interview or questionnaire, have a proven capacity to generate a greater quantity of relevant, useful reports than other monitoring techniques, so much so as to suggest that their presence is an indispensable criterion of an excellent safety program [p. 386].

Whatever the system is called—significant incident recall technique, incident recall technique, or critical incident technique—adding such an element to a safety management system to identify hazards that particularly pertain to low probability–high consequence incidents will have value.
Safety Sampling

Safety sampling is another technique that can be structured for the specific purpose of identifying hazards (causal factors) that have high severity potential. This method relies on the knowledge and expertise of personnel who are familiar with operations and well-trained in recognizing hazards (physical and operational).

A tour of operations is arranged, preferably conducted by a knowledgeable team, for the specific purpose of seeking hazards that present severe injury potential. A safety sampling system does not have to be as ultimately detailed in the creation of forms and preidentification of hazard types as is suggested in some of the literature. Knowledgeable personnel can make the system work well without such extensive formality, relying on their experience and understanding of hazards and risks. (See Appendix A — Safety Sampling, in Safety Management, 2nd edition by Dan Petersen.)

Pre-Job Planning and Safety Reviews for Nonroutine Work

I have reviewed many incident reports involving nonroutine work that resulted in severe injury. Anecdotally, I can say that the work quite surely would not have been done the way it was done if a pre-job planning and safety review had been conducted. I can also say from my experience that doing pre-job planning and safety reviews for nonroutine work is not the norm in many companies, although what I propose is comparable to the expected practice in some construction operations.

With respect to pre-job planning and safety reviews, the construction industry is ahead of other business and industry categories. An addendum in this chapter is an example of a pre-job planning and safety review prepared before work was commenced on a construction project.

But, there are signs of a growing interest in pre-job planning and safety reviews beyond the construction industry. Under the direction of Bruce Main, President of Design Safety Engineering, a study was made in Michigan that resulted in a report titled “Risk Assessment For Maintenance Activities: Preventing Injuries Before They Happen.” The report was issued in October 2001 and was made available to the public on the Internet in March 2002. In the two weeks following its being posted on the Internet, there were 375 downloads of the report.

The maintenance people who were a part of the survey usually do nonroutine work. As was previously stated, they have a disproportionate share of the serious injuries and fatalities.
I propose that adopting the concept incorporating pre-job planning and safety reviews for nonroutine work within the culture of an organization would greatly reduce the risk of severe injury and fatality. Establishing the concept will be emphasized here, with the intent of not proposing extensive procedures and reports when that is not necessary for the particular nonroutine job to be undertaken.

For many noncomplex, nonroutine jobs, it is sufficient if applying the concepts presented in the following pre-job planning and safety review outline results only from brief discussions by the people who are to do the work, it is sufficient to arrive at a go or no-go conclusion. If it became the accepted practice that the workers think through the job to be done, plan for the methods to be used, discuss the hazards and risks, and determine whether the risks are or are not acceptable, that would be a highly favorable accomplishment. Of course, if they conclude that the risks are not acceptable, help will be needed and a more thorough review and risk assessment will be necessary.

Achieving a culture change that incorporates pre-job planning and safety reviews as an accepted and expected practice for nonroutine jobs requires support from all levels of management and from the workers. Furthermore, such a culture change cannot be attained without a training program that helps workers understand the concepts to be applied.

Having pre-job planning and safety reviews accepted as a part of the culture can be achieved, as will be demonstrated by the following example. At a large location, the injury severity experience was considered excessive for nonroutine work, and the safety professionals decided that something had to be done about it. As the safety professionals prepared a course of action and talked it up at all personnel levels, from top management down to the worker level, they encountered the usual negatives: For example, the skilled trades people would never buy into the program and the skilled trades supervisors would resist any change. The safety professionals considered those negatives as normal expressions of resistance to change.

Their program consisted, in effect, of indoctrinating management and the work force on the benefits to be obtained by doing a pre-job review that encompassed productivity, meaning how to get the job done efficiently and in good time, and hazard analysis and risk assessment. Eventually, management and skilled trades personnel agreed with the proposal made by the safety professionals that classroom information sessions would be held. Subsequently, the safety professionals considered these classroom sessions vital to their success.

At the beginning of those sessions, a discussion outline was given to the attendees that set forth the fundamentals of the pre-job review
system being proposed. After discussion of the content of the outline, attendees were divided into groups to plan actual maintenance jobs that were described in scenarios that had been previously prepared. The discussion outline given to the participants was comparable to the following, which is a composite of proven pre-job planning and safety review methods.

**Pre-job Planning and Safety Review**

1. Review the scenario, which defines the work to be done. Considering both safety and productivity:
   a. Break the job down into manageable tasks.
   b. How are you going to get each of those tasks done?
   c. In what order do we do those tasks?
   d. What equipment or materials are needed?
   e. Are any particular skills necessary?

2. Will the work require: a hot work permit; a confined entry permit, lockout/tagout (of what equipment or machinery)?

3. Will it be necessary to barricade for clear work zones?

4. Will aerial lifts be required?

5. What personal protective equipment will be required?

6. Will fall protection be required?

7. What are the hazards in each task? Consider

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<td>Work at depth</td>
<td>Vibration</td>
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<td>Pinch points</td>
<td>Fall hazards</td>
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<td>Weather</td>
<td>Sharp objects</td>
<td>Steam</td>
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<td>Elevated loads</td>
<td>Stored energy</td>
<td>Dropping tools</td>
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<tr>
<td>Moving equipment</td>
<td>Forklift trucks</td>
<td>Hot objects</td>
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<tr>
<td>Conveyors</td>
<td>Access</td>
<td>Weight</td>
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(It is not suggested that this hazards list is suitable for all operations. One should be developed to suit the hazards and risks inherent in the operation.)

8. Of the hazards identified, do any present severe risk of injury?

9. Develop hazard control measures, applying the Safety Decision Hierarchy.
- Eliminate hazards and risks through system design and redesign.
- Reduce risks by substituting less hazardous methods or materials.
- Incorporate safety devices (fixed guards, interlocks).
- Provide warning systems.
- Apply administrative controls (work methods, training, etc.).
- Provide personal protective equipment.

10. Is any special contingency planning necessary? People? Procedures?
11. What is to be done if the work doesn’t go as planned?
12. Considering all of the foregoing, are the risks acceptable? If not, what action should be taken?

At this location, skilled trades supervisors really took to the idea of pre-job planning once there was recognition that it made their jobs easier, improved productivity, and reduced the risks. As one of the safety professionals said in correspondence to me on the program: “Our skilled trades supervisors that have been involved in the process have become real believers in it.” And a culture change had been achieved.

CONCLUSION

To a large extent, hazards that present severe injury or fatality potential can be identified and the risks deriving from them can be assessed. Preferably, those hazards and risks would be dealt with in the design processes — whether for facilities, equipment, operating systems, tooling, processes, or products — and in the design of the methods to perform the work.

The accident record for fatalities and serious injuries establishes that hazards and risks that have severity potential are seldom considered and reduced to a practical minimum in the design process. Thus, it is not unusual to find severe injury potential in facilities and operations in place.

Unfortunately, many safety practitioners continue to act on the premise that if efforts are concentrated on the types of accidents that occur frequently, the potential for severe injury will also be addressed. That results in the severe injury potential being overlooked, since the types of accidents resulting in severe injury or fatality are rarely represented in the data pertaining to the types of accidents that occur frequently. A sound case can be made that many accidents resulting in severe injury or fatality are unique and singular events.
But, seldom do safety management systems specifically address severe injury potential. Thus, to properly address that potential and to give it the priority consideration needed, safety practitioners must add an element within their safety management systems to undertake distinct activities to seek those hazards that present severe injury or damage potential.

REFERENCES


Main, Bruce W. Risk Assessment for Maintenance Activities: Preventing Injuries Before They Happen. Ann Arbor, MI: Design Safety Engineering, 2001 (also at Bruce@designsafe.com).


### PRE-JOB PLANNING AND SAFETY REVIEW

Work to be performed: Install siding on the outside perimeter of the welding shop using a 40’ aerial work platform

Analysis prepared by: Irene Dunne, General Supervisor  
Date: 9/9/2002  
Competent Person: T. Paine  
Qualified Person: H. Lee

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Safework Practices and Hazard Control</th>
<th>Contingency Plan</th>
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| Falling from aerial work platform. | • Employees will utilize full-body harness with lanyard attached to manufacturer’s identified anchorage point in the aerial work platform.  
• Employees will be trained to use aerial work platforms used on this project. Hard hat stickers will be issued and displayed on the hard hats of those trained.  
• At the beginning of each shift, the aerial work platform operator will perform a visual inspection and functional test according to the manufacturer’s recommendation. A copy of the inspection and test will remain with the equipment for the entire shift. | Building phones are not available. When using a cell the emergency number is (123) 456-7890 |
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<th>Contigency Plan</th>
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| Aerial work platform tip over (adjacent to an area of excavation work). Muddy ground conditions, due to poor drainage, may cause problems. | • Due to heavy rain and poor drainage, it will be necessary to monitor and test the soil conditions and terrain surrounding the building in each new area and before work begins to ensure a safe foundation for the aerial work platform and mobile crane operations. Stable conditions will be provided, where necessary, through use of mudsill blocks, cribbing, operating, or other acceptable means for effective wheel contact, outrigger placement and equipment support.  
• **T. Paine** will also be on the ground, rigging and attaching the siding panels.  
• **T. Paine** will inspect ground conditions on a daily basis and after any rain, paying close attention to areas around nearby excavations.  
• **T. Paine** will inspect the path of travel and ground conditions in each new area where the aerial work platform will be set up to install siding.  
• Siding panels will be hoisted into fastening position by using a mobile crane and proper rigging technique. | If workers in the aerial work platform are unable to operate the controls, the **competent** ground person **T. Paine** will begin a rescue by operating the ground controls. **T. Paine** is Also trained in First Aid and CPR. |
<p>| Falling sheets of siding, materials or tools. |</p>
<table>
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<tr>
<th>Hazard</th>
<th>Safework Practices and Hazard Control</th>
<th>Contigency Plan</th>
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<tbody>
<tr>
<td>Siding panels will be securely fastened before releasing the hoisting apparatus.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical shock.</td>
<td>All electrical power tools and extension cords will be GFCI protected.</td>
<td></td>
</tr>
<tr>
<td>People entering into the hazard work area.</td>
<td>Portable 42” barricades will be used to deter entry of unauthorized personnel into the hazard area</td>
<td></td>
</tr>
<tr>
<td>Inclement weather conditions.</td>
<td>Consideration will be given to weather related conditions. If the wind, rain, or storm conditions, or other situations regarding hazardous weather occur, this operation will be temporarily suspended.</td>
<td></td>
</tr>
<tr>
<td>Persons falling from roof.</td>
<td>Employees working on the roof will utilize full-body harnesses with shock-absorbing lanyards attached to the existing anchorage points(s). The capacities were verified by our PE.</td>
<td>The qualified person for fall hazard control on this job is <strong>H. Lee</strong>.</td>
</tr>
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9

OBSERVATIONS ON CAUSATION MODELS FOR HAZARDS-RELATED INCIDENTS

INTRODUCTION

A safety professional who gives advice on avoiding, eliminating, or controlling hazards in any of the three elements in the practice of safety (preoperational, operational, and post-incident) must understand how hazards-related incidents occur to be effective. It is basic in problem solving to define and understand the problem, to analyze the cause-and-effect relationships of the subsets of the problem, to consider alternate solutions, to choose and apply the solutions, and to subsequently evaluate their efficacy.

This chapter addresses the need for safety professionals to adopt an incident causation model, a thought process based on a sound understanding of the hazards-related incident phenomenon and which, when applied, identifies the reality of the causal factors in the incident process.

PROFESSIONAL SAFETY PRACTICE REQUIRES ESTABLISHING AN ACCEPTED CAUSATION MODEL

Dr. Roger L. Brauer, Executive Director of the Board of Certified Safety Professionals, made the following comment about proving the validity of causation models:


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Good science requires that safety professionals do the validation work necessary to prove that what they propose, based on the causation models they have adopted, is effective and that real risk reduction is achieved.

Safety professionals apply differing and contradictory incident causation models, and the work of some of them is misdirected and ineffective. Professional safety practice requires that the advice given to avoid, eliminate, or control hazards be based on a sound incident causation model, a thought process, so that, through the application of that model, the desired risk reduction is attained. That will not occur if the causation model used does not require identifying the actual causal factors.

At the “Safety Technology 2000” symposium held by the American Society of Safety Engineers in June of 1995, many of the papers presented made specific reference to or alluded to an accident causation concept. From a review of those papers, it was obvious that the beliefs of safety professionals about concepts of hazards-related incident causation are far from consensus. These are the extremes in the variations expressed on incident causation in those papers:

- Ninety percent of accidents are caused by unsafe acts, and the proper solution for them is to modify employee behavior.
- Causal factors for 90% of accidents are systemic, and the proper solution for them is to modify the work system.

Assume that a given hazards-related incident is to be investigated. Safety professionals who have adopted, and give prominence and near exclusivity to, one or the other of those concepts would give greatly divergent remediation advice. The advice deriving from a narrow application of either approach would not address all of the causal factors, nor would the remedial actions proposed achieve the needed risk reduction.

If we who call ourselves safety professionals are to be truly perceived as professionals, we must resolve this matter of a generally accepted hazards-related incident causation model. A major study on this subject would be to our advantage.

Safety professionals investigating a given hazards-related incident should identify the same causal factors, allowing for an occasional exception. That is unlikely if their understandings of incident causation, and the thought processes they apply, have different and sometimes contradictory foundations.

ALL INCIDENT CAUSATION MODELS CAN’T BE RIGHT

Ludwig Benner, Jr. wrote this in the Conclusions to a study titled “Rating Accident Models and Investigation Methodologies,” which was
undertaken for the Occupational Safety and Health Administration (OSHA):

The number of conceptual accident models that drive government accident investigation programs seems unnecessarily diverse. Since they conflict, all models cannot be valid [p. 124].

In that study, Benner rated 14 different accident models and 17 accident investigation methods. The two accident models given the highest ratings were the “events process model” and the “energy flow process model”; the two accident investigation methods given the highest ratings were “events analysis” and the “MORT system” (MORT — management oversight and risk tree). Those models and methods are related to each other and are excellent references in developing an understanding of incident causation.

Advice given by many safety practitioners is based on the diverse and conflicting models studied by Benner, all of which cannot be valid.

INCIDENT CAUSATION MODELS REPRESENT GREAT DIVERSITY OF THINKING

Benner rated only the models and investigation systems used in 17 selected government agencies. At least 25 causation models are referenced in safety literature. They present a great diversity of thinking.

These are but a few of them: single event theory; chain of events theory; epidemiological models; systems theory models; multilinear events sequencing; human factors models; life change unit theory; motivation-reward satisfaction models; and the management oversight and risk tree model.

The following quotation from a letter received from Benner gives one indication of the divergence of thinking about accident and causation models:

Accident models and accident causation models involve two different areas of endeavor. The point is subtle, but in my view it is absolutely imperative to recognize the difference. Causation models purport to present cause and effects without identifying the phenomenon; no beginning and end of the phenomenon is indicated. Accident models on the other hand, deal descriptively with accidents as a process that has a beginning and an end, and the elements of that process. Please help me keep my models in the latter arena when quoting any of my work to ensure that it is not thrown into the causation model arena inadvertently.

Respectfully, an attempt will be made to comply with Benner’s request. Several references will be made to Benner’s work in this chapter since it
is considered to be important — either in thinking about accident models or in thinking about accident causation models.

SOME DEFINITIONS

As used in this treatise, causation means the act or agency of causing or producing an effect. Causal factors include all of the elements — the events, the characteristics of things, and the actions or inactions of persons — that contribute to the incident process. A model is to represent the theoretical ideal for the process through which hazards-related incidents occur, a process that requires determining when the phenomenon begins and ends.

RECOGNITION OF THE NEED FOR AN ACCEPTED CAUSATION MODEL

Several authors have recognized, with some frustration, the absence of and a serious need for a generally accepted accident causation model. Robert E. McClay addressed the subject in his paper titled “Toward a More Universal Model of Loss Incident Causation”:

The most obvious example of a weakness in the theoretical underpinning of Safety Science is the lack of a satisfactory explanation for accident causation. . . . Line managers in an organization can be forgiven for being cynical about safety when the reasons for the occurrence of accidents seem so obscure. . . . What is needed is an acceptable model that explains the occurrence of accidental losses of all types across the entire discipline of Safety Science [p. 16].

In MORT Safety Assurance Systems by William G. Johnson, this appears:

Improved models of the accident sequence would be helpful in understanding the dynamics of accidents and would be a basis for data collection. No fully satisfactory model has yet been developed, but many are promising and useful [p. 85].

Ted S. Ferry wrote this, in Modern Accident Investigation and Analysis:

The scientific literature on mishap analysis offers little insight into the process by which mishaps occur [p. 153].

Variations in current practice and the need for an accepted investigation methodology were mentioned by Benner in “Accident Investigations: Multilinear Events Sequencing Methods.” Benner writes:
Approaches to accident investigations seem as diverse as the investigators. The absence of a common approach and differences in the investigative and analytical methods used have resulted in serious difficulties in the safety field. Including barriers to a common understanding of the phenomenon, popular misconceptions about the nature of the accident phenomenon. The purpose of this paper is to call attention to the need to develop generally acceptable approaches and analysis methods that will result in complete, reproducible, conceptually consistent, and easily communicated explanations of accidents [p. 67].

DEFINING THE INCIDENT PHENOMENON

One of the difficulties to be overcome in establishing a causation model is determining what is to be encompassed and what terms are to be used in the description. This is from McClay:

An ideal model should be applicable across the full spectrum of Safety Science. It becomes necessary to use a broader term than “accident causation.” The term loss incident will be used to include any event resulting from uncontrolled hazards, capable of producing adverse, immediate or long term effects in the form of injury, illness, disability, death, property damage or the like [p. 16].

Safety professionals give many names to the incidents to which a causation model would apply: accidents, incidents, mishaps, near-misses, occurrences, events, illnesses, fires, explosions, windstorms, drownings, electrocutions, and so on. Pat Clemens, a prominent safety consultant, has said that the language used by safety practitioners lacks words to convey precise and understood meanings. It’s probable that the people with whom safety professionals try to communicate are baffled by the many terms used to describe hazards-related incidents.

As an example, it’s common in safety literature to designate as “incidents” or “near-misses” the events that do not result in harm or damage, and to designate as “accidents” those that do. Differentiation is based entirely on outcomes.

Severity potential for harm or damage should determine whether a hazards-related incident is to be given priority consideration. Categorizing incidents that result in harm or damage separately from those that do not, even though the results of the latter could have been severe under slightly different circumstances, too often results in misapplication of resources.

In the term “hazards-related,” it must be understood that hazards are to include any aspect of technology or activity that produces risk (Fischhoff, p. 217). A hazard is defined as the potential source of harm.
Hazards include the characteristics of things and the actions or inactions of persons that have the potential to harm or damage people, property, or the environment.

If a hazard is not avoided, eliminated, or controlled, its potential may be realized. Whatever names we use to identify those realizations—all of the types of events previously mentioned (incidents, near-misses, accidents, explosions, electrocutions, et al.)—they are all hazards-related incidents.

So, it is proposed that a new name be created to encompass all hazards-related incidents—HAZRINS. The term HAZRIN encompasses all incidents that are the realization of the potential for harm or damage, whether harm or damage resulted or could have resulted, for all fields of endeavor that are hazards-related.

THE CASE TO BE MADE HERE

To move the discussion forward, a case will be developed here in support of these premises:

- A practice of safety based principally on the many extensions of the causation model represented by the domino sequence developed by H. W. Heinrich that focus on the so-called unsafe act or human error as the principal causal factor will be ineffective in relation to the actuality of causal factors.

- W. Edwards Deming got it right in *Out of the Crisis* when he proposed that a very large majority of the problems in any operation are systemic, that they derive from the workplace and work methods created by management and can only be resolved by management, and that responsibility for only the relatively small remainder lies with the worker (p. 315).

- Extrapolating from Deming’s premise, a very large majority of the causal factors for hazards-related incidents will be systemic, and a small minority will be employee-focused. Nevertheless, all such causal factors must be appropriately considered.

- For almost all hazards-related incidents, even those that seem to be the least complex, there will be multiple causal factors, deriving from *less than adequate* policies, standards, or procedures that impact on workplace and work methods design, operations management, and task performance practices.

- A sound causation model for hazards-related incidents must identify and stress the significance of the design management aspects *and* the operations management aspects *and* the task performance aspects
of the causal factors; and that those aspects are interdependent and mutually inclusive.

CONCERNING CAUSATION MODELS BASED ON HEINRICHEAN PRINCIPLES

In the safety literature over many years, right up to the present, the predominant causation concept applied by safety professionals derives from the writings of H. W. Heinrich. His causation concept is represented by the “domino sequence.” (I still have my set of dominoes, which is over 50 years old.) A third edition of Industrial Accident Prevention by H. W. Heinrich, published in 1950, is the source of the following:

In the middle 1920’s, a series of theorems were developed which are defined and explained in the following chapter and illustrated by the “domino sequence.” These theorems show that:

1. industrial injuries result only from accidents,
2. accidents are invariably caused by the unsafe acts of persons or by exposure to unsafe mechanical conditions,
3. unsafe actions and conditions are caused by faults of persons, and
4. faults of persons are created by environment or acquired by inheritance.

From this sequence of steps in the occurrence of accidental injury it is apparent that man failure is the heart of the problem. Equally apparent is the conclusion that methods of control must be directed toward man failure [p. 1].

After presenting a graphic display of the domino sequence, this description is given of what each is to represent:

The several factors in the accident occurrence series are given in chronological order in the following listing:

1. Ancestry and environment
2. Fault of person
3. Unsafe act and/or mechanical or physical condition
4. Accident
5. Injury [p. 12]

The following is another Heinrichean premises, one that is still often cited by safety practitioners:

A total of 88 per cent of all industrial accidents... are caused primarily by the unsafe acts of persons [p. 17].
All of these excerpts from Heinrich’s text focus on the individual. The proposal is that in 88% of industrial accidents the principal causal factor is an unsafe act committed by an employee, who has “faults of persons” that derive from his or her ancestry and environment.

For years, many safety practitioners based their work on Heinrich’s theorems, working very hard to overcome “man failure,” believing with great certainty that 88% of accidents were primarily caused by unsafe acts of employees. How sad that we were so much in error.

Heinrich’s premises, and the several causation models that are based on them, are still the foundation of the work of many safety practitioners. Indeed, most causation models have focused on the behavior of the individual who is presumed to have acted unsafely. And many safety practitioners, in the prevention measures they propose, emphasize training, quality of leadership by supervisory personnel, behavior modification, and appropriate methods of discipline — a great range of activities directed toward the control of “man failure.” These solutions are to achieve a change in the performance of the employee who, when judged retrospectively, is deemed to have acted unsafely.

Use of Heinrich’s ideas has led to oversimplification and has encouraged identifying a single causal factor for incidents focusing on employee error. Johnson makes these statements about accident causation in *MORT Safety Assurance Systems*:

The notion of probable cause (singular) is embedded in much Federal legislation and in the popular mind. The singular cause is unsound, limits preventive results and should be rejected or avoided [p. 368].

Accidents are usually multifactorial and develop through relatively lengthy sequences of changes and errors. Even in the relatively well-controlled work environment, the most serious events involve numerous error and change sequences, in series and parallel [p. 74].

**UNSAFE ACT AND UNSAFE CONDITION ARE INAPPROPRIATE TERMS**

In the same text, Johnson questioned the appropriateness of the use of the terms *unsafe conditions* and *unsafe acts*:

These categories of errors are extensively used in accident data collection. However, the fact remains that concepts of unsafe conditions and unsafe acts are usually simplistic and definitions are variable from place to place.

During OSHA hearings and down to the present, testimony has been offered to the effect that 85% (or even 95%) of work accidents are due to unsafe
acts, only 15% due to unsafe conditions. The data are unreliable and incorrect, and their use is dangerous and misleading. The “unsafe act” mythology is so widespread as to be self-perpetuating. A change to such terms as error and error-provocative situations seems warranted [p. 50].

It is not good science to use terms that cannot be defined. Definitions of the terms unsafe conditions and unsafe acts that can withstand thorough inquiry are scarce. I believe that the terms unsafe act and unsafe condition should be eliminated from the vocabulary of safety professionals, to be replaced by terms such as causal factors or risk factors — which can be defined. Safety professionals should also cease using their dominoes or the falling domino idea: They are overly simplistic representations of incident causation.

Dr. Franklin E. Mirer, Director of the Health and Safety Department of the United Auto Workers, also questioned using the term unsafe acts as a causal factor during a speech (unpublished) he gave at an American National Standards Institute workshop:

Unfortunately, the debate about whether “unsafe acts” or “unsafe conditions” cause the majority of injuries persists. No evidence supports claims that “unsafe acts” predominate as causes of injuries.

Many of the models of causation of injuries and illnesses... are operator models which are sophisticated versions of “blame the worker” safety approaches.

The best opportunities for prevention are at the production system level, and may be called “Design in Safety.”

Often, the wrong advice is given when the causation model on which the practice of safety is based focuses primarily and almost exclusively on:

- The characteristics of the individual
- Unsafe acts being the principal causes of workplace incidents
- Corrective measures being directed principally toward effecting the behavior of the individual, to correct “man failure”

MOVING THE CAUSATION EMPHASIS TO SYSTEMS, PROCEDURES, AND THE WORK ENVIRONMENT

The definition of an accident contained in the original literature on MORT (management oversight and risk tree) indicated that an injury was preceded by sequences of planning and operational errors which (a) failed to
adjust to changes in physical or human factors and (b) produced unsafe conditions and/or unsafe acts.

But, there has been a significant and appropriate change in the MORT literature concerning the identification of causal factors. In a November 1994 publication titled *Guideline to Use of the Management Oversight and Risk Tree*, this appears under “Performance Errors”:

It should be pointed out that the kinds of questions raised by MORT are directed at systemic and procedural problems. The experience, to date, shows there are few “unsafe acts” in the sense of blameful work level employee failures.

Assignment of “unsafe act” responsibility to a work level employee should not be made unless or until the preventive steps of: (1) hazard analysis, (2) management or supervisory detection, and (3) procedures safety reviews have been shown to be adequate [p. 19].

This concept shifts the emphasis away from the employee and to systems and procedures, which only management can correct.

In *Techniques of Safety Management*, Dan Petersen expressed this view, in his seventh of the Ten Basic Principles of Safety, concerning individual behavior being a derivative of the work environment created by management:

In most cases, unsafe behavior is normal behavior; it is the result of normal people reacting to their environment. Management’s job is to change the environment that leads to the unsafe behavior [p. 35].

Petersen expanded on this thought later in his text and wrote, with significance, that:

Unsafe behavior is the result of the environment that has been constructed by management. In that environment, it is completely logical and normal to act unsafely [p. 35].

In the context given, just what is unsafe behavior, if it is logical and normal? Very few authors who use the term *unsafe act* define it, for a very good reason. It seems nearly impossible to arrive at a definition that is universally acceptable. And no attempt will be made to do so here.

If the environment that has been constructed—which derives from the design of the physical aspects of the workplace, or the design of the work methods, or operational and management influences—results in logical and normal behavior that is considered unsafe, it would seem
that a HAZRIN model should give prominent emphasis to the decision making out of which those environmental causal factors arose.

Doing so would move the emphasis in the practice of safety to decisions deriving from the organization’s culture, standards, and expectations that impact on systems, procedures, and the work environment, and away from outcomes such as unsafe acts.

ON WORK THAT IS ERROR-PROVOCATIVE

Alphonse Chapanis is exceptionally well known in ergonomics and human factors engineering circles, and his writings on avoiding the design of work that is error-provocative are often cited. These are excerpts from his chapter titled “The Error-Provocative Situation,” which is in the book *The Measurement of Safety Performance*:

In general, the probability of error increases when the job, the system, or the situation does the following:

- a. Violates operator expectations;
- b. Requires performance beyond what an operator can deliver;
- c. Induces fatigue;
- d. Provides inadequate facilities or information for the operator;
- e. Is unnecessarily difficult or unpleasant; or
- f. Is unnecessarily dangerous [p. 119].

It is illogical to conclude after an incident occurred that the principal causal factor was the unsafe act of a worker if the design of the workplace or the work methods is error-provocative. Systemic causal factors should be considered primary if the design of the work was error-provocative, or overly stressful, or if the immediate work situation encouraged riskier actions than the prescribed work methods. To identify the causal factors in such situations solely or emphatically as an “employee error” or as an “unsafe act” would be wrong and ineffective.

This is a serious subject. For incident causal factors that are actions or inactions of individuals, their so-called errors may be “programmed” into the work system created for them. And a causation model has to address the “programming” sources.

At least two entities, within the same organization, are giving courses that address the need to understand and compensate for “error-likely situations.” The following appears in the literature of The Process Safety Institute, ABS Consulting, on “Preventing Human Error” (Course 124):

Most system performance problems are caused by human error. Traditionally, these mistakes are blamed on careless, ill-trained or unmotivated
employees. However, the real causes of human mistakes are generally *error-likely situations* — situations in which a person has unintentionally been “set up” to make a mistake. These error-likely situations are created in the way we design, operate, and maintain our systems; manage our organizations; write our procedures; and conduct our training (See Reference listing for Email address).

Government Institutes is also a subsidiary of ABS Consulting. Government Institutes offers a course titled “Preventing Human Error — Learn to Identify and Correct System Problems That Cause Human Error.” Its descriptive literature says:

Eliminate “error-likely” situations through proper systems design, operation, and maintenance. Gain an in-depth understanding of why human errors occur. Learn how you can identify and work toward eliminating those persistent error-likely situations in your facility that are leading to system performance problems (See Reference listing for Email address).

Trevor Kletz, in his book *An Engineer’s View of Human Error*, makes the following statement:

Almost any accident can be said to be due to human error and the use of the phrase discourages constructive thinking about the action needed to prevent it happening again; it is too easy to tell someone to be more careful [p. 182].

In the Introduction to his book, Kletz focuses on and gives emphasis to engineers developing an understanding that humans may err and that the design of the workplace and work methods should contemplate error possibility:

The theme of this book is that it is difficult for engineers to change human nature and, therefore, instead of trying to persuade people not to make mistakes, we should accept people as we find them and try to remove opportunities for error by changing the work situation, that is, the plant or equipment design or the method of working. Alternatively, we can mitigate the consequences of error or provide opportunities for recovery.

A second objective of the book is to remind engineers of some of the quirks of human nature so that they can better allow for them in design [p. 1].

Since it may occur that the design, with respect to safety, is less than adequate, does not consider people as they are, or does not anticipate possible quirky behavior, then design aspects have to be an important
causal factor in a causation model. In his book, Kletz reviewed several accidents that “at first sight were due to human error” and discussed how they could have been prevented through improved design, construction, maintenance, and better management.

Kletz also suggested that we should do away with the term “human error,” since it gets in the way of inquiry to determine real causal factors (p. 182).

Focusing on individual error won’t necessarily lead to problem identification. Mark Paradies gives this view in his article titled “Root Cause Analysis and Human Factors”:

Using the word error (as in operator error) tends to focus attention on the individual involved rather on the problem. This was driven home one day when an investigator said, “I can’t list this as operator error — the operator wasn’t at fault, the procedure was written wrong” [p. 2].

Note that the procedure was written wrong! Focusing on improving the procedure is more effective than concentrating on individual behavior.

GIVING DESIGN CAUSAL FACTORS THEIR PROPER PLACE

I have written that the greatest strides forward with respect to safety, health, and the environment are being made through the design and engineering process. In that context, process includes the design and engineering of facilities, hardware, equipment, tooling, processes, layout, work stations, and the environment and, very importantly, the design of the operating methods and the procedures for accomplishing the work.

Most causation models that have influenced the work of safety practitioners have stressed the management and behavioral aspects of safety. A very large part of the work of safety practitioners has been directed toward improving managerial and personnel practices. Thus, the design and engineering implications have been somewhat ignored. Safety professionals have, largely, not been involved in design and engineering, where great opportunities for achievement exist.

This chapter pleads for an awareness of the need for a balanced approach that gives a proper emphasis within the practice of safety to causal factors deriving from design management, operations management, and task performance.

Because of their involvement with applied ergonomics and quality management, both of which are design-based, some safety professionals now take a different view of causal factors. As an example, they say that it became apparent to them that for many ergonomics-related injuries and
illnesses for which the causes were originally classified as unsafe acts of employees, they learned that the actual causal factors were matters of workplace and work methods design.

Ergonomics problems cannot be solved, nor can superior levels of quality be achieved, without a balanced approach that includes (a) design and engineering, (b) operations management, and (c) task performance considerations.

David M. DeJoy alluded to the inadequacy of prevention efforts centered on “predispositions, motivations, and attitudes of workers” in “Toward a Comprehensive Human Factors Model of Workplace Accident Causation”:

The essence of the contribution of human factors to safety is that machines, equipment, jobs, processes and environments can be safer if they are designed with the capabilities and limitations of the worker in mind.

While the predispositions, motivations, and attitudes of workers are important to safety performance, a comprehensive human factors analysis goes well beyond these considerations [p. 15].

Key phrases in the foregoing paragraph are “designed with the capabilities and limitations of the worker in mind” and “a comprehensive human factors analysis.” They suggest an anticipatory approach in the design phase and applying human factors concepts, going beyond “predispositions, motivations, and attitudes,” which are basic in the Heinrichian theorems and in the causation models that are extensions of them.

**RECOMMENDED READINGS**

It’s proposed that safety professionals can benefit from a review of the causation models on which their practices are based. For those who would undertake such an exercise toward the development of an acceptable causation model for hazards-related incidents, the following are recommended as minimal readings:

- “5 Accident Perceptions: Their Implications For Accident Investigation” by Ludwig Benner, Jr.
- *Guide to Use of the Management Oversight and Risk Tree*
- *Modern Accident Investigation and Analysis* by Ted S. Ferry
There are significant commonalities and differences in these publications. My intent is to select from them to support a logical thought process, and add my own views. To begin with, a hazards-related incident, a HAZRIN, should have a definition.

DEFINING A HAZARDS-RELATED INCIDENT — A HAZRIN

This definition of an accident appears in the Guide to Use of the Management Oversight and Risk Tree: “An accident is defined as unwanted transfer of energy or environmental condition because of lack or inadequate barriers and/or controls, producing injury to persons and/or damage to property or the process” (p. 2).

In Investigating Accidents With STEP: “An accident is a special class of process by which a perturbation transforms a dynamically stable activity into unintended interacting changes of states with a harmful outcome” (p. 27).

McClay says: “A loss incident is an unintentional, unexpected, occurrence which — without subsequent events — has the potential to produce damaging and injurious effects suddenly or, if repetitive, over a long period of time” (p. 17).

In MORT concepts, unwanted energy releases and hazardous environmental conditions are significant causal factors. McClay approaches the subject of unwanted energy releases and introduces “mass” as an element in this manner:

It can be deduced and has also been empirically shown, that the actual damaging and injurious effects are produced by the release, transformation or misapplication of energy. Since mass and energy are interconvertable, the release, transfer, or misapplication of mass should also be seen as having the potential to produce these same adverse effects [p. 18].

If there are no unwanted releases or transfers of energy, or exposures to hazardous environments, hazard-related incidents will not occur. That
statement applies to every incident category: overexertion (back injuries, strains, and sprains); slips; falls; caught in between; struck by an object; fires; electrocution; reaction to a chemical; and so on.

A HAZRIN causation model, then, should encompass unwanted energy releases and unwanted exposures to hazardous materials within the incident process.

Dr. William Haddon, Jr. was the first director of the National Highway Safety Bureau. He is credited with having developed the energy release concept. His thinking, as expressed in “On the Escape of Tigers: An Ecologic Note,” was that an unwanted energy release or an exposure to a hazardous environment can be harmful and that a systematic approach to limiting such a possibility should be undertaken (p. 45). That is the framework on which MORT (management oversight and risk tree) is built. Having knowledge of Haddon’s energy release concepts augments professional safety practice.

Benner, Ferry, Johnson, and McClay are valuable resources concerning the hazards-related incident phenomenon. These excerpts from their writings give an indication of their thinking.

For Benner in *Investing Accidents with STEP*:

An accident is a special class of process, by which a perturbation transforms a dynamically stable activity into unintended interacting changes of states with a harmful outcome. An accident is a special class of process because it begins and occurs during some other ongoing activity [p. 27].

Because accidents are composed of sets of individual events, all of which are interrelated, each event affects one or more actors and what they do next, changing their state. [Author’s note: Actors may be things or people.] The first event in the accident process is a perturbation or an undesired or unplanned change by someone or something within the planned process. That first disruptive event initiates a sort of cascading effect, culminating in some harm or damage [p. 31].

Benner stresses that interrelated and multiple events proceed on a time scale, displayed much like a musical score, and culminate in some outcome. Events in the sequence may occur on a single track or impact on other events on parallel tracks. Events sequences are to be plotted on parallel lines along a time scale, in accord with their place in the sequence.

In several of Benner’s writings, appropriate recognition is given to MORT as a foundational thought process. Johnson in *MORT Safety Assurance Systems* gives recognition to Benner’s research. For both, charting systems are used to graphically depict events contributing to a hazards-related incident, from the beginning to the end of the process.
McClay’s approach to causation is somewhat different but also has some similarity to Benner’s postulations and the bases on which MORT is founded. McClay indicates that:

Not all factors which contribute to a loss incident occur at the same time just before the incident occurs... causal factors can be placed into two groups with respect to the temporal nature of their occurrence... causal factors which exist or occur within the same specific time frame and location as the loss incident... called proximate factors... and causal factors which do not exist or occur within the same specific time frame and general location as the loss incident... called distal factors [p. 17].

McClay’s premise, as I interpret it, is that the “loss incident” may occur over time and that there may be a variety of causal factors involved. Thus, there is some continuity in what McClay, Benner, and Johnson have written.

Ferry, Benner, and Johnson stress the complexity of HAZRINS. Ferry wrote that:

It has been found that simple mishaps tend to be complex in terms of many causal factors with lengthy sequences of errors and changes leading to the various events. This makes it essential for the investigator to have a system, a methodology for breaking down the entire sequence of events into individual events with supporting information [p. 159].

Benner in *Investigation Accidents with Step* says:

It is the accident process which is complex and requires a detailed comprehension before it can be understood adequately to control the inherent safety problems [p. 64].

In MORT Safety Assurance Systems, as previously cited:

Accidents are usually multifactorial and develop through relatively lengthy sequences of changes and errors. Even in a relatively well-controlled work environment, the most serious events involve numerous error and change sequences, in series and parallel [p. 74].

Building on the foregoing, this definition of a hazards-related incident is now proposed:

A hazards-related incident, a HAZRIN, is an unplanned, unexpected process of multiple and interacting events, deriving from the realization of uncontrolled hazards, and occurring in sequence or in parallel, which is likely to result in harm or damage.
CAUSAL FACTORS DERIVE PRINCIPALLY FROM UPSTREAM DECISIONS

To prevent the initiation of these complex, multifactorial sequences that may result in harm or damage, “intervention” is proposed by many authors, very often concentrating on the identified unsafe act or condition. I suggest that to be most effective, intervention has to impact on the beginnings of things, on the upstream decision-making out of which a system is created.

An operating system, whatever the product made or the service provided, is a reflection of an organization’s culture, its values, and its sense of responsibility to its employees and to its community, all of which determine its design decisions for hardware, facilities, and the work environment; the work methods; and the management aspects of operations.

Management policies, organization, and commitment are shown together as one element in some causation models. One could argue that management commitment and involvement deserve separate and distinct consideration since they are the reflection and extension of the organization’s culture, from which all hazard prevention and control decisions derive.

An organization’s culture and its management commitment should stand as separate and sequential items in a causation model. Aspects of less-than-adequate performance in the design aspects, the management and operational aspects, and task performance aspects of safety derive from the culture and the management commitment.

First evidence of an organization’s culture and management’s commitment with respect to safety is displayed through its design and engineering decisions. Where hazards are given the required consideration in the design and engineering process, a foundation is established that gives good probability to avoiding hazards-related incidents.

SUMMARIZING THESE OBSERVATIONS

And just what observations can be made from all this? If safety professionals choose to examine their causation models, which are the basis of the advice they give, this thought process is proposed for consideration, as a beginning:

1. Professional safety practice requires that the advice given be based on a sound hazards-related incident causation model so that, through the application of that advice, hazards are effectively avoided, eliminated, or controlled and risks are reduced.
2. A hazards-related incident, a HAZRIN, is an unplanned, unexpected process of multiple and interacting events, deriving from the realization of uncontrolled hazards and occurring in sequence or in parallel, which is likely to result in harm or damage.

3. Hazards-related incidents, even the ordinary and frequent, are complex with respect to the multiple and interacting causal factors that may contribute to them.

4. Unwanted releases of energy and exposures to hazardous environments are fundamental in the occurrence process for hazards-related incidents.

5. Causal factors include all elements of technology or activity — the characteristics of things, the actions or inactions of persons, and the events — that contribute to the incident process.

6. A HAZRIN causation model should:
   - Recognize that an organization’s culture is the primary influence concerning the development of hazards.
   - Give separate recognition to management commitment as the extension of the organization’s culture, and as the source of the decision-making affecting the avoidance, elimination, and control of hazards.
   - Move the emphasis of the practice of safety to the origins of decision-making.
   - Emphasize that a balance of considerations is needed for causal factors deriving from less-than-adequate policies, standards, or procedures that impact on the design management, operations management, and task performance aspects of safety.

   It is a necessity that the advice given by safety professionals be based on an understanding of the reality of causal factors and actually serves to attain a state for which the risks are judged to be acceptable. I will develop a systemic causation model for hazards-related occupational incidents that represents the thoughts set forth in this chapter.

REFERENCES


INTRODUCTION

This causation model for hazards-related incidents recognizes

- The impact an organization’s culture has on causal factor development, the evidence of the culture being its policies, standards, procedures, and accountability systems, and their implementation
- The need for a balanced, systemic approach that appropriately addresses design management, operations management, and task performance causal factors

This model promotes inquiry to determine the upstream sources from which causal factors originate. Its use requires applying basic problem-solving techniques to identify the reality of causal factors. Whether an organization has two or 2,000,000 employees, the model is applicable.

Most causation models have minimized less than adequate design and engineering concepts and outcomes as a source of causal factors for hazards-related incidents, with one significant exception. That exception is MORT — the management oversight and risk tree. Concepts on which MORT is based have influenced my thinking greatly, and I am indebted to all who worked on the creation and betterment of MORT.

Unfortunately, the causation model I suggest cannot be presented simply. As incident causation can be complex, so also must a model depicting
the incident phenomenon be somewhat complex. Nevertheless, I hope that the ideas on which the model depicted in Figure 10.1 is based are presented clearly.

Certain assumptions were made in the development of this hazards-related incident causation model, which

1. Recognizes that an organization’s culture is the primary influence concerning the existence of hazards.

2. Gives separate recognition to management commitment or noncommitment to safety as an extension of an organization’s culture, and as the source of the management decision-making effecting the avoidance, elimination, or control of hazards.

3. Moves the emphasis of the practice of safety to the origins of decision-making, rather than on outcomes.

4. Emphasizes that a reasoned approach is needed for the identification of causal factors deriving from less than adequate policies, standards, procedures, and accountability systems, or their implementation practices, that impact on the aspects of safety, encompassing
   a. design management,
   b. operations management, and
   c. task performance.

5. Recognizes unwanted energy releases or exposures to hazardous environments as necessary to the occurrence of hazards-related incidents.

6. Establishes that hazards-related incidents, even the ordinary and frequent, are complex and will have multiple and interacting causal factors contributing to their occurrence, acting sequentially or in parallel.

**DEFINITIONS**

To promote an understanding of this systemic, causation model, meanings are given here of the terms *incidents, hazards, HAZRINS, model, causation, causal, factors, and causal factors.*

*Incidents* as a term is to encompass all hazards-related events (HAZRINS) that have been referred to as accidents, mishaps, near misses, occupational illnesses, environmental spills, losses, fires, explosions, et cetera.
A Systemic Causation Model for Hazards-Related Incidents

The culture of an organization is established by the board of directors and senior management.

Management commitment or noncommitment is an expression of the culture and demonstrates the system of expected behavior.

Causal factors may derive from the culture and management practices when safety policies, standards, procedures, or the accountability system, or their implementation, are Less Than Adequate with respect to:

- Design Management for Operations
- Task Performance

**Task Performance causal factors**

- May originate from less than adequate design or operations practices
- or
- May be errors of commission or omission

Multiple causal factors derive from Less Than Adequate design, operations, and task performance practices.

A hazards-related incident occurs

There are unwanted energy flows or exposures to harmful environments. A person or a thing in the system, or both, is stressed beyond the limits of tolerance or recoverability.

The incident process begins with an initiating event in a series of events. Multiple interacting events occur sequentially or in parallel.

Harm or damage results, or could have resulted if exposures had been different.

Figure 10.1. A systemic causation model for hazards-related incidents.
All of the incidents to which this causation model applies derive from hazards. There are no exceptions. Hazards include all aspects of technology and activity that produce risk.

A *hazard* is defined as the potential for harm: Hazards include the characteristics of things and the actions or inactions of persons.

A hazards-related incident, a HAZRIN, is an unplanned, unexpected process of multiple and interacting events, deriving from the realization of uncontrolled hazards and occurring in sequence or in parallel, that is likely to result in harm or damage.

A *model* is to represent the theoretical ideal for the process through which hazards-related incidents occur, a process that requires determining when the phenomenon begins and ends.

*Caustion means* the act or agency of causing or producing an effect. *Causal* means of, constituting, or implying a cause. *Factor* means one of the elements contributing to a particular result or situation.

*Causal factors* include all of the elements — the events, the characteristics of things, and the actions of inactions of persons — that contribute to the incident process.

**PREMISES ON WHICH THIS CAUSATION MODEL IS BASED**

A. An organization’s culture determines the level of safety attained.

B. Management commitment or noncommitment to safety is an expression of an organization’s culture, an expression of its system of expected behavior.

C. Policies, standards, and procedures concerning safety, along with their implementation and accountability systems—all of which derive from the organization’s culture and the management commitment or noncommitment to safety—*may be*

1. *Less than adequate* with respect to hazard analyses and risk assessment processes, for the identification, avoidance, elimination, and control of hazards.

2. *Less than adequate* for design and engineering management concerning:

   a. Facilities  
e. Materials
   b. Hardware  
f. Layout and configuration
   c. Equipment  
g. Energy control/substitution
   d. Tooling  
h. Environmental concerns
3. *Less than adequate* for Operations Management concerning

- a. Work methods
- b. Personnel selection
- c. Supervision
- d. Personnel motivation
- e. Training
- f. Work scheduling
- g. Management of change
- h. Maintenance
- i. Investigations
- j. Inspections
- k. Personal protective equipment

D. *Less than adequate* design practices may be the direct source of incident causal factors, or may lead to task performance causal factors.

E. *Less than adequate* operations practices may be the direct source of incident causal factors, or may lead to task performance causal factors.

F. *Less than adequate* task performance may be the direct source of causal factors, consisting of

- a. Errors of commission or
- b. Errors of omission

G. Because of the multiple causal factors that derive from *less than adequate* design management and operations management and task performance, a hazards-related incident may occur.

H. Harm or damage results from the incident, or could have resulted if the exposures had been different.

**SUPPORTING DISCUSSION**

In this supporting discussion, the influence of system safety concepts will be evident, as will the concepts on which MORT (management oversight and risk tree) is based.

**Organizational Culture**

An organization’s culture consists of its values, beliefs, legends, rituals, mission, goals, performance measures, and sense of responsibility to its employees, to its customers, and to its community, all of which are translated into a system of expected behavior.

The Board of Directors and the senior management obtain, as a derivation of the organization’s culture, the hazards-related incident experience that it establishes as acceptable. For the personnel in the organization, what is “acceptable” is their interpretation of the reality of what management does, which may differ from what management says.

When what is acceptable to the Board of Directors and to senior management concerning safety is *less than adequate* in relation to the risks
faced by the organization, causal factors for incidents may derive, then, from the organization’s culture.

Management Commitment or Noncommitment to Safety

An organization’s culture is translated into a system of expected behavior. Management commitment or noncommitment to safety is an expression of the culture and demonstrates the system of expected behavior. All aspects of safety, favorable or unfavorable, derive from that commitment or noncommitment.

Where management commitment to safety is solid, management achieves an understanding by what it does that all in the organization are to manage their endeavors with respect to hazards so that the risks deriving from those hazards are acceptable.


The appropriateness or inappropriateness of safety policies, standards, procedures, and accountability systems, along with their implementation, derives from management’s commitment or noncommitment to safety. When such are less than adequate, causal factors may originate from them.

Hazard Analysis and Risk Assessment

Using hazard analysis and risk assessment methods is vital in achieving an acceptable risk level for the design, the operations, and the task performance aspects of safety.

A hazard analysis is a process that produces responses to these questions:

- What are the characteristics of things and the actions or inactions of persons that present a potential for harm or damage to people, property, or the environment?
- Can the potential be realized?
- Who and what are exposed to harm or damage?
- What is the frequency of endangerment?
- What will be the severity of harm or damage if the potential is realized?

A risk assessment is an analysis that addresses both (a) the probability of a hazards-related incident occurring and (b) the severity of harm or damage that may result. Effective application of hazard analysis
and risk assessment methods results in hazards being identified, avoided, eliminated, or controlled in the design or redesign process.

In \emph{MORT Safety Assurance Systems}, William G. Johnson got it right when he wrote:

Hazard identification is the most important safety process in that, if it fails, all other processes are likely to be ineffective [p. 245].

Causal factors resulting from \emph{less than adequate} hazards analyses and risk assessments must be recognized for their significance. For new facilities or modified systems, such inadequacies result in hazards being brought into the work place, inadvertently. For existing operations, failure to identify causal factors when tasks or operations are reviewed or incidents are investigated results in ineffective hazards management.

\textbf{Design Management}

Strong emphasis is given in this causation model to the causal factors that arise out of \emph{less than adequate} design management practices. As the term is used here, design encompasses all processes applied in devising a system to achieve results.

An organization’s culture regarding safety is outwardly demonstrated through its initial design decisions and subsequent redesign decisions that determine what the facilities, hardware, equipment, tooling, materials, layout and configuration, and work environment are to be.

I admit to being a disciple of W. Edwards Deming, who was world-renowned in quality management. My interpretation of Deming is that he stressed again and again in \emph{Out of the Crisis} that processes must be designed, or redesigned, to achieve superior quality if such performance is desired, and that superior quality cannot be attained otherwise. And the same principle applies to safety.

Too much emphasis cannot be given to the causal factors that derive from \emph{less than adequate} design decisions. If hazards are not adequately avoided, eliminated, or controlled in the design process, multiple causal factors will originate from those inadequacies.

\textbf{Operations Management}

This causation model puts a major focus on \emph{less than adequate} management practices that impact on the operations system as a source from which causal factors derive. A borrowing of significance is taken from the \emph{Guidelines to Use of the Management Oversight and Risk Tree} to emphasize focusing on the system:
It should be pointed out that the kinds of questions raised by MORT are
directed at systematic and procedural problems. The experience, to date,
shows that there are few “unsafe acts” in the sense of blameworthy work
level employee failures. Assignment of “unsafe act” responsibility to a
work level employee should not be made unless or until the preventive
steps of: (1) hazard analysis, (2) management or supervisory detection, and
(3) procedures safety reviews have been shown to be adequate [p. 19].

Surely, employees should be trained and empowered up to their capa-
bilities, and procedures should be established for employees to make
contributions to safety. But, employees should not be expected to do what
they cannot do. Nor should the focus be on their behavior (the so-called
unsafe act) when the causal factors for hazards-related incidents derive
principally from less than adequate design or operations management.
Employees are greatly limited by the work system—established by and
under the control of management.

While the focus is on the operations system, created by management
and which only management can change, it is not intended that the
significance of employee-centered, task performance causal factors be
diminished.

So, causal factors originate when operations practices are less than
adequate concerning work methods; personnel selection; supervision;
personnel motivation; training; work scheduling; management of
change; maintenance; investigations; inspections; and personal protective
equipment.

**Relationships: Design Decisions, Operations Practices, and
Task Performance**

The impact that design decisions and the prescribed management and
operations practices have on task performance must be recognized.
That premise reflects the work of Dr. R. J. Nertney, who developed the
“Nertney Hazard Analysis Wheel,” to which Johnson refers in *Mort Safety
Assurance Systems*. Nertney produced:

> A simple, provocative method of examining the successive phases of hard-
> ware—procedure—personnel development and also examining the all-
> important interfaces between those three elements [p. 255].

Think about it: Work methods prescribed to get a job done are deter-
mined largely by the design decisions made concerning facilities, hard-
ware, equipment, and layout and configuration, et cetera. That applies,
whatever the complexity of the tasks—cutting an invoice, or making
airplanes. Standards for the selection of personnel and their training must match the hardware and procedure decisions.

When the match of the system design and operations methods and personnel practices (selection, training, et cetera.) is less than adequate, causal factors attributable to the mismatch will arise.

Also, while less than adequate design decisions and less than adequate operations practices may be the direct source of incident causal factors, they may also lead to task performance causal factors. Causal factors will derive directly from design decisions or operations practices if the design of the workplace, or the work methods

- is overly stressful;
- induces fatigue;
- is error-provocative;
- promotes riskier behavior than prescribed work methods;
- is unnecessarily difficult or unpleasant;
- is unnecessarily dangerous;
- requires “jerry rigging” for job accomplishment; or
- does not allow easy access for the work to be done.

**Because Multiple Causal Factors Develop — A Hazards-Related Incident May Occur**

It is the exceptional hazards-related incident that does not have multiple causal factors. This is the process as causal factors develop and an incident occurs.

- There are unwanted energy flows or exposures to hazardous environments. (If there are no unwanted energy flows or exposures to hazardous environments, no incidents can occur that result in harm or damage.)
- A person or thing in the system, or both, is stressed beyond the limits of recoverability.
- The incident process begins with an initiating event in a series of events.
- As the incident process continues, multiple and interacting events occur, sequentially or in parallel.
- The series of events comes to an end.

A hazards-related incident, then, is not a single event, but a group of dynamic actions, or sets of interacting or interconnecting events.
Incident Outcome

Harm or damage to people, property, or the environment results from the incident, or could have resulted if the exposures had been different.

REFERENCES


INTRODUCTION

Why a study of the quality of incident investigation? There are three major elements in practice of safety: preoperational (in the design process); in the operation mode (integrated within a process of continuous improvement); and post-incident (after a hazards-related incident has occurred).

In this third and important element, competent investigation of hazards-related incidents is vital. Effective safety practice requires that actual causal factors — the hazards and events that contributed to the incident process — be identified, evaluated, and eliminated or controlled.

Incident investigation, done well or superficially, reflects the reality of an organization’s culture concerning safety. The quality of incident investigation gives significant messages to employees as they interpret the substance of what management does in relation to what management says.

Thorough incident investigation and follow through with remedial actions support a culture that gives importance to safety. Poorly done incident investigations give employees reasons to doubt management’s sincerity with respect to safety.

HAZARD ANALYSIS IS THE MOST IMPORTANT SAFETY PROCESS

This statement, with which I emphatically agree and often repeat, comes from MORT Safety Assurance Systems by William G. Johnson.

Hazard analysis is the most important safety process in that, if that fails, all other processes are likely to be ineffective [p. 245].

If hazard identification and analysis do not relate to actual causal factors, the resulting corrective actions proposed will be misdirected and ineffective. A superior quality of incident investigation is required to identify and evaluate actual causal factors so that appropriate corrective actions can be taken.

DATA GATHERED FOR THE FIRST OF THREE STUDIES

To study the quality of incident investigation as actually performed, a collection was made of reports completed by supervisors and investigation teams after injuries and illnesses had been reported. From 37 locations of 11 organizations, using 15 different forms, 537 investigation reports were collected and reviewed. (With emphasis, I state that the study I made would not meet the modeling and methods requirements of scientific inquiry.)

HIGHLIGHTS OF THE STUDY

General observations deriving from the study follow. They are just that — observations resulting from a subjective review of a limited number of reports, the 537 reports received. I do suggest that these observations deserve a broader consideration through a study that would meet the requirements of good science since the subject — incident investigation — is so important.

1. Using a scale for quality of investigations of 1 to 10, with 10 being best, organization scores ranged from a high of 8 to a low of 2. For the entire study, 5.5 is the weighted overall score.
2. Investigation of incidents is well done in those entities where the culture includes management accountability for hazards-related results.
3. Variations in structure and content requirements of incident investigation forms were extensive.
4. Good incident investigation cannot be achieved without training and repeated training.
5. Where supervisors had participated in job hazard analyses, they seemed to have a better understanding of causal factors and did a more thorough job of incident investigation.
6. General information entries (name, social security number, occupation, etc.) and incident descriptions were usually the most complete parts of reports.
7. Some of the incident report forms collected direct the person completing the form to select the worker’s unsafe act or an unsafe condition as the causal factor, in that order. Having selected an unsafe act as the causal factor, the person completing the report often stops there.

8. Although not necessarily intended, such report formats lead to identification of a single causal factor, usually the unsafe act, rather than stressing the concept of multiple causation. Sometimes — but only sometimes — a contributory causal factor was also identified.

9. It is probable that supervisors, who make only one, two, or three incident investigations a year, don’t fully understand the descriptions of the various causal categories given in investigation forms.

10. Form content requirements seldom lead to examinations of the design of the workplace or the design of work methods.

11. For approximately 38% of the reports reviewed, entries suggested that further inquiry should have been made with respect to design of the workplace or of the work methods.

12. In the one instance reviewed in detail, cause codes entered for subsequent computer analysis did not match the contents of the investigation reports.

13. Injury type and incident type codes were close to reality.

14. For many reports, plausible causal factors could not be identified.

Some organizations are doing a good of incident investigation. Reports received from them were commendable, proving that effective incident investigation can be achieved. In other companies, what is accepted indicates (a) inadequate knowledge by those completing investigations and (b) an absence of management accountability for the quality of incident investigation. Completion of reports in those instances is obviously a perfunctory exercise, with little value.

Structure and content variations in incident investigation forms were extensive, and precise and equivalent evaluations could not be made in report reviews. As an example, one of the simplest forms consisted in its entirety of these questions. What happened? Why did it happen? What should be done? What have you done so far? How will this improve operations?

**METHODOLOGY AND SCORING**

Using subjective judgments, scorings of these individual subjects were first given where possible:
General information
- Incident descriptions
- Causal factor determinations
- Corrective actions proposed

Then, the entire incident report was scored. Subsequently, a composite score for the entity’s incident investigation system as a whole was computed.

A quality score of 10 was best, using a 1 to 10 scale. All scores were rounded to whole numbers. Composite scores ranged from a high of 8 to a low of 2, with an overall weighted score of 5.5 for the entire study. Table 11.1 shows the range of the scoring for the 11 entities whose reports were reviewed.

Table 11.1. Composite scores

<table>
<thead>
<tr>
<th>Entity</th>
<th>Scores</th>
<th>Overall weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>5.5</td>
</tr>
</tbody>
</table>

| Entity xxxx xx | Scores x x x x x x x |

**COMMENTS BY SAFETY PROFESSIONALS**

Discussions of achievements with safety professionals whose organizations had top scores did not produce any surprises. Incident investigation for hazard identification and analysis gets done best where the organization’s culture includes accountability for superior performance. Here is an aggregate list of the comments made in discussions with safety professionals in those entities with the best incident investigation systems:

- A focus on safety in those entities comes from the top, as a reflection of the organization’s culture.
- If incident investigation is important to the boss, if it is a part of the accountability system, it will be well done. Where that is the case, safety professionals will receive requests for help from all levels of management.
- For everyone from the senior vice president down to the floor supervisor, the annual performance review includes safety results.
- Safety performance is an element scored in the bonus program.
- There is an annual competition on safety performance. Statistics produced monthly are treated seriously.
Only one award made within a company has the president’s name on it: the safety achievement award. Presentation of the award is made by the president at a significant social event.

For every recordable incident, the location manager is required to submit a report to the group vice president.

At all manufacturing and warehousing locations, there is a job hazard analysis for every job.

Supervisory personnel cannot do a good job of investigation if they have not had the necessary training. Thus, incident investigation training is given and repeated.

**REPORT TITLES**

Incident investigation reports received had a variety of titles, although some were identical. They come under these names, which in themselves have significance:

- Investigation and Findings of Injury/Illness
- Supervisors Report of Accident Investigation
- Mishap Report
- Accident Investigation Report
- Injury/Illness Report
- Incident Investigation Report: Personal Investigation
- Supervisor’s Investigation Report
- Occupational Injuries or Illnesses Report

**GENERAL INFORMATION REQUIRED**

General information entries were usually well-completed. A summary of entries required by all forms include:

- Name
- Social security number
- Sex
- Clock number
- Shift/time
- Marital status
- Date of birth
- Address
- Department/division/sector
- Occupation/job title
- Seniority date/company service
- Number of years/months on job
- Date of accident/illness
- To whom was accident reported
- Where sent/hospital/home/other
- Describe medical treatment
- Did employee die
- Basic cause code
204 INCIDENT INVESTIGATION: STUDIES OF QUALITY

Contributory cause code  Accident code
Injury/illness code  Place of accident
Was place of accident on employer’s premises

INCIDENT DESCRIPTIONS

Incident descriptions were often the most complete parts of reports. In many instances, incident descriptions were the only complete parts of reports. It is easier, obviously, to describe what happened than it is to determine causal factors and what corrective actions should be taken.

QUALITY OF CAUSAL FACTOR DETERMINATION

Variations in the quality of causal factor determination were extreme. Of the 15 forms received, 10 direct the person who completes the form to first identify the unsafe act of the employee. That requires seeking evidence of the “man failure,” which is foundational in “Heinrichean” premises.

After a review of his “theorems,” developed in the 1920s and illustrated by the “domino sequence,” H. W. Heinrich wrote this in the 3rd edition of Industrial Accident Prevention. From this sequence of steps in the occurrence of accidental injury it is apparent that man failure is the heart of the problem. Equally apparent is the conclusion that methods of control must be directed toward man failure [p. 2].

It is a prominent practice, whether intended or not, to put the principal responsibility (not blame) for the incident on something the employee did or did not do—that is, to seek evidence of “man failure.” Some of the forms also asked that unsafe conditions be recorded. Sometimes, but seldom, they contain references to design and systems shortcomings.

In those organizations where incident investigation is done well, supervisors who obviously had training in incident causation and who were familiar with job hazard analysis procedures would frequently go beyond the form requirements. It was not unusual for those supervisors to pose questions about and seek help on the design of the workplace and on the design of work methods. It regularly occurred in those organizations that supervisors would record on incident investigation reports something like “this job needs a new job hazard analysis.”

For about 38% of the reports received, incident descriptions and discussions of causal factors suggested that further inquiry should have been
made as respects design of the workplace or design of work methods. In far too many cases where recordings indicated that a review of workplace design or work methods design might be beneficial, unsafe acts of employees were selected as the primary incident causes. And the corrective actions proposed were to obtain behavior modification.

Of the 15 variations of incident investigation reports received, six promote an overly simplistic and inappropriate approach to causal factor determination. They reflect this instruction, although somewhat ancient, given in a publication of the American National Standards Institute, the *Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries*—Z16.2.

It is recognized that the occurrence of an injury frequently is the culmination of a sequence of related events, and that a variety of conditions or circumstances may contribute to the occurrence of a single accident. A record of all these items unquestionably would be useful to the accident preventionist.

Any attempt to include all subsidiary or related facts about each accident in the statistical record, however, would complicate the procedure to the point of impracticality. The procedure, therefore, provides for recording only one pertinent fact about each accident in each of the specific categories or classifications.

Usually, there are multiple causal factors for hazard-related incidents. Yet, there seems to be a desire to retain an age-old theme of simplicity. If people who make incident investigations are directed to select “one pertinent fact . . . in each of the specific categories,” more than likely that is what they will do. And the value of the investigation is diminished. Where incident investigation is done best, multiple causal factors are sought, and it is the exception when only a single causal factor is recorded.

Generally, few supervisors did a good job of ergonomics problem identification. Although there has been an emphasis on ergonomics as a significant aspect of the practice of safety, that emphasis was not seen in the content of the incident investigation reports reviewed.

It is a too common practice that personnel with “safety” in their titles place their signatures, indicating acceptance and approval, on incident investigation reports that are far from adequate, particularly concerning causal factor determination.

Surprisingly, the terms “careless” or “carelessness” or “should have been more careful” appeared as causal factors only seven times in 537 reports.

Although “employee empowerment” has been prominent in contemporary management literature, there were no indications in this study that
personnel other than supervisors or investigation teams were completing incident investigation reports.

CAUSE CATEGORIES USED IN FORMS MAY NOT BE UNDERSTOOD

Terms such as *basic cause*, *contributory cause*, *immediate cause*, and *management cause* appear in the forms. Definitions on the forms were understandably brief. Some were confusing. I was not always certain of their meanings. Entries on the forms indicate that supervisors, who may complete one, two, or three incident investigation reports a year, do not understand what the terms mean.

CAUSAL FACTOR CODES MAY NOT MATCH REPORT CONTENT

Five of the 15 forms received require entry of codes for causal factors, incident types, and injury types. When computer analysis programs first became available, I had been an aggressive promoter of the entry of causal factor codes for later analysis. That proved to be inappropriate because accurate causal data are often not included in supervisors’ investigation reports or in insurance claims reports. Now, I recommend that computer-based analysis systems not include provision for causal data entry. They serve analysis purposes quite well for types of accidents, injury types, parts of body injured, and identification data (location, age, job title, etc.).

For a group of 121 reports, basic cause codes were entered in the boxes for such codes, all of them employee action-related, as shown in Table 11.2.

*Basic cause codes selected did not match the written entries on the forms.* In the entities that submitted those reports, supervisors were doing a better job of identifying possible causal factors than the codings indicated. Corrective actions taken were in greater depth than would be required by the cause code entries. Computer runs would identify, erroneously,

<table>
<thead>
<tr>
<th>Table 11.2. Cause code entries</th>
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<tbody>
<tr>
<td>28% Failure to follow established procedure</td>
</tr>
<tr>
<td>27% Haste, inattention, shortcut</td>
</tr>
<tr>
<td>6% Improper use of equipment, tools, or materials</td>
</tr>
<tr>
<td>61%</td>
</tr>
</tbody>
</table>
the principal causal factors based on the cause code entries. Making an assumption that the data are factual would result in a misdirection of efforts.

Safety professionals who have instituted systems requiring the entry of cause codes on investigation reports for which computer summaries are produced might want to conduct a similar exercise to determine whether the computer output matches reality. I suggest a close look at the causal data being obtained, along with a realistic assessment of what can be achieved.

**INJURY TYPE AND INCIDENT TYPE CODES**

Injury type and incident type codings were at a much higher accuracy level than codes for causal factors. Incident type and injury type analyses would provide information from which to commence further inquiry.

**INVESTIGATIONS BY TEAMS WERE SUPERIOR**

In some entities, it is required that an incident investigation team be selected and gathered if the results of the incident were serious or could have been serious under other circumstances. Reports prepared by investigation teams (12 of them were received) were a pleasure to read. Everyone reflected an understanding of multiple causation and pursued several routes in causal factors determination and in selecting corrective actions.

**OBSERVATIONS FROM A SECOND STUDY**

Later, while researching for Chapter 24, “Measurement of Safety Performance,” I observed that companies with superior OSHA rates also had lower workers compensation costs than did other companies. I then wanted to determine whether the quality of investigation of hazards-related incidents would also be superior. (For this second study, it must also be said that the methodology used would not stand the test of good science.)

The public perception is that the operations of the industry I chose for this inquiry, the chemical industry, are high hazard even though its average OSHA rate is commendably low. For the six companies that provided the 328 investigation reports I reviewed, the range of their OSHA recordable rates is 1.6 to 2.9. For their lost work day case rates, the range is 0.6 to 1.3. Comparable rates for private industry, overall, were 8.5 for OSHA recordables and 3.8 for lost work day cases.

With just but a bit of refinement, the scoring system used for the quality of investigations was the same as that used in the first study, a scale of
1 to 10, with 10 being highest. Entity scores in the second study ranged from a low of 7.4 to a high of 8.7. Entity scores in the original study had a low of 2 and a high of 8. Overall, the weighted score was 8.1 in the second study: it was 5.5 in the first study. Obviously, outcomes were significantly different.

In each of the six companies, a sound safety culture has existed for several years. Management personnel at all levels are held accountable for hazards-related results.

While very few of the incident reports collected in the first study were completed by investigation teams, every report submitted in this second study by three companies was a team effort. In the other three companies, teams are assigned to investigate every OSHA recordable incident.

Since that seemed a bit much in relation to what is done elsewhere, I asked a safety director how the activity was supported in these times of lean staffs. His answer went like this: “We know that the time expended may seem excessive, but the procedure gets a lot of people involved and that reinforces their belief that in our company safety is truly important. Thorough incident investigation is a part of our culture.”

For most reports, causal factors identified were plausible, with a good balance between consideration of design and engineering practices, operation practices, and task performance. Citing multiple causal factors was prevalent. References to written job procedures deriving from job hazard analyses or other job study methods were frequent. As in the original study, supervisors who had participated in job hazard analyses had a better understanding of causal factors and did a more effective job of investigation.

Seldom was there a mention of ergonomics-related causal factors in the reports collected for the original study. In this second study, extensive knowledge of ergonomics is displayed. Obviously, the ergonomics awareness and training initiatives undertaken have had an effect.

While this study cannot be considered conclusive, it is probable that a further and more scientific study would establish that effective incident investigation reaps many benefits — as a productive means of eliminating or controlling hazards and achieving fewer injuries and illnesses, as an augmenting factor in attaining reduced workers compensation costs, and as a supporting element within a sound safety culture.

A THIRD STUDY

In preparation for presentations I was to make early in 2002, I asked that 40 randomly selected incident reports be sent to me by the entity that had
engaged me. This is a very large company. A drive initiated by the board of directors was underway to improve incident experience, and since it was known that incident investigation was not well done, I was to address that subject.

My analysis confirmed the impressions of those who sent me the reports. Quality of incident investigation varied from very poor to very good. Variations were extreme. Using the scoring system previously applied, a 5.1 score was given.

I conducted workshops on selected incident reports they had sent me. To help the attendees explore the reality of accident causation, they were given copies of the exhibit “A Systemic Causation Model for Hazards-Related Incidents” shown in Chapter 10. It works as a reference base. The point to be made was this: The employees in that entity could do a good job of investigation if management so required.

At the locations where the quality of investigations was good, it was determined that safety professionals had made much of the subject in their giving counsel, and management insisted on the job being well done. Also, as was found in previous studies, incident investigations conducted by teams produced exemplary reviews of causal data, in depth.

After one of my presentations, an attendee spoke to me about the poor quality of incident investigation reports that reached her desk. I had spoken of the need to emphasize systems causal factors and to get away from the excessive concentration shown in some of their investigation reports on what the worker had done in the accident process. She said that almost all of the investigation reports that came to her desk suggested a corrective action that would improve worker behavior, and stopped there.

I asked her what her job was. She said she was the plant manager. And I tactfully said to her that she was the problem. After brief discussion of the pattern of expected behavior with respect to incident investigation that had developed, she agreed that it was her place to set higher standards of acceptability. She also said that she knew how to do that. I suggested that she take up my principal theme, which was this:

Management, if you want incident investigation to be done well, you can have it; all you need to do is hold the people who report to you responsible for doing it well. But, understand that if it’s not done well at your location now, you will have to achieve a culture change to get major improvement.

In that entity, the guidelines for incident investigation are well written, and there is adequate safety staff. As this entity found, it’s easier to write good procedures than it is to get them applied. And they will be well applied only if that is a part of management’s accountability system.
Incident frequency in that entity has been reduced. A major effort is now underway to investigate and analyze incidents that result in severe injury.

**CONCLUSION**

Incident investigation is a vital segment of the practice of safety. Superior performance can be achieved only if top-quality incident investigation is required by management and expected as a part of an organization’s culture. Incident investigation, done well or superficially done, reflects the reality of an organization’s culture concerning safety. The quality of incident investigation gives significant messages to employees as they interpret the substance of what management does in relation to what management says.

Thorough incident investigation and follow through with remedial actions support a culture that gives importance to safety. Poorly done incident investigations give employees reasons to doubt management’s sincerity with respect to safety.

**REFERENCES**


INTRODUCTION

It would be folly to suggest that an incident investigation system could be drafted that would universally apply in all organizations. This chapter is to serve as a reference for those who are to design, or redesign and improve, an incident investigation system, taking into consideration:

- The very large majority of entities that have not achieved a level of sophistication that would be expected if all investigations were made by trained investigation teams or safety professionals.
- What realistically can be expected of line supervisors, middle managers, and location managers in such organizations.

More specifically, this chapter will assist a safety professional in originally crafting or updating:

- An instructional guide on incident investigation
- An investigation form or outline
- A refresher guide for causal factor and corrective action determination
- A training program

In determining what incident investigation system is to be adopted, an assessment should be made of what is practically attainable. That requires
making assumptions about the organization in which a safety professional resides. If there is little management support for incident investigation or if training cannot be given to those who are to make investigations, it would be best to opt for simplicity. But including a modest stretch goal in the system would be a good idea.

REALITY OBSERVATIONS

Effective investigation and analysis of hazards-related incidents is an important element in a quest to achieve superior results in safety. A high quality of incident investigation and analysis not only results in risk reduction, but also serves as a positive reinforcement for the safety policies and practices that management has established.

As three studies have shown, to which reference is made in Chapter 11, “Incident Investigation: Studies of Quality,” the effectiveness of incident investigation varies greatly among and within organizations. To a large extent, the variations reflect the differences in organizational culture, the level of safety performance that is established by management policies and practices as being acceptable, and the resources made available.

Understandably, the safety-related texts that include principles and practices to be applied in incident investigation treat the subject conceptually and ideally without considering the reality of what may be attainable in a given organization. Consider these two real-world situations.

1. In a major company with exceptionally good OSHA recordable and lost workday case rates, the chief executive officer declared that results were still not acceptable and that significant reductions in injuries and illnesses were to be made. The extensive and well-qualified staff of safety professionals convinced management to use incident investigation as one means of reinforcing its intent to achieve better results.

A new procedure was put in place to have all OSHA recordable incidents, and those incidents that were judged to have severity potential but did not result in harm or damage, investigated by teams, the talent for which would be selected in relation to the specifics of the incident. For other incidents, the practice of having immediate supervisors make investigations was continued. Retraining sessions on incident investigation were conducted.

A safety professional has to sign off on each completed report, as does the location manager. For a lost workday case, the location manager is required to report, personally, to the executive next upward in the reporting structure.
A high level of sophistication in incident investigation is attained in that organization. A similar level of sophistication exists only in a small percentage of organizations.

2. Another entity has 8000 employees at 40 locations, none of which has more than 290 employees. One safety professional is employed—at headquarters. Assume that senior management, because of higher workers compensation costs, says that location managers are to be held to a higher level of accountability for the incident experience. Incident investigation guidelines are to be rewritten and the safety professional is to develop a training program and lead training sessions in the six largest locations. Training is to be given at the other locations by resident human resources persons.

Surely, the level of sophistication attainable in this second situation will be much lower. That should be taken into account by the safety professional in the process of developing and implementing the incident investigation guidelines and the training program. It is also important in that process to try to assess what changes were to take place, actually, in the accountability system. What the boss wants done will be done. If the boss doesn’t hold people accountable for top-quality incident investigation, the results will inevitably be less than desirable.

**BEING SYMPATHETIC TOWARD SUPERVISORS**

Another major reality that must be considered is that supervisors may complete only one, two, or three incident investigation reports a year. Although training may be given, knowledge retention is a problem. A properly drafted investigation report form and a causal factor and corrective action refresher guide would be of great help to supervisors who make investigations infrequently.

As the actuality of incident investigation practices is considered, one can’t help but feel sorry for the supervisor. It is commonly said in the literature, as Ted Ferry did in *Modern Accident Investigation and Analysis: An Executive Guide*, that the supervisor is closest to the action, that the mishap takes place in the supervisor’s domain, and that initial responsibility for investigation is very often assigned to the supervisor (p. 9).

Although Ferry went on to say that being close to a situation may preclude a supervisor from taking an unbiased approach to those causal factors that may reflect on his performance, he was nevertheless close in his estimate that first-line supervisors investigate about 90% of reported incidents (p. 9).

Ferry also wrote that if it is the supervisor’s duty to investigate, then the supervisor has every right to expect management to provide the training
required for the task (p. 9). A minimum goal, wrote Ferry, should be to provide those who have responsibility to investigate incidents with sufficient knowledge, and tools, to make the simpler investigations effectively (p. 18). That often is not done.

ADOPTING FROM WHAT HAS BEEN LEARNED

As a safety professional attempts to improve the quality of incident investigation, consideration should be given to what has been learned about incident causation in recent years. A good example of the lessons learned derives from ergonomics, which has emerged as a more significant segment of the practice of safety.

Ergonomics is design-based. A proper dealing with ergonomics situations promotes an appropriate balance between the design and engineering management, operations management, and task performance aspects of causation.

For instance, incident investigation methods should direct inquiry very early on into what may have been “programmed” into work systems through the design of the workplace or work methods. They should promote inquiry that determines whether the design of the work is error-conducive. For all injuries, the first question should be, Are there workplace design or work methods design implications?

To extend that idea, this example is quoted from an essay written by Alphonse Chapanis and titled “The Error-Provocative Situation: A Central Measurement Problem in Human Factors Engineering.” It is in the book The Measurement of Safety Performance by Dr. William E. Tarrants.

Six infants had died in the maternity ward ... because they had been fed formulas prepared with salt instead of sugar. The error was traced to a practical nurse who had inadvertently filled a sugar container with salt from one of two identical, shiny, 20-gallon containers standing side by side, under a low shelf in dim light, in the hospital’s main kitchen. A small paper tag pasted to the lid of one container bore the word “Sugar” in plain handwriting. The tag on the other lid was torn, but one could make out the letters “S ... l” on the fragments that remained. As one hospital board member put it, “Maybe that girl did mistake salt for sugar, but if so, we set her up for it just as surely as if we’d set a trap” [p. 99].

For how many hazards-related incidents has the work situation “set a trap” for injured workers? In Chapter 11, “Incident Investigation: Studies of Quality,” I wrote that in a substantial number of the investigation reports collected as a part of a study project, entries suggested that further
inquiry should have been made into the design of the workplace or work methods. In many cases, those incidents occurred in error-provocative situations. Yet, often in those instances, only unsafe acts of employees would be recorded as the incident causes.

Dr. Chapanis offered four axioms that deserve thought both in determining what incident causation model is to apply and in drafting an incident investigation report form.

**Axiom 1.** Accidents are multiply determined. Any particular accident can be characterized by the combined existence of a number of events or coincidence of a number of events or circumstances.

**Axiom 2.** Given a population of human beings with known characteristics, it is possible to design tools, appliances, and equipment that best match their capacities, limitations, weaknesses.

**Axiom 3.** The improvements in system performance that can be realized from the redesign of equipment is usually greater than the gains that can be realized from the selection and training of personnel.

**Axiom 4.** For purposes of man–machine design there is no essential difference between an error and an accident. The important thing is that both an error and an accident identify a troublesome situation [p. 100].

**RESOURCES ON INCIDENT INVESTIGATION**

Very few safety texts treat incident investigation in depth. For those who would study the subject, these references are recommended.

- *Modern Accident Investigation and Analysis: An Executive Guide* by Ted S. Ferry
  This text helps in thinking about how incidents occur and how they should be investigated. These are excerpts.

  Accident prevention depends to a large degree on lessons learned from accident investigation . . . . We cannot argue with the thought that when an operator commits an unsafe act, leading to a mishap, there is an element of human or operator error. We are, however, decades past the place where we stopped there in our search for causes. Whenever an act is considered unsafe, we must ask why. Why was the unsafe act committed? When this question is answered in depth it will lead us on a trail seldom of the operator’s own conscious choosing [p. 56].

  While the traditionalist will seek unsafe acts or unsafe conditions, the systems person will look at what went wrong with the system,
To promote learning about incident investigation, Ferry wrote extensively about and suggested inquiry into System Safety, Change Analysis, The MORT Process, Multilinear Events Sequencing, and D. A. Weaver’s Technic of Operations Review.

  The heart of the book is its presentation of Sequentially Timed Events Plotting (STEP). The accident investigation methodology presented relies on a new conceptual framework, building on system safety technology and the safety assurance systems of MORT (management oversight and risk tree).

- *MORT Safety Assurance Systems* by William G. Johnson
  This text serves well both for incident causation model building and for incident investigation. The accident investigation chapter states that while accident investigation has always been a major element in safety, pre-accident hazard analysis is preferable (p. 347).

- *Guide to Use of The Management Oversight and Risk Tree (MORT)*, a Department of Energy publication.
  This is an excellent resource. The MORT system starts with the assumption that an incident has occurred. This is what is said about MORT in the Abstract.

  MORT is a comprehensive analytical procedure that provides a disciplined method for determining the systemic causes and contributing factors of accidents. Alternatively, it serves as a tool to evaluate the quality of an existing system. While similar in many respects to fault tree analysis, MORT is more generalized and presents over 1,500 specific elements of an ideal “universal” management program for optimizing environment, safety and health, and other programs.

  MORT in its entirety will be considered by many to be a bit much for the majority of incidents. Nevertheless, MORT offers a sound thought process on which to build an incident investigation system.

  This 51-page publication is highly recommended as a reference for those who would evaluate and improve their incident investigation systems. A “Guide for Identifying Causal Factors and Corrective Actions” is its centerpiece. Use of the Guide requires a systematic
approach to identifying multiple causal factors and selecting corrective actions. There are four major sections in the Guide:

- Equipment
- Environment
- People
- Management

For each category, there is a listing of questions under the caption “Causal Factors.” Opposite the questions are listings of “Possible Corrective Actions.” These two abbreviated examples come from the Guide.

<table>
<thead>
<tr>
<th>Causal Factors</th>
<th>Possible Corrective Actions</th>
</tr>
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<tbody>
<tr>
<td>Did the design of the equipment/tool(s) create</td>
<td>Review human factors</td>
</tr>
<tr>
<td>operator stress or encourage operator error?</td>
<td>engineering principles Alter</td>
</tr>
<tr>
<td></td>
<td>equipment/tool(s) compatible with human capability and limitations. Encourage employees to report potential hazards created by equipment design</td>
</tr>
<tr>
<td>Were any tasks in the job procedure too difficult to</td>
<td>Change job design and procedures</td>
</tr>
<tr>
<td>perform (for example, excessive concentration or</td>
<td></td>
</tr>
<tr>
<td>physical demands?</td>
<td></td>
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</tbody>
</table>

In a form appropriate to the organization in which a safety professional provides counsel, a system of the sort outlined in this National Safety Council publication should result in focusing on actual causal factors and on the development of effective corrective actions. For those who make incident investigations infrequently, a modification of the “Guide for Identifying Causal Factors and Corrective Actions” would serve as a valuable memory jogger. Such a Guide is included in this chapter.

- “Incident Investigation, Analysis, and Costs” is the title of a chapter in the 12th edition of the National Safety Council’s *Accident Prevention Manual: Administration & Programs*.

This chapter briefly sets forth the fundamentals for incident investigation, makes reference to the previously mentioned “Guide for Identifying Causal Factors & Corrective Actions,” and discusses incident costs.
CHOOSING A CAUSATION MODEL

When designing an incident investigation and analysis process, a determination must be made concerning the causation model on which the process is to be based. What the designer of the process believes are the facts about incident causation has to be established before an instructional guide can be written or a training program developed. Consider these extremes.

Assume that a decision is made that Heinrich’s principles of incident causation are to be the bases for the design of an incident investigation system. Then, the system would accentuate avoiding “man failure,” a Heinrichean term. Emphasis would be on eliminating unsafe acts of employees, through training or some form of behavior modification.

Or, assume that the causation model is to relate to the concepts on which the management oversight and risk tree is based: (a) the system safety idea and (b) an understanding that causal factors may derive from workplace or work methods design.

To assist in deciding on the causation model to be applied, I suggest a review of Chapter 9, “Observations on Causation Models for Hazards-Related Incidents, and Chapter 10, “A Systematic Causation Model for Hazards-Related Incidents.”

I propose that the system designer make a review of the findings in Chapter 11, “Incident Investigation: Studies of Quality,” and relate them to the existing incident investigation system. Then, I suggest a self-audit be made of the quality of the incident investigation system in place, using the following self-audit outline.

Quality of Incident Investigation Self-Audit Outline

1. First, which incident causation model is to apply must be determined. All that follows in this outline regarding causal factors will relate to that model.
2. Take a sample of incident investigation reports completed by supervisors and rate the following for quality:
   a. General information data
   b. Incident descriptions
   c. Recording of injury and illness data
   d. Completion of code entry requirements
   e. Causal factors determinations
   f. Actions to be taken to prevent recurrence
   g. Completion of questions particular to the organization
   h. The quality of the report, overall
3. Using the same sampling of reports, make these assessments.
   a. Are the terms on the forms understood?
   b. Are requirements for causal entries on the forms too simplistic?
   c. Do requirements for causal entries fit with the concepts of incident causation to be applied?
   d. Does the quality of the reports show a need for additional training in incident investigation?
   e. Do the contents of forms indicate a need for additional job hazard analyses?
   f. Does the data gathered allow meaningful analyses?
   g. Is the needed managerial attention given to reports?
   h. Are safety personnel fulfilling their responsibilities?

4. Concerning written incident investigation procedures or guidelines, and the incident investigation report.
   a. Do they clearly convey an understanding of causation principles?
   b. Are the definitions clear? Is the language ambiguous?
   c. Do they properly balance consideration of design and engineering practices, and management and operations practices, and personnel task performance practices?
   d. Do they clearly establish which incidents are to be investigated?
      - Personal injuries (at what level)
      - Property damage (at what level)
      - Environmental incidents (at what level)
      - A frequency of minor injuries, property damage, or environmental incidents
      - Incidents not resulting in injury or damage, but which may have had serious consequences in other circumstances
   e. Are responsibilities for investigation clearly defined?
      - Supervisors
      - Upper management
      - When incident teams are to be used
      - Safety personnel
   f. For report distribution
      - Are the approval levels what they should be?
g. For corrective action
   • Are responsibilities precisely established?
   • Is the follow-up procedure appropriate?

h. Do the procedures or guidelines and the incident investigation form need revision and re-issuance?

5. Concerning training in incident investigation.
   a. Should the program be improved?
   b. Has it been given to all who need training?
   c. Are refresher courses given?
   d. Is an additional focus on training needed?

6. Is there a need to convince management that giving greater significance to quality incident investigation will assist in their achieving their goals?

7. Having made this self-audit, what actions are to be taken to improve the system?

In determining the actions to be taken as a result of an internal audit, a review of what follows in this chapter could be of assistance.

ESTABLISHING THE PURPOSES OF INCIDENT INVESTIGATION

In the guidelines to be published and in training programs to be conducted, the purposes and objectives of incident investigation should be established and communicated in a language understood in the organization, particularly in relation to its established safety policies and procedures. Some such statements of purpose, taken from issued publications, follow. Choose and adopt from those that are helpful:

- One fundamental element of our comprehensive environment, safety, and health endeavors is the investigation of incidents that may result in harm or damage to people, property, or the environment.
- The objective of this (guideline, standard, procedure) is to establish a uniform method for incident investigation that
  
  Reduces injuries and illnesses
  Identifies hazards in the workplace
  Implements consisting reporting
  Permits evaluation of the preventive actions taken
  Provides lessons learned that can be applied to other operations
A systematic approach to incident investigation, a proper identification of causal factors, and a follow-through on the implementation of corrective actions is essential to a good safety management and engineering system. These incident investigation concepts and procedures are to

Prevent the human suffering that results from occupational incidents
Identify causal factors (basic, primary, immediate, secondary, contributing, ancillary)
Provide for the identification of corrective actions
Establish an accountability system for proper treatment of the corrective actions proposed
Prevent similar incidents from occurring
Provide the information necessary for report preparation and record keeping
Allow the accumulation of data for subsequent analysis

The primary purpose of incident investigation is to prevent similar occurrences and to discover hazards. Collateral purposes, deriving from a study of the nature of the incident and from identifying causal factors, are to improve policies and standards and their implementation. Additional benefits include impressing employees on the depth of management concerns and improving general performance, supervision, and management abilities.

DEFINING THE TERMS TO BE USED

Keeping in mind the supervisors who complete just one, two, or three incident investigation reports a year, and for whom the training given may be less than the safety professional desires, attaining an understanding of the terms used in procedures and report forms can be a problem.

Whatever the terms used and their complexity or simplicity, their descriptions should be ultimately clear to ensure that they communicate what is intended. After reviewing hundreds of incident investigation reports, I suggest that we not assume that we communicate effectively through the terms we use.

INFORMING ON WHAT INCIDENTS ARE TO BE INVESTIGATED

Texts on incident investigation often propose the improbable when informing on which incidents are to be investigated. These are typical statements, as they appear in the texts:
• All accidents are to be investigated, regardless of the injury or property damage.
• The policy should be to investigate all accidents.

It is impractical and uneconomical for an entity to try to achieve the theoretical ideal and investigate every incident that results in even the slightest property damage. Resources are always limited, and priority setting is a must. Some things that are desirable won’t get done; choices have to be made. A composite follows of designations actually used by safety professionals when giving instructions on the categories of incidents to be investigated. For each category of incident, definitions would be given.

• First-aid treatment
• Minor injuries or illnesses requiring treatment by a doctor
• A frequency of minor injuries or illnesses
• Injury resulting in restricted activity or job reassignment
• Any injury that prevents return to work
• Injury requiring hospitalization
• OSHA recordable incident
• OSHA reportable incident
• An incident resulting in injury to two or more employees
• A fatality
• Minor property damage, product loss, or fires (dollar value set)
• Major property damage, product loss, or fires (dollar value set)
• Environmental spills or releases (air, water, land)
• Incidents that did not result in personal injury or property or environmental damage, but could have had serious consequences had circumstances been different

It’s suggested that a higher-than-usual priority be given to those incidents that did not result in injury or damage but had the potential to do so under other circumstances. Resources should be allocated to those incidents which, if repeated, have the potential to result in serious injury or damage. Severity potential is the proper determinant.

INVESTIGATION AND REPORTING RESPONSIBILITY

Since hazards-related incidents occur during the work activity for which supervisory personnel have initial responsibility, it follows that they—those closest to operations—should have initial responsibility for incident
investigation. (Of course, it would be established in an organization that employees are to report all incidents to their supervisors.)

Guidelines on incident investigation should categorize the incidents for which reporting is only to be by supervisors to location management, and those for which location management is to report upward in the organizational structure, and how soon. Also, incident categories requiring that an investigation team be gathered should be defined.

In a few organizations, the term *major incident*, or something similar, is used to designate the types of incidents for which immediate upward reporting is necessary. This is a composite of the categories of *major incidents* that safety professionals have set forth in their guidelines.

**Major Incident**

- An OSHA reportable incident
- Hospitalization of an employee for more than 3 days
- An incident resulting in injury to three or more employees
- A fatality
- An incident, including a fire, resulting in property damage in excess of $10,000
- A product loss valued in excess of $10,000
- An environmental incident (air, water, land) that must be reported to a governmental authority
- An incident that required building or job site evacuation
- An incident that required emergency shut down of operations
- An incident that could incite public interest
- An extraordinary or unusual incident creating a crisis or significant emergency
- An incident that did not result in harm or damage, but could have had serious consequences under other circumstances
- An incident that will provide a lesson learned for other locations

**INCIDENT INVESTIGATION TEAMS**

Incident categories requiring investigation by teams would be precisely defined. Such teams may include employees directly involved, supervisory personnel, technical specialists, safety professionals, union personnel, middle management, and possibly the plant manager and headquarters personnel.
A team chairperson with management status, and having the necessary authority and experience for the task, should be designated and given the responsibility for assembling the team. The team chairperson should

- See that an appropriate action plan, with specifics suitable to the situation, is developed and distributed, to include
  - Identification of team participants
  - Meeting schedule
  - Arrangements for meeting facilities
  - Transportation, suggested or arranged
  - Clearance for team members to visit the incident site
  - Arrangement of photographic needs
  - Liaison with the press and public bodies

- Arrange liaison with employee representative(s), government agencies, and news media
- Call and preside over meetings
- Control the scope of team activities by identifying the line of investigation to be pursued
- Assign tasks and establish a schedule
- Ensure that no potentially useful data source is overlooked
- Keep interested parties advised of progress
- Oversee the preparation of the final report

Qualifications to be considered when selecting the team members should include

- Relevant knowledge and experience
- Familiarity with design and engineering, the work methods, the process or operation
- Impartiality
- Analytical capability
- Ability to work with others

IMMEDIATE ACTIONS TO BE TAKEN

An understanding is necessary of the actions to be taken by the supervisor immediately responsible, and other management personnel, immediately after knowledge is received that an incident has occurred. First priority is to properly care for the safety of employees and members of the public.
In outlining immediate actions that supervisors and others are to take, consideration would be given to including the following points:

- Immediately visit the incident location.
- Determine whether anyone was injured.
- If necessary, undertake rescue operations.
- Arrange for medical attention if needed.
- Determine whether the area should be secured, barricaded, or otherwise isolated.
- Arrange for collection and preservation of material relative to the incident.
- Prevent use of any equipment involved.
- Shut down the operation, if necessary.

NOTIFICATION PROCEDURES

For those incidents for which upward reporting is necessary, a notification procedure, kept current, should be in place to which all employees and location management personnel can refer, to ensure that all interested personnel receive proper notification. Such a notification procedure would:

- Identify who is responsible for the reporting.
- Include the names and phone numbers of the persons to be notified (senior executives, corporate environmental, health, and safety personnel, legal department, public relations, union personnel).
- State the communication means to be used for reporting.
- Give instructions on how the reporting is to be accomplished during other-than-usual business times (evenings, weekends, holidays).
- Outline what is to be reported: date and time the incident occurred; location; description of the incident; identification data for employees injured (name, badge number, regular occupation, length of employment, length of time on the job involved); estimated potential injury, property damage, or environmental damage; immediate actions taken; further short-term actions to be taken; reports made or to be made to OSHA, EPA, insurance carriers; actions taken to assemble an investigation team.
FACT FINDING—AVOIDING THE IMPRESSION OF PLACING BLAME

An incident investigation is made to identify the reality of the causal factors and to recommend corrective actions that will reduce the probability of similar incidents occurring. Under no circumstances should investigations be viewed as having the purpose of placing blame. And this principle has to be imparted through incident investigation guidelines and training programs to all who are to make incident investigations.

Incident investigation requires a particular skill to assure that injured persons and those involved with the incident will be forthcoming with the pertinent causal factors. If an impression is created that the intent is to place blame, persons involved will usually become protective of their well-being, important information may be withheld, and the probability of having a valid investigation will be diminished.

INCIDENT INVESTIGATION TECHNIQUES

Instruction should be given on how to go about doing the investigation job effectively. The following guidelines apply, after following the procedures set forth under “Immediate Action to Be Taken”:

- Timeliness is important — the work should be started before the scene has changed and memories are dimmed.
- Identify your purpose — you are seeking information to identify causal factors to prevent recurrence, not to place blame or find fault.
- Describe the incident — from beginning to end.
- Seek the versions of those involved, those who are to be interviewed — don’t try to influence what they say.
- Ask open-ended questions — what, why, when, where, how.
- Confirm your understanding of what has been said, repeating back what you thought you heard.
- Take great care with physical evidence.
- Assume that those interviewed have knowledge of value, and seek from them suggestions on the possible causal factors, to include all elements that contributed to the incident process: the characteristics of things (hardware, equipment, materials), and management, operational, and personnel task performance practices.
- Again, assume that those interviewed have knowledge of value and seek suggestions on the corrective actions that should be taken.
• Above all, be tactful, don’t blame or threaten.
• Take good notes — do not use a recorder unless it was agreed that you could do so.
• Review and validate the findings.
• Initiate taking the corrective actions identified.
• Complete the incident investigation report.

INCIDENTS USUALLY HAVE MULTIPLE CAUSAL FACTORS

Seldom do hazards-related incidents have only one causal factor. Incident causation can be complex, even for incidents that do not seem complex. Yet, there is an expressed desire in some organizations for simplicity in causal factor determination. In some procedure guides, the instruction is given to “identify the cause” — the term cause being singular.

If the single causal factor identified is an employee “unsafe act,” the investigation process, although not intended to, may seem to place blame because it concentrates on the behavior of an individual, rather than on the work system.

If people who make incident investigations are encouraged to take the easy route through instructions given in incident investigation forms and through the investigation procedures established, and to select only one superficial causal factor, more than likely that is what they will do. And that diminishes the value of the investigation. Instructions given in procedure guides should clearly establish that

• Most incidents will have multiple causal factors.
• Causal factors may include acts of omission or commission concerning design and engineering management, operations management, and task performance practices.

DESIGNER INCIDENT INVESTIGATION REPORTS, AND A REFERENCE FOR CAUSAL FACTORS AND CORRECTIVE ACTIONS

What follows is intended particularly for the very large majority of entities that have not or cannot achieve the performance level expected if all investigations were made by trained investigation teams or safety professionals. In developing this material, thought was given to (a) what realistically can be expected of supervisors, middle managers, and location managers in such organizations and (b) the importance of providing
them with supportive information that leads to more effective causal factor and corrective action determination.

Also, it was recognized that an increasing number of safety professionals now have responsibilities including environmental affairs as well as safety and health, and perhaps fire prevention and protection. Thus, they have a need to provide guidance on reporting for a broad range of incident types.

Since personnel who make very few incident investigations in a year would benefit from having a thought prompter, a draft of a “Reference for Causal Factors and Corrective Actions” is provided.

Subjects to be included in an incident investigation report should be contained within the front and back of one page, leaving room for comment. For some items in the following list, explanatory comment is given that is typical of what is found in procedure guidelines on incident investigation. It is understood that other items could be added to this list to meet organizational needs.

**Incident Investigation Report Subjects from Which Selections Can Be Made**

1. Name, title, and department of person completing the report, and the date the report is prepared.
2. Facility, division, department: Enter the location at which the incident occurred, the division within the company, and the department within the location.
3. Name of injured person: Enter employee’s full name: Last name, first name, and middle initial.
4. Social security number: Personnel will have it, if unknown.
5. Age: Enter number of years (e.g., 40), not birthday.
7. Clock number.
8. Employee category: Full time, part time, temporary, hourly, salaried.
9. Date incident occurred: Enter the exact date of occurrence.
10. Shift and time the incident occurred: Enter shift number (1,2,3) and the time (AM, PM), as closely as possible.
11. Date incident reported: This is the date the incident is first known to the person completing the report.
12. Exact location of the incident: Enter precise location (i.e., at weighing station 4).
13. Type of incident: Record injury or illness, fire, property damage, environmental incident, product loss, or significant event that did not result in harm or damage but had the potential to do so.

14. Severity of injury, damage, or release: Be as precise as possible; list all personal injuries or illnesses, and give an estimate of the value of the property damage, or details on the amount of the spill or release.

15. Date lost time (disability) began.

16. Date released to regular work or selected work.

17. Was incident reported to a government entity? Yes or No. If yes, comment fully in narrative.

18. Employee’s usual job title: To what occupation is employee usually assigned?

19. Job title at time of incident: To what occupation was employee assigned when incident occurred?

20. Time in job held when incident occurred: How long had the injured person been assigned to that job?

21. Length of company service: Give the number of years the injured person was employed by the company.

22. Is there a Job Hazard Analysis (JHA) for this job? Yes or No. If no, and the company requires job hazard analyses, further comment would be expected.

23. Is there a written procedure for this job? Yes or No. If no, and the company requires written job procedures, further comment would be expected.

24. Describe the incident in detail: Record all that preceded the incident that was relevant; what the persons involved did or failed to do; and what equipment, materials, or aspects of the work environment were involved.

(At this point, the designer of the form has at least two options. One is to give instructions such as those in items 25 and 26 and provide a separate, detailed “Reference for Causal Factors and Corrective Actions.” Or, the form designer could select from the “Reference for Causal Factors and Corrective Actions” those subjects appropriate to operations and enter them directly on the form, preceded by check-off boxes, as a part of items 25 and 26. A form can be designed, albeit using small print, that includes abbreviations of 20 or more of the causal factors and all of the corrective actions included in the exhibit that follows, leaves enough room
DESIGNER INCIDENT INVESTIGATION

for narrative comment for all but unusual incidents, and still fills only the front and back of a page.)

25. Causal factors: Enter all of the causal factors (circumstances, events, design of tools, equipment, or the work area, condition of equipment, properties of materials, work methods considerations, management systems, actions or inactions of persons) that contributed to the incident. Almost always, there will be multiple causal factors.

26. Corrective actions: (a) Record actions already taken, (b) list actions to be taken, (c) identify persons responsible for items in (b), and (d) give expected completion dates. Typically, several corrective actions are identified through the investigation process.

27. Investigation report approvals: Give names, titles, and approval dates. The approval structure would be set forth in issued procedure guidelines.

If a “Reference for Causal Factors and Corrective Actions” as thorough as the following is to provided, it could be included as pages 3 and 4 of the Incident Investigation Report Form. (In readable print, it can easily be contained in two pages.) Or, it could be a stand-alone reference (perhaps encased in plastic for preservation purposes) to be maintained in a suitable file, or just included in the procedure manual containing the instructions on incident investigation.

I emphasize that this “Reference For Causal Factors and Corrective Actions” is presented as a resource for the designer of an incident investigation system, with the assumption that the designer would make revisions in it to suit organizational needs.

Whatever option is selected, provision would be made for the person completing the investigation report to enter check marks indicating that each subject had been considered, and also identifying those that were applicable.

Reference for Causal Factors and Corrective Actions

Workplace Design Considerations

1. Hazards derive from basic design of facilities, hardware, equipment or tooling.
2. Hazardous materials need attention.
3. Layout or position of hardware or equipment presents hazards.
5. Work space for operation, maintenance, or storage is insufficient.
6. Accessibility for maintenance work is hazardous.

**Work Methods Considerations**
1. Work methods are overly stressful.
2. Work methods are error-inducing.
3. Job is overly difficult, unpleasant, or dangerous.
4. Job requires performance beyond what an operator can deliver.
5. Job induces fatigue.
6. Immediate work situation encouraged riskier actions than prescribed work methods.
7. Work flow is hazardous.
8. Positioning of employees in relation to equipment and materials was hazardous.

**Job Procedure Particulars**
1. No written or known job procedure.
2. Job procedures existed but did not address the hazards.
3. Job procedures existed but employees did not know of them.
4. Employee knew job procedures but deviated from them.
5. Deviation from job procedure not observed by supervision.
6. Employee did not match work procedures or equipment.
7. Employee not capable of doing this job (physically, work habits, or behavioral reason).
8. Correct equipment, tools, or materials were not used.
9. Proper equipment, tools, or materials were not available.
10. Employee did not know where to obtain proper equipment, tools, or materials.
11. Employee used substitute equipment, tools, or materials.
12. Defective or worn out tools were used.

**Hazardous Conditions**
1. Hazardous condition had not been recognized.
2. Hazardous condition was recognized but not reported.
3. Hazards condition was reported but not corrected.
4. Hazardous condition was recognized, but employees were not informed of the appropriate interim job procedure.
Personal Protective Equipment

1. Proper personal protective equipment (PPE) not specified for job.
2. PPE specified for job but not available.
3. PPE specified for job, but employee did not know requirements.
4. PPE specified for job, but employee did not know how to use or maintain.
5. PPE not used properly.
6. PPE inadequate.

Management and Supervisory Aspects

1. General inspection program is inadequate.
2. Inspection procedure did not detect the hazards.
3. Training as respects identified hazards not provided, inadequate, or didn’t take.
4. Maintenance with respect to identified hazards is inadequate.
5. Review not made of hazards and right methods before commencing work for a job done infrequently.
6. This job requires a job hazard/task/ergonomics analysis.
7. Supervisory responsibility and accountability not defined or understood.
8. Supervisors not adequately trained for assigned safety responsibility.
9. Emergency equipment not specified, not readily available, not used, or did not function properly.

Corrective Actions to Be Considered

1. Job study to be recommended: job hazard/task/ergonomics analysis needed.
2. Work methods to be revised to make them more compatible with worker capabilities and limitations.
3. Job procedures to be changed to reduce risk.
4. Changes are to be proposed in work space, equipment location or work flow.
5. Improvement is to be recommended for environmental conditions.
6. Proper tools to be provided along with information on obtaining them and their use.
7. Instruction to be given on the hazards of using improper or defective tools.
8. Job procedure to be written or amended.
9. Additional training to be given concerning hazard avoidance on this job.
10. Necessary employee counseling will be provided.
11. Disciplinary actions deemed necessary, and will be taken.
12. Action is to be recommended with respect to employee who cannot become suited to the work.
13. For infrequently performed jobs, it is to be reinforced that there is to be a pre-job review of hazards and procedures.
14. Particular physical hazards discovered will be eliminated.
15. Improvement in inspection procedures to be initiated or proposed.
16. Maintenance inadequacies are to be addressed.
17. Personal protective equipment shortcomings to be corrected.

Training in Incident Investigation

It is fundamental that those who are to investigate incidents have the training and re-training and the practical experience necessary to acquire the special knowledge and skills needed. I recommend that training programs be tailored precisely to the actual needs of those being trained and that the organization’s incident experience and a study of the hazards in its operations be considered in the tailoring. I admit that what I suggest will be unattainable, sometimes.

Having reviewed four purchasable incident investigation training programs, all with video cassettes and leader and trainee work books, the best that I could say is that they’re all right. For each of them, I thought that I would want considerable supporting discussions of incident data that pertained to the actual experience in the entity for which the training was being given, and of its hazards and risk problems.

As a generality, the training programs I reviewed were superficial for causal factor determination. To be of value, a training program must provide knowledge of incident causation and what the corrective actions ought to be.

It is easy to write that if incident investigation is to be done well, effective training must be provided. Where training resources are limited, the choice in crafting a program should be for that which is attainable. Still, Ted Ferry was right when he wrote in *Modern Accident Investigation and Analysis* that if it is the supervisor’s duty to investigate, then the supervisor has every right to expect management to provide the training required for the task (p. 9).
Fortunately, it is not the norm for hazards-related incidents to occur frequently in a given operation. But, that presents another problem. Knowledge acquired through a training program may not be retained by those who make investigations infrequently. Thus, retraining is necessary, and a reference source should be available that helps on the few occasions when investigations are made.

**CONCLUSION**

Incident investigation, done well, gives positive messages within an organization concerning management’s intent for safety. This chapter is to assist in having it done better. For quite some time, incident investigation has been recognized as a vital element in the practice of safety. And that is evidenced by the frequency of writings on the subject. For example, 51 books or articles referencing accident investigation are entered in the data bank at the National Safety Council library with publication dates later than 1996, the year the second edition of this book was written. For additional reading, a selection of 10 of those publications follows.


REFERENCES


INTRODUCTION

All risks to which the practice of safety applies derive from hazards. There are no exceptions. Furthermore, the entirety of purpose of those accountable for safety, in fulfilling their societal responsibilities, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are at an acceptable level.

Thus, safety professionals must have an understanding of hazards and risks and their relationship to fulfill their responsibilities and to be successful in communicating with those to whom counsel is given.

Hazards and risks are not synonymous terms, though some authors use them interchangeably. Also, hazards and risks may be equated in the literature with exposures and perils. Unfortunately, the literature on hazards and risks and exposures and perils can be baffling. We safety professionals, to be effective communicators, seriously need to establish what we mean when we use the terms hazards and risks. As John V. Grimaldi and Rollin H. Simonds wrote in Safety Management:

Unless there is common understanding about the meaning of terms, it is clear that there cannot be a universal effort to fulfill the objective they define [p. 10].
DEFINING HAZARDS: RELATING HAZARDS TO RISKS

Appendix C in *Improving Risk Communication* is titled “Risk: A Guide to Controversy.” In that appendix, Baruch Fischhoff wrote:

By definition, all risk controversies concern the risks associated with some hazard . . . the term “hazard” is used to describe any activity or technology that produces risk [p. 217].

Fischhoff properly relates hazards to risks. A hazard is defined as the potential source of harm. Hazards include the characteristics of things, the technology, and the actions or inactions of persons that have the potential to harm or damage people, property, or the environment.

Hazards must be considered in the broad context of that definition. Every element within the safety management process should serve to avoid, eliminate, or control the aspects of personal activity or inactivity and the aspects of technology that present a potential for harm or damage and produce risk.

SIGNIFICANCE OF HAZARDS WITHIN THE SAFETY PROCESS

Whether the concern of a safety professional is occupational safety, occupational health, product safety, environmental affairs, fire protection, transportation safety, or any other safety-related practice, the generic base for that endeavor is hazards. In every one of those fields of endeavor, all activities should be similarly directed to encompass both the possible actions or inactions of people and the characteristics of properties, equipment, machinery, or materials that present the potential for harm or damage.

Furthermore, whatever the particular safety process — management involvement, safety in the design stages, employee training, hazards communication, incident investigation, use of personal protective equipment, behavior modification, and so on — its fundamental purpose is to avoid, eliminate, or control hazards.

HAZARD IDENTIFICATION

In the definition of hazards given, *potential* is the key word. If a hazard is the potential source of harm, and if a hazard is not avoided, eliminated, or controlled, the potential may be realized.

Two considerations are necessary in determining whether a hazard exists. Do the characteristics of the thing or the actions or inactions of people present the potential for harm or damage? And, can people, property, or the environment be harmed or damaged if the potential is realized?
Many methods are available to identify hazards—from historical data, from codes and standards, from the observations of learned people, and from the use of one of several analytical methods such as the more simple What-If system through to the more complex Fault Tree Analysis. And the literature, of which there is a great deal, speaks extensively of those methods.

DEFINING EXPOSURE
To complete a hazard analysis after a hazard has been identified and evaluated, the exposure must be assessed. An exposure assessment would be a determination of the number of people, the extent of the property, and aspects of the environment in a particular setting that could be affected by the realization of the hazard, as well as the extent of harm or damage that could result. Exposure is not the hazard, nor is it the risk.

DEFINING PERILS
In the insurance-related literature, peril is a frequently found term. It may be used synonymously with hazard or risk or exposure. Perils insured against are commonly considered to be fires, explosions, falling aircraft, windstorms, floods, automobile accidents, embezzlements, et cetera. Perils are incidents that occur when hazards are realized. Perils are events; they are not hazards or risks or exposures.

ACQUIRING ADDITIONAL KNOWLEDGE OF HAZARDS
There are two significant thought processes, one built on the other, of which knowledge is a requirement in professional safety practice. They are Haddon’s unwanted energy release concept, extended by him to include exposures to hazardous environments, and the concepts on which MORT (management oversight and risk tree) was developed.

I encourage safety professionals to give particular attention to Haddon’s concepts and to MORT. Both establish that if there are no unwanted energy releases or exposures to hazardous environments, no hazards-related incidents will occur.

ALL WORK REQUIRES THE EXPENDITURE OF ENERGY
In *The Loss Rate Concept in Safety Engineering*, R. L. Browning wrote:

Work requires the expenditure of energy, in fact, energy is measured by the work it is capable of performing. It follows that the capability to cause—the
key element in the search for valid loss exposures — will be an inventory of potentially destructive energy [p. 17].

Browning’s statements are thought-provoking. Certainly, being causal factors oriented is a fundamental in the practice of safety. And, it seems that “potentially destructive energy,” the release of which occurs in hazards-related incidents, is directly related to the definition of hazards previously given.

Obviously, the purpose of people in an occupational setting is to work. All work requires the expenditure of energy. If the energy expended is undesired or excessive in relation to human capabilities, that energy expenditure can be an incident causal factor. Safety professionals cannot do a proper job of giving advice on preventing or mitigating harm or damage without extensive knowledge of causal factors that include unwanted releases of “potentially destructive energy.” This applies to all types of incidents: material handling incidents, slips and falls, contact with objects or equipment, and so on.

**HADDON’S UNWANTED ENERGY RELEASE AND HAZARDOUS ENVIRONMENT CONCEPT**

Dr. William Haddon, who was the first Director of the National Highway Safety Bureau, conceived the energy release theory. Its concept is that unwanted transfers of energy can be harmful (and wasteful) and that a systematic approach to limiting their possibility should be taken.

Although Haddon stated in his paper “On the Escape of Tigers: An Ecologic Note” that “the concern here is the reduction of damage produced by energy transfer,” he also said that “the type of categorization here is similar to those useful for dealing systematically with other environmental problems and their ecology.” Excerpts follow from “On the Escape of Tigers: An Ecologic Note.”

A major class of ecologic phenomena involves the transfer of energy in such ways and amounts, and at such rapid rates, that inanimate or animate structures are damaged.

Several strategies, in one mix or another, are available for reducing the human and economic losses that make this class of phenomena of social concern. In their logical sequence, they are as follows:

- Prevent the marshalling of the form of energy;
- Reduce the amount of energy marshalled;
- Prevent the release of the energy;
• Modify the rate or spatial distribution of release of the energy from its source;
• Separate, in space or time, the energy being released from that which is susceptible to harm or damage;
• Separate, by interposing a material barrier, the energy released from that which is susceptible to harm or damage;
• Modify appropriately the contact surface, subsurface, or basic structure, as in eliminating, rounding, and softening corners, edges, and points with which people can, and therefore sooner or later do, come in contact;
• Strengthen the structure, living or non-living, that might otherwise be damaged by the energy transfer;
• Move rapidly in detection and evaluation of damage that has occurred or is occurring, and counter its continuation or extension; and
• After the emergency period following the damaging energy exchange, stabilize the process.

All hazards are not addressed by the unwanted energy release concept. Examples are the potential for asphyxiation from entering a confined space filled with inert gas, or inhalation of asbestos fibers. But all hazards are encompassed within a goal that is to avoid both unwanted energy releases and exposures to hazardous environments. Many authors have recognized the importance of Haddon’s writings.

John V. Grimaldi and Rollin H. Simonds in Safety Management recognized Haddon’s work (p. 284). Dr. Roger L. Brauer, in Safety and Health for Engineers (p. 20), commented on the energy release theory and listed the 10 strategies for preventing or minimizing adverse results as outlined by Dr. Haddon. In MORT Safety Assurance Systems, William G. Johnson also listed Dr. Haddon’s 10 energy management strategies and made these comments concerning them.

Haddon systemized a set of 10 energy management strategies in a progressive order, which can be used in various combinations. Haddon points out that the larger the energy, the earlier in the strategy list should control be sought. This author would add, the larger the energy, the greater the need for redundant, successive strategies and barriers. The systematic review of available strategies and the creation of optimum mixes to reduce harm have not been customary in safety. The application of Haddon’s concepts was tested in early trials of MORT [p. 28].

As a result of the testing and early trials, Haddon’s strategy was introduced into the MORT system with an extended hierarchy of preventive measures, of which there are 12 (p. 29).
Ted Ferry in *Safety and Health Management Planning* wrote about energy transfers and barriers and listed “13 strategies for systematic energy control” as cited by the Department of Energy (p. 244).

Unwanted releases of energy or exposures to hazardous environments contribute as causal factors for all hazards-related incidents. Haddon’s 10 energy management strategies are greatly expanded in this book in Chapter 17, “Guidelines: Designing for Safety,” under the caption “General Design Requirements: A Generic Thought Process for Hazard Avoidance, Elimination, or Control.”

**ON THE SIGNIFICANCE OF MORT**

I also recommend that safety professionals develop an understanding of the concepts on which the management oversight and risk tree (MORT) is based and the thought process it promotes. In the excerpts that follow, taken from the *Guide to Use of the Management Oversight and Risk Tree,* the relationship of MORT to Haddon’s original work will be evident.

This document is the User’s Guide for MORT (Management Oversight and Risk Tree), a logic diagram in the form of a “work sheet” that illustrates a long series of interrelated questions. MORT is a comprehensive analytical procedure that provides a disciplined method for determining the systemic causes and contributing factors of accidents. Alternatively, it serves as a tool to evaluate the quality of an existing system. While similar in many respects to fault tree analysis, MORT is more generalized and presents over 1,500 specific elements of an ideal “universal” management program for optimizing environment, safety and health, and other programs [Abstract].

MORT conceives the accident occurred when an unwanted energy flow or environmental condition that results in adverse consequences reaches persons and/or objects. MORT combines this concept and others into a functional accident definition as follows: An unwanted transfer of energy or environmental condition because of lack of or inadequate barriers and/or controls, producing injury to persons and/or damage to property or the process [p. 2].

After an accident occurs, the first step in the MORT process is to consider the adequacy of the amelioration process, their intent being to limit the severity of the consequences. Then MORT users would determine the unwanted energy flows or hazardous environmental conditions, whether barriers and controls were less than adequate, and whether vulnerable people or property were exposed.
While MORT is based on the fault tree method of system safety analysis, its logic diagram does not require statistical entries and computations for event probabilities. MORT is presented as an incident investigation methodology and as a basis for safety program evaluation.

Its thought process could also serve well the safety professional who participates in design concept discussions. MORT is soundly based on the unwanted energy release and environmental exposure concept, and its use leads to a good understanding of hazards, exposures, and risks.

A first approach to MORT could be intimidating: Its logic diagram presents over 1500 elements. It can seem daunting, but it should not be so judged. Thousands have successfully completed MORT seminars, and have gained considerably from exposure to its thought process.

I would like to repeat the quotation from Baruch Fischhoff’s *Risk: A Guide to Controversy* which appeared earlier in this chapter:

> By definition, all risk controversies concern the risks associated with some hazard . . . the term “hazard” is used to describe any activity or technology that produces risk [p. 217].

Risks with which safety professionals deal derive from hazards. We need to know more about risks.

**DEFINING RISK AND THE ROLE OF THE SAFETY PROFESSIONAL WITH RESPECT TO RISK**

Risk is defined as a combination of the probability of occurrence of harm and the severity of that harm (ISO/IEC Guide 51:1999(E), Safety aspects—Guidelines for their inclusion in standards.) In producing the measure that becomes a statement of risk, it’s necessary that determinations be made of the following:

- The existence of a hazard or hazards
- The exposure to the hazard
- The frequency of endangerment of that which is exposed to the hazard
- The severity of the consequences should the hazard be realized (the extent of harm or damage to people, property, or the environment)
- The probability of the hazard being realized

If the exercise is stopped after the severity of possible consequences is determined, the result is a hazard analysis. To determine risk, the probability of an occurrence must also be estimated. Estimating risk requires
determining both the probability of a hazard-related incident occurring and the consequences of the incident.

Thus, in fulfilling their responsibilities, safety professionals must consider the two distinct aspects of risk:

- Avoiding, eliminating, or reducing the probability of a hazard-related incident occurring
- Minimizing the severity of harm or damage that could result

As safety practice further evolves, the required attention will be more often given to the avoidance of hazards in the design and redesign processes. As more safety professionals are successful in establishing themselves as consultants in those processes, they will become more familiar with concepts of risk and how risk reduction is effectively achieved.

Along the way, questions will arise concerning what the content of professional safety practice ought to be and how it is best applied in giving advice that actually attains a significant reduction of risk.

Some safety practitioners are directed by their managements to apply all of their efforts to obtaining compliance with laws, codes, standards, and regulations. Surely, being in compliance is a laudable goal. Unfortunately, merely being in compliance usually means achieving a minimal level of hazards management. It should not be assumed that actions taken to be in compliance with legal requirements address an organization’s principal risks or that doing so, by itself, will attain effective hazards management.

A safety director tells the story of convincing his management to spend $1,000,000 to comply with OSHA standards. Later, he was asked what impact the expenditures would have on the types of employee injuries and illnesses that had occurred. Injury and illness records were available for 30 years. Not one of the reported incidents was related to the expenditures for OSHA compliance. Yes, risks of employee injury and illness were reduced through the expenditures to comply with OSHA standards, but by how much?

UNDERSTANDING MANAGEMENT’S VIEW OF RISK

A successful communication with management personnel on risk is not possible until an understanding has been reached on the meaning of the term as it is to be used in those communications. That’s important, because risk is a term with far too many meanings.

On any given day, managements may hear the term in a variety of contexts: in examining a financial venture, in considering the possible increase in the price of a commodity, in receiving a phone call from a
stockbroker who proposes a risk management program. It’s also important that safety professionals appreciate the culture of an organization and the perception of risk a management staff may have, its fears and logic concerning risk, and its tolerance for risk. Managers are risk takers; so are safety professionals.

ON ACCEPTABLE RISK

Safety was defined as the freedom from unacceptable risk. Conversely, safety may be defined as that state for which the risks are judged to be acceptable. These definitions imply a determination of risk, as well as a judgment of the acceptability of risk. Often, when the term *acceptable risk* is used, the response of the uninformed may be, How dare you suggest that some risk is acceptable.

But consider this: Every safety professional who writes a recommendation to eliminate or control a hazard makes a risk acceptance decision. It cannot be presumed that complying with the recommendation achieves zero risk. No thing or activity is risk-free. Also, in the practical world, all risks will not be eliminated. Even when deciding which risks are to be given priority consideration, a risk acceptance decision is made about those risks to be dealt with later, if only for the short term.

A few safety practitioners object to the idea that they make risk acceptability decisions. They create an atmosphere of being above that sort of thing, of super-righteousness. Perhaps they believe that if all that they propose is favorably acted upon, a risk-free environment will be achieved. Safety professionals know that is not possible. If they want to be a part of the management team, they must share in risk acceptance decisions. Chapter 14, “Acceptable Risk,” is devoted to this subject.

RISK REDUCTION ADVICE

Safety professionals must acquire knowledge of risk determination concepts to give validity to the proposals they make to reduce risk. Since there are always resource and scheduling and time constraints, the advice given should ideally include

- Risk categorization and priority indications
- Possible alternative remediation measures
- Expected effectiveness of each alternative in risk reduction
- Remediation costs
RISK MANAGEMENT DECISIONS MAY NOT BE BASED ON LOGIC

Although a safety professional may present logically developed data on risks, it should be understood that risk reduction decisions might not be made on that data alone, particularly when dealing with the perceptions the public or employees may have of risk. Richard F. Griffiths wrote in *Dealing with Risk: The Planning, Management and Acceptability of Technology Risk* that

> The applicability in risk assessment and acceptability is that for low-frequency events the probability estimate is not based on a large number of trials and the public evaluation may well be more conditioned on how bad the outcome might be, with little regard for arguments as to how likely it is [p. 12].

In this one paragraph, Griffiths introduces two important subjects: that probability estimates used for low-frequency/high-consequence incidents may be questionable; and that public concerns may reflect only perceptions of severity of outcomes.

At a symposium on risk sponsored by the National Safety Council and ILSI Risk Science Institute, the theme for which was “Regulating Risk: The Science and Politics of Risk,” one speaker expressed the view that public risk concerns would best be considered as public outrage. Even though at times it may be believed that the public outrage is illogical, it will often be a significant factor in risk decision-making. All risk reduction measures may not be based entirely on risk assessment logic. And it may be that in dealing with public outrage, or employee concerns, or perceived risks, facts will not be convincing.

When risk decisions are made, it will not be unusual that the decision process is influenced by elements of fear and dread, and the perceived risks of employees, the immediate community, a larger public, and management personnel.

QUESTIONING THE VALIDITY OF SOME QUANTITATIVE RISK ANALYSES

Since so many subjective judgments are necessary in applying what are otherwise sound statistical quantification systems, I believe that, except when statistical concepts can be applied to the known such as the face markings of dice, or when empirical probability evidence has been produced, all quantitative risk analyses are really qualitative risk analyses.
Vernon L. Grose in *Managing Risk: Systematic Loss Prevention for Executives* appropriately cautioned on several occasions against an over-reliance on numbers in determining risk when the numbers may not be sound. A reasoned skepticism would serve safety professionals well concerning the validity of the numbers used in what appear to be precise determinations of both the probability of an incident occurring and an assessment of its consequences.

Both probability and consequence numbers may be greatly overstated or understated. Grose may have exaggerated only slightly when he wrote the following:

> Because desire overrode reality, the unfortunate gamesmanship that has evolved supposedly to upgrade reliability and safety has come to be called “numerology”, defined in the dictionary as follows:

> A system of occultism (hidden, secret, or beyond human understanding) involving divinations (the practice of trying to foretell the future by mysterious means) by numbers [p. 263].

Grose indicates that when there is a demand for numbers and an inventing to fill the need, the numbers eventually appear in print and there is no way to recognize their illegitimacy. Thus a caution: Be wary of the numerologists.

Grose is not alone in expressing concern about the validity of risk quantification systems. These quotes come from *Improved Risk Communications*, a text prepared under the guidance of the Committee on Risk Perception and Communication as a project of the National Research Council:

> Analysts are prone to overlook the ways human errors or deliberate human interventions can effect technological systems [p. 46].

> The need to quantify risks as an aid to decision making creates special difficulties because the choice of which numerical measures to use depends on values and not only on science [p. 48].

Emphasis is given here to the phrase “the choice of which numerical measures to use depends on values and not only on science.”

I quote again from Griffiths’ *Dealing with Risk: The Planning, Management and Acceptability of Technological Risk*:

> If one compares the experts’ best estimates of the consequences of an accident with the historical record it is often found that the estimates are greatly in excess of the consequences actually manifested [p. 14].
My experience requires an opposite observation to what Griffiths says about consequence estimates being greatly in excess of the actual consequences. Over many years, I observed that estimates of possible property damage losses developed by fire protection engineers in relation to described hazard scenarios were often notably less than the actual damage when an incident occurred. Nevertheless, the point is this: Estimating consequences of an accident is not an exact science.

I also offer a caution concerning numerical risk scoring systems. For example, I was presented with risk data to which a scoring system was to be applied and risk priority ratings given. An incident with a probability of 1 per 100 plant operating years for which devastating results were calculated, including many fatalities, was given a lower priority than a single disabling back injury with a probability of 1 per plant operating year. Such may not be in the best interest of employees, management, or the public.

Nevertheless, there is a growing demand for risk scoring systems, which are the sort of thing that engineers like because of their preciseness. Chapter 9 in *Innovations in Safety Management: Addressing Career Knowledge Needs* is titled “Risk Scoring Systems,” and the following excerpts come from it.

Users of (risk scoring) systems should be inquisitive and cautious concerning their content, the meanings of the terms adopted, the numericals applied to the gradations within elements to be scored, and how they are applied in determining risk levels.

- Risk scorings begin with subjective judgments on the individual elements to be considered, and those subjective judgments are translated into numbers, not followed by any qualifying statements. What starts out as judgmental observations become finite numbers, which then attain an image of preciseness.

  Further, those numbers are multiplied or totaled to produce a risk score, giving the risk assessment process the appearance of having attained the status of science. In reality, the risk assessment process is as much art as science.

- The numbers assigned to the elements to be scored are entirely judgmental, have no basis in fact or good science, and vary for the same subject in different systems. There are no universally applied rules to assign value numbers to elements to be scored. All values in risk scoring systems reflect the experience and views of those who create the system.

- Frequency of exposure has, historically been one of the elements considered in determining event probability. But, giving frequency
COMMENTS ON HAZARDS AND RISKS

of exposure its own multiplier, separate from and in addition to a probability multiplier (as is done in at least one system obtaining notoriety), diminishes the needed emphasis on the severity of harm or damage that could result from an event.

- Meanings of the terms probability, likelihood, frequency of exposure or endangerment, and severity as used in risk scoring systems are not consistent. Also, it may be that within a system: a term may appear more than once and have different usages; and consistency in the meanings of the terms used initially in the system may not be maintained.

- If risk-scoring systems are applied rigidly whereby a higher score indicates a greater risk than a lower score, and the scores are not considered in light of the employee, community, social, and financial concerns of the organization, its best interests may not be well served. This applies especially to low probability events that may have severe consequences, for which risk scores may be low [p. 171].

Having considered all of the cautions in the foregoing, a three-dimensional risk scoring system, incorporating severity levels, frequency of exposure, and incident probability was developed. In the text material on the risk scoring system, the fact that subjective judgments are to be made in its use is stressed, terms are clearly defined, and a rigid and unqualified application of it in decision-making is discouraged. As is written in Innovations in Safety Management, this risk scoring model:

- Serves the needs of those who are more comfortable with statistics in their risk assessments
- Addresses the strong beliefs of those who want frequency of exposure given separate consideration in the risk assessment process (e.g., having frequency of exposure included as an element in a risk decision matrix was much debated in the meetings out of which the ANSI B11.TR3 report was developed)
- Maintains credibility and efficacy [p. 189].

After running many plausibility and efficacy tests, the following risk scoring formula was developed:

\[
\text{Risk score} = (\text{Probability rating} + \text{Frequency of exposure rating}) \\
\times \text{Severity rating}
\]

\[RS = (PR + FER) \times SR\]
Intelligent use of this risk scoring system is proposed. Users of it should recognize that the risk assessment process is as much art as science and that the statistical outcomes derived from its application are to be just one element in the decision-making.

ON RISK ESTIMATES THAT RESULT IN A MONEY NUMBER

Several authors propose that risk be expressed as a precise numerical quantification, in dollars. The computation would derive from a formula through which probability is multiplied by consequence to obtain the expected loss per unit of time or activity. This is a typical formula:

\[
\text{Risk (in money terms)} = \text{Probability} \times \text{Consequence}
\]

where probability is the event frequency per unit of time or unit of activity, and consequence is the amount of money loss or cost per event.

Similar formulas abound, intended to produce a finite, numerical quantification of risk in money terms. When a hazard analysis is completed, the outcome may sometimes be expressed in a money number representing the value applied to the harm or damage done. In safety management, why that money number must be multiplied by a probability number to obtain a risk cost per unit of time or activity is a mystery. A review of the literature does not give adequate explanation of the soundness of such an exercise for individual risks. The concept has validity in actuarial practice when dealing with large numbers of risks.

CONCLUSION

To be effective, safety professionals must understand hazards, risks, the relationship between hazards and risks, and hazards analysis and risk assessment techniques. In the use of hazard analysis and risk assessment matrices, judgments of incident probability and consequence will often be made on a subjective basis. And such systems can be made to work. They should be considered more art than science.

REFERENCES


HAZARD ANALYSIS AND RISK ASSESSMENT

INTRODUCTION

All hazards do not have equal potential for harm or damage. All hazards-related incidents do not have equal probability of occurrence. Nor will the adverse effects from those incidents be equal.

It is the norm that several hazards will be known to exist at the same time. Giving appropriate advice concerning them requires that

- Risk assessments be made, during which
  - hazards are identified, analyzed, and categorized as to the possible severity of harm or damage that could result and
  - estimates are given of the probability of hazards-related incidents occurring.
- Risks are ranked as to their significance and the priority that should be given them.
- Costs are determined of alternate proposals to reduce risks.
- Expected risk reduction benefits are given for each remediation proposal.

WHY EMPHASIZE HAZARD ANALYSIS AND RISK ASSESSMENT

Why make so much of analyzing hazards and assessing risks when dealing with several hazards at the same time? This, typically, is what happens.
A hazard is identified, and it is assumed that injury or illness or damage can result if the potential of the hazard is realized. Or a hazard may be considered a violation of a standard or regulation. Almost automatically, the safety practitioner presents a recommendation addressing the hazard to the decision-makers.

In that process, little thought is given to the significance of the hazard in relation to other hazards, to the priority it deserves, or to the possible effectiveness of the measures proposed to achieve risk reduction. That doesn’t speak well of real accomplishment or effective resource utilization.

In the real world, the safety professional has to recognize that:

- Some risks are more significant than others.
- Resources will always be limited, and staffing and money are never adequate to attend to all risks.
- The greatest good to employees, to employers, and to society is attained if available resources are applied to effectively and economically obtain risk reduction.

A safety professional implicitly has a responsibly to give the advice that results in

- Efficient use of resources, *on a priority basis*, to avoid, eliminate, or control hazards.
- Attaining a state for which the risks are judged to be acceptable.

**GIVING PRIORITY TO SEVERITY POTENTIAL**

Since resources are always limited, and since some risks are more significant than others, safety professionals must be capable of distinguishing the more important from the lesser important. They would, then, allocate the necessary time to those risks that have the greatest potential for severe harm or damage.

We can learn from what is known as Pareto’s law. Pareto observed from analyses of monetary patterns that the significant items in a group will usually constitute a relatively small portion of the total. Those in financial fields often refer to Pareto’s findings as the 80–20 rule, with 20% of the statistical body representing 80% of the total impact.

I have observed over the years, but not through scientific study, that Pareto’s principle applies generally to employee injuries and illnesses, fires, auto incidents, product liability incidents, and environmental incidents.
A study known as “The Vital Few” made by Employer’s of Wausau, an insurance company, indicates that

- 86% of total workers compensation injuries represent only 6% of the total cost;
- 14% of total injuries represent 94% of total costs; and
- 2% of total injuries (a part of the 14%) represent 70% of total costs.

This study included several hundred thousand cases. It supports Pareto’s premise. Obviously, the 14% of total injuries representing 94% of the total costs include the most severe injuries.

Experiences of individual organizations will not fit that distribution precisely. But many safety directors with rather large statistical bases have also observed that the principle applies, generally. For example, just previous to this writing, discussions were held with a safety director who had produced his own analysis of severity potential. His results showed that 15% of worker injuries represented 85% of total costs. These differences do not contradict the 80–20 rule; they support it. Whether the percentage of severe cases moves up or down a bit from the preciseness of the 80–20 rule is not significant. The premise holds: A relatively small percentage of total incidents represent a very large part of the financial impact.

Assume that resources are limited and that a safety professional assumes a shared responsibility for having resources effectively applied. When giving hazards management advice, priorities of the employee, the employer, and society in general would be considered. From all viewpoints, it is obvious that hazards presenting the potential for the most severe harm or damage, those for which consequences are most costly, should be given the highest priority.

Whatever the field of endeavor—occupational safety, occupational health, product safety, transportation safety, fire protection engineering, et cetera—Pareto’s law applies. And it prompts some interesting questions about whether we spend far too much time on the insignificant.

Chapter 8 is devoted to addressing severe injury potential. It makes the case that safety professionals must undertake separate and distinct activity to seek those hazards that present the most severe injury or damage potential so that they can be given priority consideration. To do that effectively, they must be capable of making hazards analyses and risk assessments.
SUBJECTIVITY IN HAZARDS ANALYSIS AND RISK ASSESSMENT

In Chapter 13, “Comments on Hazards and Risks,” I discussed the unlikeliness of having accurate numbers representing the probability of incident occurrence and the severity of their consequences in making hazards analyses and risk assessments. I suggested that safety professionals be wary of numerologists, and of scoring systems whose creators suggest that they are to be the ultimate factor on which decisions are based.

Through my personal experiences, I developed an awareness of the folly of making elaborate computations based on subjective assumptions. While making those elaborate computations may create the appearance of being scientific, the activity is unprofessional when the work being done is based on many subjective judgments.

Fire protection engineers on my staff made many computations of property damage and business interruption loss estimates for their clients. A reasonable-worst-case hazard and exposure scenario—a modeling of an event—would be written. It would include assumptions about hazards being realized, where on the property the incident would most likely occur, the value of the facilities and equipment in that area, and the monetary value of the damage to property that could occur. Clients provided the values of properties used in the computations, and they were often inaccurate.

If a chemical was involved and its release could produce a vapor cloud, assumptions were made about the quantity of material released, its characteristics, the point of release, the shape of the vapor cloud that would develop, wind direction and speed, the barometric pressure, et cetera.

Following a long-used concept, the energy potential of the released material was converted into an equivalency for TNT. Computations would be made and circles drawn on maps indicating blast overpressures in pounds per square inch. Damage levels were reduced as the distance from the blast point increased.

Forgetting the subjectivity of the original assumptions, infinite and excruciating computations expressed as dollar loss estimates were made for a variety of blast overpressure circles. That was done even though it was understood that if one of the assumptions originally made—the variables—was slightly changed, the outcome could be substantively different.

Client personnel would participate in developing hazard and exposure scenarios. They understood the impact of making changes in the variables for which assumptions had been made and that loss estimates at best would be largely subjective.
I made the decision that, for the purposes of producing such property loss estimates, we would make computations to define only the 3-psi damage circle and assume that the value of the salvage within that circle would equal the value of the damage outside the circle. That greatly limited the calculations and avoided the appearance of being overly scientific. Thus, the property damage loss estimate would be the equivalent of 100% of the value within the 3-psi circle. That became known, initially in jest, as the Manuele Theory of Loss Estimating. And it was applied by many.

Charles A. Pacella, then Vice President and National Coordinator for Property Services at M&M Protection Consultants, made a comparative study that included a loss estimating system used extensively in the United States, two such systems commonly used in Europe, and the Manuele Theory of Loss Estimating. He wrote that

The conclusion from this comparison is that the simplified method requires the least time and effort, has the fewest assumptions, and yields credible, realistic results.

Why should that history be relevant? It indicates that where subjective judgments prevail at the outset, little is gained in making laborious computations as the hazard analysis proceeds.

MAKING A HAZARD ANALYSIS PRECEDES AND IS NECESSARY TO CONCLUDING A RISK ASSESSMENT

Results of the loss estimate studies made by fire protection engineers represented the first part of a risk assessment. They began with hazard identification and, presuming that the hazard’s potential was realized, considered that which was exposed to determine the possible consequences. What was produced was a hazard analysis, always assuming the reasonable worst case.

Risk is expressed as a combination of the probability of a hazards-related incident occurring and the severity of harm or damage that could result. A hazard analysis concludes with an estimate of the severity of the consequences of a hazard being realized. A hazard analysis does not require that the probability of an incident occurring be determined. Estimating incident probability is the additional and following step necessary in concluding a risk assessment.

DEVELOPING A HAZARD ANALYSIS AND RISK ASSESSMENT MATRIX

While the literature speaks of many hazards analyses and risk assessment techniques, I propose that a safety professional develop a matrix and a thought process that suits client needs.
Several texts include hazard analysis and risk assessment decision matrices. Every matrix I found has been adopted from those included in what was originally known as *Military Standard—System Safety Program Requirements, MIL-STD-882*. Its most recent version is now named *Standard Practice for System Safety, MIL-STD-882D, 2000*. Influence of that standard will be obvious in the remainder of this chapter.

In considering the development of a matrix and a thought process for its application, an awareness of reality will help.

- Because of staffing and time constraints, it is not possible to know of or to analyze all hazards. Since all hazards are not equal, subjective but learned judgments will be necessary concerning which hazards to study.
- Be aware that some situations defy statistical analysis.
- Keep it simple: You don’t have to complicate things.
- Making hazards analyses and risk assessments is an art. It is not a science. Achieving absolute certainty in determining incident probability or consequence is not possible. A variation of a thought attributed to Descartes applies: If you can’t know the truth, you ought to seek the most probable.
- To communicate with decision makers, terms must have been defined and agreed upon. While identical terms may be used in the several hazard analysis methods described in the literature, those terms may be given different meanings in the text material describing them.
- Also, in communicating with decision makers, it would be well to understand their perceptions and tolerance of risk, and appreciate that perceived risks as well as elements of employee and public fear and dread, along with client interests, may impact on risk decisions.
- Implementing a logical hazard analysis and risk assessment model is more important than which model is chosen.

**HAZARD SEVERITY**

Hazard severity categories displayed in Tables 14.1 and 14.2 are to provide guidance in developing a hazard analysis/risk assessment matrix. As will be evident, severity categories can be applied to the many subsets of the practice of safety. Table 14.1 is a composite reflecting several sources, my own views, and particularly MIL-STD-882D. Table 14.2 is more specific in designating severity levels. It is an adaptation from MIL-STD-882D and Sverdrup Technology publications (with permission).
Table 14.1. Hazard severity categories

<table>
<thead>
<tr>
<th>Description</th>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>I</td>
<td>Death, permanent disability, system loss, devastating property damage or environmental damage</td>
</tr>
<tr>
<td>Critical</td>
<td>II</td>
<td>Severe injury or occupational illness, or major system, property, or environmental damage</td>
</tr>
<tr>
<td>Marginal</td>
<td>III</td>
<td>Minor injury or occupational illness, or minor system, property, or environmental damage</td>
</tr>
<tr>
<td>Negligible</td>
<td>IV</td>
<td>No occupational injury or illness, or system, property or environmental damage</td>
</tr>
</tbody>
</table>

Table 14.2. Hazard severity categories, adapted from MIL-STD-882D and Sverdrup Technology Publications

<table>
<thead>
<tr>
<th>Category: Descriptive Word</th>
<th>People, Employees, Public</th>
<th>Facilities, Product, or Equipment Loss</th>
<th>Operations Down Time</th>
<th>Environmental Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>Fatality</td>
<td>Exceeds $1M</td>
<td>Exceeds 4 months</td>
<td>Major event, requiring several years for recovery</td>
</tr>
<tr>
<td>Critical</td>
<td>Disabling injury or illness</td>
<td>250K to $1M</td>
<td>2 weeks to 4 months</td>
<td>Event requires 1–5 years for recovery</td>
</tr>
<tr>
<td>Marginal</td>
<td>Minor injury or illness</td>
<td>1K to 250K</td>
<td>1 day to 2 weeks</td>
<td>Recovery time is less than 1 year</td>
</tr>
<tr>
<td>Negligible</td>
<td>No injury or illness</td>
<td>Less than 1K</td>
<td>Less than 1 day</td>
<td>Minor damage, easily repaired</td>
</tr>
</tbody>
</table>

Adapting a variation of Tables 14.1 and 14.2 will require developing an understanding of what the terms selected are to mean in an individual operation. Particularly, definitions are necessary of the ranges of consequence to which the terms such as system loss or property damage, major or minor system or environmental damage, and severe and minor injury and occupational illness apply if comparable terms are to be used.

HAZARD PROBABILITY

The probability that a hazards-related incident will occur is to be described in probable occurrences per unit of time, events, population, items, or
HAZARD ANALYSIS AND RISK ASSESSMENT

activity. A qualitative probability may be derived from research, analysis, and evaluations of the historical safety data on similar systems, as well as from a composite of opinions of knowledgeable people. Supporting rationale for assigning a hazard probability should be documented. Table 14.3 is an example of a qualitative hazard probability ranking. It is my composite, but borrows from MIL-STD-882D and the Air Force System Safety Handbook.

Table 14.3. Hazard probability rankings

<table>
<thead>
<tr>
<th>Probability Level</th>
<th>Category</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent</td>
<td>A</td>
<td>Likely to occur repeatedly</td>
</tr>
<tr>
<td>Probable</td>
<td>B</td>
<td>Likely to occur several times</td>
</tr>
<tr>
<td>Occasional</td>
<td>C</td>
<td>Likely to occur sometime</td>
</tr>
<tr>
<td>Remote</td>
<td>D</td>
<td>Unlikely but possible to occur</td>
</tr>
<tr>
<td>Improbable</td>
<td>E</td>
<td>So unlikely, it can be assumed occurrence may not be experienced</td>
</tr>
</tbody>
</table>

Definitions apply for the selected unit of time, events, population, items, or activity.

ACHIEVING ACCEPTABLE RISK LEVELS

Use of a combination of the hazard severity and hazard probability tables given allow a qualitative assessment of risk from which determinations can be made that risks are acceptable, or not acceptable, and from which priorities can be set for actions to be taken.

It must be understood that the charts on hazard severity and probability are to serve only as guides and that definitions of terms within them must be refined to suit the needs of a particular operation.

For further guidance, three examples are given in Tables 14.4, 14.5 and 14.6 indicating how a combination of the hazard severity and probability charts can be used to develop qualitative risk assessments. Table 14.4 is a Risk Assessment Matrix. Table 14.5 sets forth Management Decision Levels pertaining to the risk categories in Table 14.4. Remedial action or acceptance levels must be attached to the risk categories to permit intelligent management decision-making. Possibilities set forth in Table 14.4 are to serve as a base of reflection for those who craft a risk assessment matrix.

Table 14.6 is a Hazard/Risk Assessment Matrix that also includes suggested action levels. It is an adaptation of one of two examples
Table 14.4. Risk assessment matrix

<table>
<thead>
<tr>
<th>Occurrence Probability</th>
<th>Severity of Consequence</th>
<th>Catastrophic</th>
<th>Critical</th>
<th>Marginal</th>
<th>Negligible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent</td>
<td>High</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Probable</td>
<td>High</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Occasional</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Remote</td>
<td>Serious</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Improbable</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

Table 14.5. Management decision levels

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Remedial Action or Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Operation not permissible</td>
</tr>
<tr>
<td>Serious</td>
<td>Remedial action to have high priority</td>
</tr>
<tr>
<td>Medium</td>
<td>Remedial action to be taken in appropriate time</td>
</tr>
<tr>
<td>Low</td>
<td>Risk is acceptable: remedial action discretionary</td>
</tr>
</tbody>
</table>

Table 14.6. Hazard/risk assessment matrix

<table>
<thead>
<tr>
<th>Occurrence Probability</th>
<th>Severity of Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>A — Frequent</td>
<td>1-A 2-A 3-A 4-A</td>
</tr>
<tr>
<td>B — Probable</td>
<td>1-B 2-B 3-B 4-B</td>
</tr>
<tr>
<td>C — Occasional</td>
<td>1-C 2-C 3-C 4-C</td>
</tr>
<tr>
<td>D — Remote</td>
<td>1-D 2-D 3-D 4-D</td>
</tr>
<tr>
<td>E — Improbable</td>
<td>1-E 2-E 3-E 4-E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazard Risk Index</th>
<th>Suggested Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-A, 1-B, 1-C, 2-A, 2-B, 3-A</td>
<td>Unacceptable: risk reduction action is necessary</td>
</tr>
<tr>
<td>1-D, 2-C, 2-D, 3-B, 3-C</td>
<td>Undesirable, written management decision required as to the corrective action to be taken, and when</td>
</tr>
<tr>
<td>1-E, 2-E, 3-D, 3-E, 4-A, 4-B</td>
<td>Acceptable, with management review</td>
</tr>
<tr>
<td>4-C, 4-D, 4-E</td>
<td>Acceptable, without management review</td>
</tr>
</tbody>
</table>

It must not be assumed that for the two “acceptable” categories, action is not to be taken to eliminate or control the hazards.

While the indication given in Table 14.5 for the “Low” risk category is “Risk is acceptable: remedial action discretionary,” that does not mean that action would not be taken to reduce risk if the remedial action could stand a cost–benefit test. Also, remedial action is taken in some such situations for personnel relations purposes to reduce the fear factor when the risk is perceived by workers to be more significant than it is.

Going through the exercise of creating and reaching agreement on a risk assessment matrix adds immensely to a safety practitioner’s effectiveness in communicating about risks and obtaining serious consideration of the remedial actions being recommended. That applies, whatever hazard analysis and risk assessment technique is used.

**RISK IMPACT**

To discriminate between hazards having the same hazard risk index, a risk impact determination is necessary. An impact determination consists of a review of the effect of an event economically, socially and politically. *(Example: Release of a small amount of chemical into a stream may not cause measurable physical damage, but extreme political and social damage could result.)*

**RESIDUAL RISKS**

No matter what actions are taken to avoid, eliminate, or control hazards, some residual risks will still exist. If the safety process meets its goal, none of the residual risks will be unacceptable for those operations undertaken or continued.

**CONDUCTING A HAZARD ANALYSIS AND A RISK ASSESSMENT**

For many hazards and the risks that derive from them, knowledge gained by safety practitioners through education and experience will lead to proper conclusions on how to attain an acceptable risk level, without bringing teams of people together for discussion. For the more complex situations, it is vital to seek the counsel of experienced personnel who are close to the work or process.

Reaching group consensus on the judgments made would be the goal. Sometimes, for what the safety practitioner considers obvious, having discussion and achieving consensus is still desirable so that buy-in is obtained for the actions to be taken and the expenditures to be made.
A general guide follows on how to make a hazard analysis, and then concluding with a risk assessment.

Whatever the simplicity or complexity of the hazard/risk situation, and whatever the analysis method used, the following thought and action process is applicable.

1. Establish the Analysis Parameters

Select a manageable task, system, process, or product to be analyzed, establish its boundaries and operating phase (standard operation, maintenance, startup), and define its interface with other tasks or systems, if appropriate.

Determine the scope of the analysis in terms of what can be harmed or damaged: people (the public, employees); property; equipment; productivity; and the environment.

2. Identify the Hazards

A frame of thinking should be adopted that gets to the bases of causal factors, which are hazards. This question would be asked: What are the characteristics of things or the actions or inactions of people that present a potential for harm.

Depending on the complexity of the hazardous situation, some or all of the following may apply.

- Use intuitive engineering and operational sense: This is paramount, throughout.
- Examine system specifications and expectations.
- Review codes, regulations, and consensus standards.
- Interview current or intended system users or operators.
- Consult checklists.
- Review studies from other similar systems.
- Consider the potential for unwanted energy releases and exposures to hazardous environments.
- Review historical data: industry experience, incident investigation reports, OSHA and National Safety Council data, manufacturer’s literature.
- Brainstorm.
3. Consider the Failure Modes

Define the possible failure modes that would result in realization of the potentials of hazards. Ask the question, How could the undesirable event happen?

4. Determine the Frequency and Duration of Exposure, and What is Exposed to Harm or Damage

For each harm or damage category selected in step 1 for the scope of the analysis (people, property, etc.), estimate the frequency and duration of exposure to the hazard (the frequency and duration of endangerment) and the number of people and the extent of the property that is exposed to harm or damage. This is a very important part of this exercise. More judgments than one might realize will be made in this process.

5. Assess the Severity of Consequences

Learned speculations are to be made on the consequences of an occurrence: the number of fatalities, injuries, or illnesses; the value of property or equipment damaged; the time for which productivity will be lost; and the extent of environmental damage. Historical data can be of great value as a baseline. On a subjective basis, the goal would be to decide on the worst credible consequences should an incident occur, not the worst conceivable consequence. When the severity of consequence is determined, a hazard analysis will have been completed.

6. Determine Occurrence Probability

Unless empirical data are available, and that would be a rarity, the process of selecting the probability of an incident occurring will again be subjective. For the more complex hazard scenario, brainstorming with knowledgeable people is advantageous.

Probability has to be related to an interval base of some sort, such as a unit of time or activity, events, units produced, or the life cycle of a facility, equipment, process, or a product.

7. Define the Risk

Conclude with a statement that addresses both the probability of an incident occurring and the expected severity of adverse results. Categorize each risk as acceptable or unacceptable.
8. Rank Risks in Priority Order

To properly communicate with decision makers, a risk ranking system should be adopted so that priorities can be established. Since the hazard analysis and risk assessment exercise is subjective, the risk ranking system would also be subjective.

9. Develop Remediation Proposals

When required by the results of the risk assessment, alternate proposals for the design and operational changes necessary to achieve an acceptable risk level would be recommended. In their order of effectiveness, the action listing shown in “The Safety Decision Hierarchy” mentioned in Chapter 15, “Acceptable Risk,” would be the base upon which remedial proposals are made. For each proposal, remediation cost would be determined and an estimate of its effectiveness in achieving risk reduction would be given.

Care should be taken that remedial actions do not introduce new hazards. If that occurs, the risk is to be reevaluated and other countermeasures proposed.

Having an accepted and well-understood risk assessment matrix makes reaching consensus easier to assess the severity of consequences, determine event probability, define the risk, and rank risks in priority order.

Although a hazard analysis and a risk assessment would result from applying the preceding outline, good management requires that the remaining steps in “The Safety Decision Hierarchy” be taken, which are — decide and take action, and measure for effectiveness.


RISK ASSESSMENT TECHNIQUES


As a beginning, a safety practitioner should be learned in at least three of those techniques. They are preliminary hazard analysis, what-if analysis, and failure modes and effects analysis. Comments follow on
those techniques, taken from the previously mention chapter titled “A Primer on Hazard Analysis and Risk Assessment” in *Innovations in Safety Management*.

**Preliminary Hazard Analysis (PHA)**

The original intent of the preliminary hazard analysis technique was to serve as the initial effort to identify and evaluate hazards in the early stages of the design process. But, in actual practice the technique has attained broader use. The principles on which preliminary hazard analyses are based are used not only in the initial design process, but also in reassessing the safety of existing products or operations.

For example, the hazard analysis and risk assessment requirements of the European Standard ISO 14121, *Safety of Machinery — Principles for risk assessment* (formerly EN 1050), have been adequately met in some companies in the design or redesign stages by applying an adaptation of the preliminary hazard analysis technique.

Furthermore, when simpler techniques (i.e., what-if analyses, checklist analyses) reveal hazardous situations needing additional review, the substance of the preliminary hazard analysis technique may be used. In reality, the technique needs a new name because it has achieved broader use than the original intent, which was as a preliminary assessment system to be used in early concept and design stages for a product or system.

Headings on preliminary hazard analysis forms will include the typical identification data: date, names of evaluators, department, and location. The following information is typically included in a preliminary hazard analysis form.

- A hazard description, sometimes called a hazard scenario.
- A description of the task, operation, system, or product being analyzed.
- Which exposures are the subject of the analysis: people (employees, the public); facility, product or equipment loss; operation downtime; environmental damage.
- The probability interval to be considered: unit of time or activity; events; units produced; life cycle.
- A numerical or alpha indicator for the severity of harm or damage that might result if the hazard’s potential is realized.
- A numerical or alpha indicator for the occurrence probability.
- A risk assessment code, using the agreed-upon risk assessment matrix.
- Remedial action to be taken, if risk reduction is needed.
A communication accompanies the analysis, explaining the assumptions made and the rationale for them. Comment would be made on the assignment of responsibilities for the remedial actions to be taken, and when. An example of a preliminary hazard analysis worksheet appears as Addendum A in this chapter, courtesy of Sverdrup Technologies, Inc. This form requires entry of severity, probability, and risks codes before and after countermeasures are taken.

**What-If Analysis**

For a what-if analysis, a group of people (as few as two, but often several more) would use a brainstorming approach to identify hazards, hazard scenarios, how incidents can occur, and what their probable consequences might be.

Questions posed in the brainstorming session may commence with What-if, as in “What if the air conditioning fails in the computer room?,” or may be expressions of more general concern, as in “I worry about the possibility of spillage and chemical contamination during truck offloading.”

In a typical procedure, all of the questions are recorded and then assigned for investigation. Each subject of concern is then addressed by one or more team members. They would consider the potential of the hazardous situation and the adequacy or inadequacy of risk management controls in effect, suggesting additional risk reduction measures if appropriate.

**Checklist Analysis**

Checklists are primarily used when published standards, codes, and commonly accepted industry practices exist. There are many such checklists. They consist of lists of questions pertaining to the applicable standards and practices — usually with a yes or no or not applicable response. Their purpose is to identify deviations from the expected, and thereby possible hazards. A checklist analysis requires a walk-through of the area to be surveyed.

Checklists are easy to use and provide a cost-effective way to identify customarily recognized hazards. Nevertheless, the quality of checklists is dependent on the experience of the people who develop them. Furthermore, they must be crafted to suit particular needs. If a checklist is not complete, the analysis may not identify some hazardous situations.

**What-If/Checklist Analysis**

A what-if/checklist hazard analysis technique combines the creative, brainstorming aspects of the what-if method with the systematic approach of the
checklist. The combination of techniques can compensate for the weaknesses of each. The what-if part of the process, using a brainstorming method, can help the team identify hazards that have the potential to be the causal factors for incidents, even though no such incidents have yet occurred. The checklist provides a systematic approach for review that can serve as an idea generator in the brainstorming process. Usually, a team experienced in the design, operation, and maintenance of the operation performs the technique. The number of people required depends, of course, on the operation’s complexity.

Failure Modes and Effects Analysis (FMEA)

In several industries (automobiles, semiconductors), failure modes and effects analysis has been the technique of choice by design engineers for reliability and safety considerations. They are used to evaluate (a) the ways in which equipment fails and (b) the response of the system to those failures. Although an FMEA is typically made early in the design process, the technique can also serve well as an analysis tool throughout the life of equipment or a process.

For each item of equipment, an FMEA produces qualitative, systematic lists that include the failure modes, the effects of each failure, safeguards that exist, and additional actions that may be necessary. For example, for a pump, the failure modes would include the following: fails to stop when required; stops when required to run; seal leaks or ruptures; and pump case leaks or ruptures. Both the immediate effects and the impact on other equipment would be recorded. Generally, when analyzing impacts, the probable worst case is assumed and analysts would conclude that existing safeguards are or are not sufficient.

Although an FMEA can be made by one person, it’s typical for a team to be appointed when there is complexity. In either case, the traditional process, as follows, is similar.

1. Identify the item or function to be analyzed.
2. Define the failure modes.
3. Record the failure causes.
4. Determine the failure effects.
5. Enter a severity code and a probability code for each effect.
6. Enter a risk code.
7. Record the actions required to reduce the risk to an acceptable level.

Note that the FMEA process described here requires entry of probability, severity, and risk codes. A typical FMEA form in which such
entries would be made is provided as Addendum B, courtesy of Sverdrup Technology, Inc.

The FMEA technique is principally a design and redesign analysis tool. Safety practitioners who become involved in the design aspects of safety would benefit greatly by having knowledge of the technique.

**INFLUENCE OF ORGANIZATIONAL CULTURE**

Incidents for which consequences are graded as catastrophic and critical must be addressed. Most such incidents would have low occurrence probabilities. In the decision-making for those events, an organization’s culture would be determinant—its values, its concern for its employees and the public, its sense of responsibility, and its assumptions with respect to the risk it can bear.

This sort of question, considered from many views, would be typically asked in the decision process: If it happens, can we stand it? Aspects of an organization’s culture cannot be fitted into a risk assessment system.

**INITIATING A HAZARD ANALYSIS AND RISK ASSESSMENT SYSTEM**

If a safety professional initiates a more formal procedure for hazard analysis and risk assessment, thought should be given to how those measures might succeed. It may be that what is being proposed requires a significant change in management practice. Thus, the concepts applicable in successfully achieving change would apply. Too much at one time may be disruptive.

A planned effort will be necessary to convince decision makers that the safety professional’s counsel on hazard analysis and risk assessment can be of value. Small steps forward, proving value, are recommended. In preparing for such an endeavor, I suggest that safety professionals:

- Develop an awareness of the risk tolerance beliefs held by decision makers.
- Study the approach to be made to decision makers; consider history, risk tolerance, their needs, and how decision makers could be influenced to conclude that what is being proposed is of value in their achieving their goals.
- Work with a team of knowledgeable people and obtain agreement on the benefits to be obtained from the use of an additional hazard analysis and risk assessment system, the methodologies to be used,
and the meanings of terms in the hazard analysis/risk assessment decision matrix developed.

• Determine which risks deserve priority consideration.
• Select one or two higher category hazard/risk situations.
• Follow the outline under “Conducting a Hazard Analysis/Risk Assessment.”
• Continue to try, assess, modify, and try again.

RESOURCES ON HAZARD ANALYSIS AND RISK ASSESSMENT

Many hazard analysis and risk assessment techniques have been developed. These are just a few of the methodologies mentioned in the literature: preliminary hazard analysis; gross hazard analysis; hazard criticality ranking; catastrophe analysis; change analysis; energy flow/barrier analysis; energy transfer analysis; event tree analysis; human factors review; the hazard totem pole; and double failure analysis. There are many other hazard analysis systems.

For an education in hazard analysis and risk assessment, these references are suggested.

• “A Compendium of Hazard Identification and Evaluation Techniques for System Safety Applications” by P. L. Clemens
• System Safety Engineering and Management by Harold E. Rowland and Brian Moriarty
• System Safety 2000 by Joe Stephenson
• System Safety Analysis Handbook, a Sourcebook for Safety Practitioners by Richard Stephan and Warner W. Talso
• MORT Safety Assurance Systems by William G. Johnson
• Safety and Health For Engineers by Roger L. Brauer
• Managing Risk: Systematic Loss Prevention For Executives by Vernon L. Grose
• Standard Practice for System Safety, MIL-STD-882D, Department of Defense
• Air Force System Safety Handbook

CONCLUSION

Professional safety practice requires that hazards be analyzed, that the risks deriving from those hazards be assessed, and that a risk ranking system be utilized. Also, it must be understood that hazard analysis is
the first step in the safety process, and that the quality of all other safety initiatives follows the quality of hazards analyses.

REFERENCES


## ADDENDUM A: PRELIMINARY HAZARD ANALYSIS FORM

### Sverdrup Technology, Inc.

**Preliminary Hazard Analysis**

(Brief Descriptive Title: Position of System/Sub-system/Operational Phases covered by this analysis):

<table>
<thead>
<tr>
<th>Probability Interval: 25 years</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Number:</td>
<td>Analysis: □ Initial □ Revision □ Addition</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazard No./Description</th>
<th>Hazard Target</th>
<th>Risk Before</th>
<th>Description of Countermeasures</th>
<th>Risk After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Identify countermeasures by appropriate code letter(s):</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D = Design Alteration  E = Engineered Safety Feature</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>S = Safety Device  W = Warning Device</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P = Procedures/Training</td>
<td></td>
</tr>
</tbody>
</table>

Prepared by/Date: __________________________

*Target Codes: P—Personnel  E—Equipment  T—Downtime  R—Product  V—Environment*

Approved by/Date: __________________________
### ADDENDUM B: FAILURE MODES AND EFFECTS ANALYSIS FORM

<table>
<thead>
<tr>
<th>IDENT. NO.</th>
<th>ITEM/ FUNCTIONAL IDENT.</th>
<th>FAILURE MODE</th>
<th>FAILURE CAUSE</th>
<th>FAILURE EFFECT</th>
<th>RISK ASSESSMENT</th>
</tr>
</thead>
<tbody>
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<td>SEV</td>
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</table>

<table>
<thead>
<tr>
<th>ACTION REQUIRED/REMARKS</th>
</tr>
</thead>
</table>

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**Hazard Analysis and Risk Assessment** (Page 125 in *Innovations in Safety Management*)
ACCEPTABLE RISK

INTRODUCTION

A majority of safety professionals accept the premise that absolute safety, a zero risk state, is not attainable. But, some safety practitioners profess that only a risk-free environment is acceptable. Consider these two examples.

1. At a recent safety conference, a speaker reviewed the hazard analysis and risk assessment methods used in his company and said the outcome to be achieved through the use of those methods was acceptable risk. During the question period, some questioners implied by the nature and tone of their questions that no risk is acceptable. They asked: What do you mean by acceptable risk? Are you suggesting that some risk is acceptable? Acceptable to whom?

The speaker gave a general response saying that a risk is acceptable if the probability of an incident occurring and the severity of harm that might result are low. Thus, the speaker defined the acceptable risk level for his company.

2. Safety practitioners attending a course on hazard analysis and risk reduction were outspoken in their opposition to the idea that any level of risk is acceptable. They stated their sincere belief that, in the workplace, attaining zero risk is a legitimate goal. The instructor could not convince them otherwise.
Individually and collectively we are risk acceptors. And risk acceptance is situational: Variations in the risk levels that individuals and organizations accept in given situations are exceptionally broad. Nevertheless, in an attempt to promote an understanding of the acceptable risk concept, this chapter does the following:

- Establishes that designing and operating to a zero risk level is not attainable.
- Provides definitions of key terms for an ongoing discussion.
- Shows how some entities have, in practice, defined acceptable risk levels.
- Provides examples illustrating the diverse views people have of risk acceptance in certain situations.
- Discusses imposed risks.
- Presents a methodology to achieve an acceptable risk level.

**ONLY RELATIVE SAFETY IS ACHIEVABLE**

The premise that absolute safety, a zero risk state, is not attainable has become broadly recognized, as evidenced by the following examples.

One of the most significant and influential books on the concept of acceptable risk was written by William W. Lowrance. Its title is *Of Acceptable Risk: Science and the Determination of Safety*. Lowrance notes that:

Nothing can be absolutely free of risk. One can’t think of anything that isn’t, under some circumstances, able to cause harm. Because nothing can be absolutely free of risk, nothing can be said to be absolutely safe. There are degrees of risk, and consequently there are degrees of safety [p. 8].

Since the taking of both personal and societal risks is inherent in human activity, there can be no hope of reducing all risks to zero. Rather, as when steering any course, we must continuously adjust our heading so as to enjoy the greatest benefit at the lowest risk cost [p. 11].

Under the caption “The Concept of Safety” (Section 5), this appears in the ISO/IEC Guide 51: Safety Aspects — Guidelines for Their Inclusion in Standards.*

There can be no absolute safety: some risk will remain, defined in this Guide as residual risk. Therefore a product, process or service can only be relatively safe.

---

*ISO stands for the International Organization for Standardization. IEC stands for the International Electrotechnical Commission.
Safety is achieved by reducing risk to a tolerable level, defined in this Guide as tolerable risk.

To repeat the previous quote from ISO/IEC Guide 51, “There can be no absolute safety: some risk will remain, defined in this Guide as residual risk.” In the real world, attaining zero risk, whether in the design process or in operations, is not possible. Nevertheless, the residual risk, after risk avoidance, elimination, or control measures are taken, should be acceptable, as judged by the decision makers.

For some situations, the residual risk may be high and still be considered by the participants in an activity to be acceptable. In other situations, no matter how effective the design and control measures, the residual risk will be judged to be unacceptable.

ON THE NATURE OF RISK

Risk is determined by assessing its two components: the severity of harm or damage resulting from a hazard-related event; and the probability that the event could occur. Table 15.1 presents a sample Risk Assessment Matrix, illustrating how these two factors are combined to obtain a risk level. A review of the many published risk assessment matrices appears in chapters titled “A Primer On Hazard Analysis And Risk Assessment” and “Risk Scoring Systems” in this authors book titled Innovations In Safety Management.

The purpose of a risk management matrix is to (a) provide a logical framework for hazard analysis and risk assessment and (b) assist risk decision makers in arriving at their risk reduction and risk acceptance or declination conclusions. The implicit goal is to achieve acceptable risk levels. Several standards and guidelines now include the concepts of residual risk and acceptable or tolerable risk (e.g., ANSI/B11 TR3, ISO/IEC Guide 51, SEMI S10—see references for full titles).

<table>
<thead>
<tr>
<th>Occurrence Probability</th>
<th>Severity of Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catastrophic</td>
</tr>
<tr>
<td>Frequent</td>
<td>High</td>
</tr>
<tr>
<td>Likely</td>
<td>High</td>
</tr>
<tr>
<td>Occasional</td>
<td>Serious</td>
</tr>
<tr>
<td>Remote</td>
<td>Serious</td>
</tr>
<tr>
<td>Improbable</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Achieving understanding of the terms used in risk assessment matrices is vital for their use in a particular organization. For example, in actual practice, a variety of definitions are used of the terms establishing probability and severity levels, as in Table 15.1. Terms applicable to a discussion of acceptable risk are presented in the following definitions.

DEFINITIONS AND COMMENTS

The following is typical of what is becoming universally accepted language with respect to hazards and risks. The section numbers appearing after some definitions refer to the ISO/IEC Guide 51.

- **A hazard** is defined as the potential source of harm (3.5). Hazards include both the characteristics of things and the actions or inactions of people. Identifying hazardous human error potential, as well as the physical aspects of hazards, is an important part of the hazard identification process. All risks with which safety practitioners deal derive from hazards. There are no exceptions. For any particular hazard, the first and best approach is to eliminate the hazard. If there are no potentials for harm, there are no hazards. If there are no hazards, there are no risks. Hazards eliminated result in zero risk from those hazards. But, it is not possible to eliminate all hazards.

- **Probability** is defined as the likelihood of a hazard being realized and initiating an event or series of events that could result in harm or damage — for the selected unit of time, events, population, items or activity.

- **Residual risk** is defined as the risk remaining after protective measures have been taken (3.9).

- **Risk** is defined as a combination of the probability of occurrence of harm and the severity of that harm (3.2).

- **Safety** is defined as freedom from unacceptable risk (3.1).
  
  *An alternate.* To avoid the negative, I have defined safety as that state for which the risks are judged to be acceptable.

- **Severity** is defined as the worst credible consequence should a hazard-related incident occur.

- **Tolerable risk** is defined as that risk which is accepted in a given context based on the current values of society (3.7).
  
  *An alternate.* For those who prefer to deal in terms of acceptable risk, the definition just given is reversible. Thus, acceptable risk is defined as that risk which is tolerated in a given context based on current values of society.
A MATTER OF SEMANTICS

Meanings variously given to the terms acceptable risk and tolerable risk present a semantics problem. For some people, the terms are synonyms; for others, they have markedly different meanings. Dictionary definitions of acceptable and tolerable differ slightly. Two descriptions for each term follow.

Acceptable:  
1. Capable or worthy of being accepted
2. Pleasing to the receiver, satisfactory, agreeable, welcome

Tolerable:  
1. Capable of being tolerated, endurable
2. Fairly good, not so bad

In these definitions, tolerable as a term is less demanding: endurable, but only fairly good, not so bad. To be acceptable, the risk level should be satisfactory and agreeable, in accord with the dictionary definition.

Even though these dictionary definitions differ slightly, in daily practice they are commonly used as synonyms. In Roget’s Thesaurus, tolerable is given as a possible replacement for acceptable, and thus as a synonym. Although there may be a small technical difference between the terms acceptable and tolerable, they can and should be accepted as synonyms. Continued and interchangeable use will lessen the debate over which term should be used. (As I have witnessed, such debates can be vigorous.)

EXAMPLES OF ACCEPTABLE RISK

Real-world descriptions of acceptable risk levels are demonstrated by these examples. They vary considerably.

1. NASA-STD-8719.7, January 1998 defines Acceptable Risk as follows:

   Loss of life as a result of hazards in this facility is unlikely. Hazards may result in no lost workday injuries or no restricted duty cases, loss of facility operational capability of less than 1 day, or damage to equipment or property less than $25,000.

2. In a major manufacturer of heavy mobile equipment, if it can be reasonably assumed that a user of the equipment can lose a day’s work, the risk is not acceptable. The risk situation must be dealt with through equipment redesign or through strengthening the operations manual, thus alerting users to the hazard’s potential and providing appropriate instructions.

3. In a smaller operation, the design and operation standard requires that if a hazard presents the potential for injury that requires medical
treatment beyond first aid, the risk deriving from that hazard must be reduced to a level to avoid such injury to be considered acceptable.

**USING RISK DECISION MATRICES TO ACHIEVE ACCEPTABLE RISK LEVELS**

Earlier in this chapter, reference was made to a speaker who reviewed the hazard analysis and risk assessment methods used in his company, which relied on typical risk assessment and decision-making matrices, to achieve acceptable risk levels. Use of such matrices is a method some organizations apply to arrive at acceptable risk levels. Table 15.1 is an example of such a risk assessment matrix. Using the results from Table 15.1, levels of remedial action or risk acceptance for individual risk categories can be established, as in Table 15.2.

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Remedial Action, or Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Operation not permissible</td>
</tr>
<tr>
<td>Serious</td>
<td>Remedial action to have high priority</td>
</tr>
<tr>
<td>Moderate</td>
<td>Remedial action to be taken in appropriate time</td>
</tr>
<tr>
<td>Low</td>
<td>Risk is acceptable; remedial action discretionary</td>
</tr>
</tbody>
</table>

Table 15.2 is a guide: It is not intended to imply that, in all situations, an activity is to proceed only if the risk is in the “low” risk category. Furthermore, while in Table 15.2 the indication given for the “low” risk category is “Risk is acceptable; remedial action discretionary,” that does not mean that action would not be taken to reduce the risk if the remedial action could stand a cost–benefit test. Also, remedial action is taken in some such situations for personnel relations purposes to reduce the fear factor when the risk is perceived by workers to be more significant than it is.

**DIVERSE VIEWS**

A review of several real-world situations follows to provide examples of the diverse views that people have about acceptable risk.

1. Consider these excerpts from an extensive article on auto racing that appeared in the February 14, 2001 issue of the *Chicago Tribune*. Its title is “A risky profession becomes a little safer.”
Mario Andretti is quoted as saying: At the beginning of a season, I would look around at a drivers’ meeting and I would think, ‘I wonder who’s not going to be here at the end.’ There were years when we lost as many as six guys.

A history of fatalities in auto racing is given in the article, as well as the notable measures taken over the years to make racing less risky. Nevertheless, the number of driver fatalities in relation to the number of drivers involved would be considered unacceptable in other employment settings.

The article continues with a reference to Richard Petty, who, it says, in his 35 years of NASCAR racing often admonished his wife:

If I get killed, if you ever sue anybody over it, I will haunt you. I know the risk. I take all the responsibility.

Auto racing is a form of employment. Drivers, auto owners, promoters, television broadcasters, and viewers are aware of the risks, and apparently they accept them. No public outcry has arisen concerning this high-risk activity. To the contrary, it has been reported that the numbers of television viewers for auto racing continues to increase. This suggests that in certain instances relatively high risks are considered acceptable to both individuals and society.

2. The following appears in a paper titled “Spacecraft Human-Rating System Safety — Beyond the Numbers” by D. F. Kip Mikula.

In the 21st century, new human-rated spacecraft for Earth-to-orbit, on-orbit transfer and work (including space suits), long term on-orbit living, and return from Earth orbit will be appearing on the horizon. Each of these must, as a minimum due to their human-rating, be designed to be safe for those human operators, passengers, and occupants. In particular, these humans must be safe from the risk of death or serious and minor injury (i.e., casualty).

In defining the human-rating requirements for these vehicles, NASA document JSC 28354 Human Rating Requirements has been published. Among other requirements for such things as crew escape, this document has established a Loss of Crew (LOC) probability risk requirement of 1 in 10,000 missions. Stated another way, this requirement equates to a probability of success of 0.9999. This means that over a period of time encompassing 10,000 missions of a specific human-rated space vehicle design that only one casualty will occur. In addition, the document also establishes a Loss of Vehicle (LOV) probability requirement of 1 in 1,000 missions.
Is the risk acceptable? When I asked a group of safety practitioners if the risk of 1 failure resulting in Loss of Crew (LOC) in 10,000 missions was acceptable, their overwhelming response was no. But, they could not reach a consensus to recommend the complete shutdown of space ventures. Those taking part in journeys to outer space are aware of the risks and volunteer for the opportunity to be astronauts, which is a form of employment. So, the managers at NASA and the Congressional Committees that provide oversight to NASA are also aware of the risks. And space ventures will continue.

Understandably, the level of acceptable risk in operations where most safety practitioners have influence is much lower than those tolerated in space ventures. For example, a major equipment failure of 1 in 1000 startups — the NASA design standard for Loss of Vehicle (LOV) probability — would be unacceptable in all but the exceptionally unusual situation.

3. Now to get the discussion down to a more mundane subject, one in which most all safety practitioners participate — motor vehicle operation. According to Injury Facts, 2001 Edition, a National Safety Council publication, motor vehicle operation resulted in 43,000 fatalities in the United States in 2000, and 2,300,000 persons sustained disabling injuries (p. 82). Assume a U.S. population of 283,800,000; the probability of a resident, on average, being killed in an auto accident in 2000 was 1 in 6600. The probability of sustaining a disabling injury was 1 in 123.

Those are serious odds, on the negative side. Nevertheless, we continue to drive. Is the risk acceptable? Or are we engaging in a tolerable activity to which the dictionary definition “fairly good; not so bad” applies, and we accept the risks?

Admittedly, we expect a continuing effort to make motor vehicle transportation safer and presume that the risks will be reduced. But, presently, no matter how skilled a person may be as a defensive driver, the risk of fatality or disabling injury is substantial while in traffic. It is never zero. Always, the probability exists of being injured by the actions of another driver.

DESIGNING BEYOND STANDARDS

Many authors have written on the benefits of designing to exceed the requirements of published standards. Achieving an acceptable risk level very often requires doing so. Complying with industry or government standards (e.g., OSHA, ANSI, European Community) will meet the consensus arrived at by the industry or government group that wrote the
standard. However, complying with such standards will not necessarily achieve an acceptable risk level.

To give an example, a learned colleague frequently reminds me that complying with the National Electrical Safety Code or the applicable OSHA lockout/tagout standard will not ensure that electrical disconnects are placed in locations conducive to employee use. All too often, the design of lockout/tagout systems is error-provocative, thus encouraging hazardous human error. Although the design complies with the standards, the residual risk may be unacceptable.

Ergonomic design practices offer another example of how designing to the prevalent norm for the workplace may result in unacceptable residual risk. A common ergonomic design practice is to develop designs that accommodate the 5th to 95th percentile of the target users. Examples of the criteria used are stature, reach, strength, et cetera. Typically, ergonomics design and operations standards that address the dimensions and capabilities of these 90% of the work population are considered acceptable. As a result, there will be some residual ergonomics risks with respect to those in the lower and upper 5% of the population that prove to be excessive.

Furthermore, consider OSHA’s permissible exposure limits for hazardous substances or the guidelines in that field issued by the American Conference of Governmental Industrial Hygienists. Although exposure limits are established, it is not presumed that all persons will avoid illness at those levels. Thus, in some companies, say their safety directors, the intent is to achieve operating exposure limits considerably less than generally accepted standards. These companies have set a goal to achieve superior, world-class safety records and have recognized that to do so they must operate at exposure levels lower than the standards. However, they also recognize that even at these improved levels, some small amounts of residual risk remain.

**IMPOSED RISKS**

Literature is abundant on the opposition people have to risks they believe to be imposed on them. For some safety practitioners, their resistance to the acceptable risk concept derives from their view that imposed risks are objectionable and are to be rebelled against. Conversely, they accept the risks of activities in which they choose to engage—for example, skiing, bicycle riding, driving an automobile.

In the occupational setting, risks are mostly imposed. Joe Stephenson got it right when he wrote this in *System Safety 2000*.
The safety of an operation is determined long before the people, procedures, and plant and hardware come together at the work site to perform a given task [p. 10].

Start from the beginning: Consider, first, a site survey for ecological considerations, and move into the construction and fitting out of a facility. Thousands of safety-related decisions are made in the design process that result in an imposed level of risk. Usually, those decisions meet (or exceed) applicable safety-related codes and standards with respect to such as (to name but a few): the contour of exterior grounds; sidewalks and parking lots; building foundations; facility layout and configuration; floor materials; roof supports; process selection and design; determination of the work methods; aisle spacing; traffic flow; hardware; equipment; tooling; materials to be used; energy choices and controls; lighting, heating, and ventilation; fire protection; and environmental concerns.

Designers and engineers make decisions on the foregoing in the original design process. Those decisions establish what the designers implicitly believe to be acceptable risk levels. Thus, the risk levels are largely imposed, once a facility is in place and operating. Some may accept that realization only reluctantly, but that’s the real world. Safety practitioners, and others, can rail about the undesirability of risks being imposed in the occupational setting if they choose, but the energy expended in so doing is largely a waste.

W. Edwards Deming’s 85–15 Rule has a bearing on this discussion. Mary Walton, a Deming colleague, cites the rule in *The Deming Management Method*:

> The Rule holds that 85 percent of the problems in any operation are within the system and are the responsibly of management, while only 15 percent lie with the worker” [p. 242].

Although the 85–15 Rule pertains to quality, the concept also applies to safety. Quality, safety, and risk problems in a system derive from the decisions made in creating or redesigning the system. Thus, the work system, for both quality and safety, is largely imposed through the design process. (For further discussion of quality management and safety management similarities, see Chapter 20, “On Quality Management and the Practice of Safety.”)

**THE ILLUSIVENESS OF A UNIVERSAL DEFINITION OF ACCEPTABLE RISK**

When commencing this chapter, one intent was to develop a definition of acceptable risk that was universally applicable in all risk situations — one
that was more specific than the prevailing general definitions, such as previously given here. Unfortunately, the original intent proved to be illusive.

Although the concept of acceptable risk is becoming more commonly adopted throughout the world, definitions of the term acceptable risk can only be generally written. While it can be said that safety is that state for which the risks are judged to be acceptable, and that tolerable risk is defined as that risk which is accepted in a given context based on the current values of society, applications of those premises in individual situations result in great variations.

Acceptable risk is a function of many factors, and it varies considerably across industries — for example, mining versus medical devices versus farming. Even within a single global company, the acceptable risk levels can vary. The culture dominant in a company and the culture of a country in which a facility is domiciled play an important role in risk acceptability as has been experienced by safety colleagues working in global companies. Training, experience, and resources can also influence acceptable risk levels. Risk acceptability is also time-dependent, in that what is acceptable today may not be acceptable tomorrow, next year, or the next decade.

I believe that developing a distinct and numerically explicit definition of an acceptable risk level that is universally applicable is not possible. There are so many variables.

A METHODOLOGY TO ACHIEVE AN ACCEPTABLE RISK LEVEL

If the residual risk for a task or operation is never zero, for what risk level does one strive? At best, we can say that the concept of designing and operating to attain risk levels as low as reasonably achievable or practicable should be applied to the situation being considered.

ALARA and ALARP are commonly used acronyms in risk assessment and reduction activities. ALARA stands for as low as reasonably achievable; ALARP is short for as low as reasonably practicable. Although now broadly used, ALARA originated in the atomic energy field. This is taken from the Reference Library, Glossary of Terms at www.nrc.gov.

ALARA: Acronym for “As Low As Reasonably Achievable,” means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in
relation to utilization of nuclear energy and licensed materials in the public interest (see 10/CFR 20.1003).

The concepts inherent in the terms ALARA and ALARP serve as guidelines in determining whether a risk is acceptable, but cannot be used as absolutes in decision-making. It should be understood that in an exceptional situation, even though the risk level attained is as low as reasonably achievable or practicable, a decision will be made that the residual risk is not acceptable and that the operation should not proceed.

The concept embodied in the terms ALARA and ALARP applies to the design of products, facilities, equipment, and the work environment. (If there is a substantive difference between the intent of ALARA and ALARP, it’s difficult to establish.)

Determining whether a risk is acceptable requires consideration of many variables. An additional excerpt from ISO/IEC Guide 51, Section 5, helps in understanding the concept of designing and operating for risk levels as low as reasonably practicable.

Tolerable risk is determined by the search for an optimal balance between the ideal of absolute safety and the demands to be met by a product, process or service, and factors such as benefit to the user, suitability for purpose, cost effectiveness, and conventions of the society concerned.

In the real world of decision-making, benefits represented by the amount of risk reduction to be obtained, and the costs to achieve those reductions, become important factors. Trade-offs are frequent and necessary. An appropriate goal in those deliberations is to have the residual risk be as low as reasonably achievable.

Ensuring that a high level of risk avoidance, elimination, or control is achieved in new or altered facilities and equipment requires considerable effort. Ideally, safety practitioners should be a part of, and influential in, the design processes; the earlier, the better. More specifically, organizations need to work toward

- Having effective design safety standards in place
- Establishing and rigidly applying safety specifications for equipment and materials to be followed by suppliers
- Requiring documented risk assessments
- Implementing and supporting design safety review systems that impact decision-making

To assist those who are to decide if a risk is acceptable, a guide follows, in Figure 15.1, captioned “The Safety Decision Hierarchy.” It
A. Problem Identification and Analysis
1. Identify and analyze hazards
2. Assess the risks

B. Consider These Actions, in Their Order of Effectiveness

![Diagram]

1. Eliminate hazards and risks through system design and redesign
2. Reduce risks by substituting less hazardous methods or materials
3. Incorporate safety devices
4. Provide warning systems
5. Apply administrative controls (work methods, training, etc.)
6. Provide personal protective equipment

C. Decide and Take Action

D. Measure for Effectiveness: Re-Analyze as Needed

Figure 15.1. The safety decision hierarchy.

is taken from the book *Innovations in Safety Management*. This hierarchy encompasses hazard identification and analysis and risk assessment, the appropriate risk reduction actions, applied in an order of effectiveness — within a sound problem-solving methodology.

As in any sound problem-solving technique, the process commences with identifying and analyzing the problem — that is, identifying and analyzing hazards and assessing the risks. Having done so, risk reduction actions are then taken, in accord with a hierarchy of effectiveness.

In the use of this hierarchy, the terms contained in the definition previously given of ALARA are relevant:

- Making every reasonable effort
- Consistent with the purpose undertaken
- The state of technology
- The economics of improvements in relation to benefits

Comments follow in support of the logic for the risk reduction actions and the significance of their order of effectiveness. They are excerpted from the chapter “The Safety Decision Hierarchy” in *Innovations in Safety Management*. In all but the rare situation, application of this hierarchy will result in attaining an acceptable risk level.
LOGIC IN SUPPORT OF THE SAFETY DECISION HIERARCHY

1. If the hazards are eliminated in the design and redesign processes, risks that derive from those hazards are also eliminated. If there are no hazards, there is no potential for harm and, thereby, no risk. Obviously, hazard elimination is the most effective way to eliminate risk.

2. By substituting less hazardous methods or materials (e.g., using automated material handling equipment rather than manual material handling, using a less hazardous degreasing material), risks can be substantially reduced in the operations or product design and redesign process, and reliance on the performance of people is minimized.

3. When safety devices are incorporated in the system or product in the form of engineering controls, risk reduction can markedly be achieved and reliance on the worker or product user is further reduced.

4. Warning signs, labels, and instructions have been partially effective. Warning systems are reactionary. They alert persons only after the development of a situation for which a hazard’s potential is in the process of being realized (e.g., the smoke alarm in a house). Warning system effectiveness relies considerably on training, the quality of maintenance, and people reactions.

5. Administrative controls, only some of which are included here, rely entirely on the performance of people, for whom to err is human. Some administrative controls are: development of appropriate work methods and procedures, personnel selection, training, supervision, motivation, work scheduling, job rotation, scheduled rest periods, maintenance, management of change, investigations, inspections, and behavior modification.

6. The proper use of personal protective equipment relies on an extensive series of supervisory and personnel actions, such as the identification of the equipment needed, its selection, fitting, training, inspection, maintenance, et cetera.

In accord with good problem-solving techniques, the subsequent steps are to (a) decide upon and take action and (b) measure for the effectiveness of the actions taken, reanalyzing as needed.

CONCLUSIONS

Comments follow, based on the study made of the concept of acceptable risk.

1. We must accept that a state of zero risk cannot exist where hazards have not been eliminated.
2. Where hazards cannot be eliminated, the goal should be to reduce risks so that the residual risks are acceptable.

3. It should be recognized that application of The Safety Decision Hierarchy will, in all but the exceptional situations, attain an acceptable risk level.

4. The safety community should debate and consider accepting the proposed definitions for the terms defined herein.

5. The terms acceptable risk and tolerable risk should be considered synonyms rather than as having distinct and different meanings.

6. Risk assessments and the risk decision process should become more structured and documented in accordance with recent guidelines and standards, such as B11.TR3, SEMI S10, ANSI/RIA R15.06-1999, and ISO 14 121 (previously identified as EN 1050).

7. We should recognize that a universally applicable definition of an acceptable risk level cannot be attained, other than in broad general terms, because of the many variables in individual risk situations.

As has been noted here, some safety standards and guidelines issued in recent years include provisions for hazard analysis and risk assessment. That progression will continue, and its impact will be extensively felt. Those standards and guidelines recognize that, even though hazard avoidance, elimination, and control measures are taken, there will always be residual risk, and that such risk should be acceptable—or tolerable, if you prefer.

Having knowledge of hazard analysis and risk assessment methods and the concept of acceptable risk has become a necessity for the professional practice of safety.

*Note*: A brief version of this chapter appeared as an article in the January 2002 issue of *Occupational Hazards*. Bruce Main, PE, CSP, President of Design Safety Engineering, was a contributor.

**REFERENCES**


SAFETY PROFESSIONALS AND THE DESIGN PROCESS

INTRODUCTION

To effectively assist clients to avoid bringing hazards into the workplace and to minimize the distribution of hazardous products, safety professionals must influence the design process. Their purpose would be to provide counsel to designers and engineers with respect to the identification, analysis, and assessment of hazards and risks.

Many of the chapters in this book speak of the implications of design and engineering within the practice of safety. We are compelled, as professionals, to take into account the recognition that evolved that engineering is the preferred course of action to avoid, eliminate, or control hazards. For the greatest effectiveness in recognizing hazards and treating with the risks that drive from them, the design and engineering considerations should be addressed in the concept stages of project, process, or product development.

For all but a few safety professionals, what I propose is an entirely new venture—that they undertake to influence design decisions and acquisition and purchasing practices. That requires taking an anticipatory approach to safety, rather than being reactive. This new venture spells opportunity.

For many years, I have believed that the greatest strides forward with respect to safety, health, and the environment are being made in the design
process. Slowly, a greater awareness has emerged of the soundness of that premise. Recent developments lead to the conclusion that, over time, the level of safety achieved will relate directly to the caliber of the design of facilities, hardware, equipment, tooling, operations layout, the work environment, the work methods, and products. Design, as the term is used here, encompasses all processes applied in devising a system to achieve results.

SOME HISTORY, AND A VIEW OF THE FUTURE

When I first entered the safety profession, almost all of the work done was of an engineering nature and dealt primarily with the physical aspects of facilities and equipment. Quite often, the three E’s—engineering, education, and enforcement—were cited in the literature as the foundation for the practice of safety. And engineering was quite prominent in what we did.

Then came the behaviorists and the management systems people, who have had a significant influence on the safety profession. Their premises are based on the belief that about 90% of all industrial accidents are caused primarily by employee unsafe acts. Some safety professionals, being greatly influenced by those who profess that the worker is the problem, give minimum attention to the influence of design and engineering decisions on incident causation.

A few prominent writers would have you believe that behavior modification, training, and management systems (consisting largely of what is referred to in OSHA literature as administrative controls) are almost the entirety of the practice of safety. How absurd!

Yet, in one subset of hazards management, the principal emphasis has been on design and engineering, with great success. Fire protection engineers have achieved an earned recognition for their capabilities as design consultants and are often brought into discussions by architects and engineers who seek their counsel on design specifications. (Some of the clients to which fire protection engineers on my staff provided counsel established an understanding with architects, engineers, and contractors that construction for a new project was not to be commenced until our fire protection consultants approved the design specifications for the fire protection system.)

Obviously, then, it can be done. Others engaged in the practice of safety can learn from the successes of fire protection professionals.

Very little safety literature published in the last 20 years contained references to the design and engineering aspects of hazards management. Until recently, design and engineering considerations had largely fallen out
SAFETY PROFESSIONALS AND THE DESIGN PROCESS

of our concerns, unless they were imposed on us by legislation. But, that
is changing and the astute safety practitioner will observe the significance
of the changes and recognize that they spell opportunity.

RECENT DEVELOPMENTS AFFECTING THE PLACE OF DESIGN
AND ENGINEERING IN THE PRACTICE OF SAFETY

In the six years since the second edition of On the Practice of Safety
was published, several developments have taken place that require or
propose that hazards be recognized and analyzed in the design process
and that risk assessments be made toward achieving an acceptable risk
level. Safety practitioners — pay attention. Comments on some of those
developments follow.

European Influence

Standards adopted by the European Community for Standardization gov-
erning the safety of workplace machinery have had considerable impact
on American manufacturers who export machinery to Europe. There are
several European Committee standards governing the safety of equipment
that is to go into the workplace. Two are particularly pertinent here: They
are EN 292 and ISO 14121 (formerly known as EN 1050).

Standard EN 292 has two parts. Part 1 is titled Safety of machin-
ery — Basic concepts, general principles for design. It covers basic ter-
minology and methodology. Part 2 covers Technical principles and spec-
fications. Although this standard was published in 1991, its full impact
was not felt until 1997.

EN 292 requires that hazards be identified and risks be assessed in the
design process for machinery and equipment that is to go into a workplace.
Manufacturers who sell such equipment to buyers in the European Com-

munity are to apply a “CE” mark, a label, indicating that the requirements
of EN 292 have been met.

But EN 292 does not include a methodology to identify hazards and
assess risks. To clarify the intent of EN 292 and to provide a frame-
work manufacturers could consider, standard EN1050 was developed and
published in 1997. Its title is Safety of machinery — Principles for risk
assessment. In 1999, EN 1050 was adopted by the International Com-
mittee for Standardization as International Standard ISO 14121, without
change. ISO 14121 does what it purports to do: It sets forth a hazard
identification and risk assessment methodology.

Many companies now have designated personnel on their staffs to see
that the hazard analysis and risk assessment requirements of the European
standards are followed.
Robotics

A noteworthy first was achieved in the United States when approval was given in June 1999 for ANSI/RIA R15.06–1999, which is the *American National Standard for Industrial Robots and Robot Systems—Safety Requirements*. The Robotic Industries Association is the Secretariat for the Standard.

Why should generalists in the practice of safety whose field of influence does not include robots pay attention to this standard? This is the first occupational safety standard issued by the American National Standards Institute in which conducting a comprehensive risk assessment is presented as a means to determine the design requirements, the safeguarding to be applied, and the subsequent administrative controls that may be needed.

Other standards writing groups are paying attention to this robotics standard. That further suggests that safety practitioners whose work is influenced by ANSI standards should become proficient in hazard analysis and risk assessment methods because those methodologies may be applied in the original design process or in subsequent redesign activities.

B11.TR3

A subcommittee formed by the Machine Tool Safety Standards Committee (B11) of the American National Standards Institute (ANSI) adopted the acronym TR3 to designate its work. TR stands for technical report. The Committee, B11.TR3, has issued a document titled *Risk assessment and reduction—A guideline to estimate, evaluate and reduce risks associated with machine tools*. The Secretariat for this work is The Association for Manufacturing Technology. TR3 became a registered document at ANSI in November 2000.

This guideline has already had a broad impact on the machine tool industry and its design, hazard analysis, and risk assessment provisions will influence many standards. Also, since other standards writing groups have noted that *the content of the guideline is largely generic*, they have acquired the document for their consideration. Over time, this guideline will have significant impact.

Lockout/Tagout

An accredited ANSI standards committee is working on a revision of ANSI Z244, titled *Control of Hazardous Energy—Lockout/Tagout and Alternative Methods*. Its June 2002 draft requires that a risk assessment be performed in the design of lockout/tagout systems to determine the
need for and design sufficiency of appropriate energy isolating devices and systems.

This revision of an important ANSI standard is another indication of a trend, which emphasizes the need for safety practitioners to have knowledge of hazard analysis and risk assessment techniques. Almost all businesses and industries have lockout/tagout needs.

**Aviation Ground Safety**

The International Air Transport Section of the National Safety Council achieved one of the most interesting innovations in recent years regarding hazard analysis and risk assessment. This group is truly international: Its *Aviation Ground Operation Safety Handbook* is used throughout the world. A fifth edition was published in July 2000.

New material titled “Risk Management Guide for the Aviation Industry” is contained in the Handbook. This publication pertains to aviation ground safety. These excerpts are taken from the Introduction to that material.

Risk management takes aviation safety to the next level. It is a six-step logic-based, common approach to making calculated decisions on human, material, and environmental factors before, during and after operations. Risk management enables senior leaders, functional managers, supervisors and individuals to maximize opportunities for success while minimizing risks.

The air transport group has outlined a way of thinking about and dealing with hazards and risks, applying a logical and sequential methodology. They have developed a unique “process to detect, assess, and control risk.”

**The Semiconductor Industry**

Guidelines issued by the semiconductor industry provide another indication of a trade association having recognized the value of hazard analysis and risk assessments in the design process to eliminate or control hazards and to attain acceptable risk levels. To do what the issued guidelines propose requires that manufacturers have personnel on their staffs who are skilled in hazard analysis and risk assessment.

SEMI S2-0200 is titled *Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment*. It applies principally to suppliers and what they are to do with respect to hazards and risks in the design and manufacturing process.

SEMI S10 is titled *Safety Guideline for Risk Assessment*. This is the purpose of S10.
This document provides a method for assessing the risk associated with any hazard and for ranking different hazards according to the risks they present. The method can be used to differentiate between those hazards which are acceptable and others which require further mitigation to reduce their risk to acceptable levels.

Procedures set forth establish that, in the risk assessment process, both the expected severity of consequences of an incident resulting from a hazard’s potential being realized and the probability of its occurrence be evaluated. In a logical sequence, the guideline indicates that after the hazard analysis and risk assessment are concluded, decisions are to be made about whether the risk is acceptable or whether further mitigation is necessary.

**Institute for Safety through Design**

A development at the National Safety Council is another indicator of the awareness that has developed with respect to the societal benefits that can be obtained if hazards are addressed in the design process for the workplace, environmental considerations, and products. In 1995, the Council created an Institute for Safety Through Design, with the following being two of its stated purposes:

- To have the concepts of designing for safety included in courses taken by engineering students.
- To develop course materials on designing for safety for the thousands of engineers now employed.

With the support of major companies in the years immediately after its founding, the Institute published a text titled *Safety Through Design*, conducted several seminars on the subject, developed course materials to be used by engineering professors, et cetera. Safety practitioners should be aware that there is a safety through design movement in progress and that they will be influenced by it over the long term.

**IT’S THE SYSTEM THAT IS THE PROBLEM, NOT THE WORKER**

I believe that W. Edwards Deming got it right when he wrote in *Out of the Crisis* that a large majority of the problems in any operation are systemic, deriving from the workplace and work methods created by management, and that responsibility for only the relatively small remainder lies with the worker (pp. 135 and 315). Thus, to be effective, safety professionals must have an impact on upstream decision-making that determines the
initial design of the workplace and work methods, and on decisions that subsequently effect the redesign of systems.

Just how effective is a safety professional’s work if it does not impact on system design or redesign and consists mostly of what OSHA refers to as administrative controls?

Robert Andres takes an appropriate and futuristic view of the role of the safety professional in designing for safety in these excerpts from the Summer 1996 edition of the Engineering News Letter issued by the American Society of Safety Engineers.

If we are to reduce injuries further and properly utilize scarce resources, we must dig deeper and think more logically. This is the mandate of our profession as we ‘engineer types’ have always envisioned it. In designing machines and processes, manufacturers must gain greater insight into projected uses, and misuses, of equipment — including planned and unplanned maintenance. Hazard identification must recognize all the possible hazards of the system — from the time it comes off the truck, until it becomes scrap.

In the next millennium, design and manufacturing engineers will have a stronger safety background — and surviving safety professionals will offer a whole lot more than blind acceptance of regulations and an ability to write reports. The vista for the true safety engineer is wide open!

For all three major elements in the practice of safety — preoperational, operational, and post-incident — the impact of design decisions is significant.

**DESIGN IMPLICATIONS IN THE PREOPERATIONAL STAGE**

Opportunities are greatest for the identification and analysis of hazards and for their avoidance, elimination, or control in the preoperational mode. In the design process, the goal is to avoid bringing uncontrolled hazardous situations into the workplace and to avoid the distribution of hazardous products. That presents great opportunity for upstream involvement by safety professionals who would influence those who make design and purchasing decisions. Their activities would include providing design specifications, giving consultation to those who design on the safety goals to be achieved, assisting in design reviews, and developing specifications for the purchase of new equipment.

Requirements to achieve an acceptable risk level in the design process can usually be met without great cost if the decision-making occurs sufficiently upstream. When hazards and risks are not properly dealt with in the design process, and retrofitting to eliminate or control hazards is proposed later, the cost may be so great as to be prohibitive. The result may be a situation in which, subsequently, the risks are judged to be
excessive. And, unfortunately, administrative controls are relied on for mitigation purposes.

Joe Stephenson got it right when he wrote this in his book System Safety 2000:

The safety of an operation is determined long before the people, procedures, and the plant and hardware come together at the work site to perform a given task [p. 10].

It is a hard truth that most of the significant, work-related and product safety decisions are made in the design process. That is why the emphasis given here is so strong in support of safety professionals taking an anticipatory and proactive approach and becoming involved in the design process.

**DESIGN IMPLICATIONS IN THE OPERATIONAL MODE**

The goal in the operational mode is to eliminate or control hazards *before their potentials are realized and hazards-related incidents occur*. Achieving that goal should be undertaken within a continuous improvement process. For every safety initiative in the operation mode, the first consideration should be, Can hazards be eliminated or controlled through redesign of the workplace or work methods?

Examples of the type of counsel-giving activities by safety professionals in an existing setting for which redesign considerations should be paramount are: any discussion of hazards, task reviews, giving advice to safety committees and inspection teams, and job hazard analyses.

*A job hazard analysis is a job design review* that is to assess the physical hazards and the task performance hazards, taking into consideration the capabilities and limitations of people, and their possible quirky behavior. For work hazards that are not to be eliminated or controlled through a redesign initiative, obviously, the appropriate administrative practices would be applied. In so doing, the procedures employed should keep the risks of employee injury or illness or environmental damage at an acceptable minimum.

**DESIGN IMPLICATIONS IN THE POST-INCIDENT MODE**

The goal of investigations of hazards-related incidents is to identify and eliminate or control their causal factors. If that job is done properly,
many of the causal factors identified will relate to workplace and work methods design problems. Benefits to be obtained through effective incident investigation are discussed in Chapter 12, “Designer Incident Investigation.” Much is made in this book of not assuming — post-incident — that employee error, the so-called unsafe act, is the principal causal factor when the reality is that work methods design causal factors were primary.

Consider these cases. In each one, the initial conclusion was that the employee action was the principal causal factor.

**Case 1**

Because of a glitch in production scheduling, delivery of parts by a conveyor to a workstation ceased. The design of the conveyor was such that parts would regularly fall off and accumulate beneath it. An employee, wanting to keep up with production needs, went beneath the conveyor to retrieve the parts that had collected there. Her hair was caught in a drive belt, and part of her scalp was torn away.

There were highly emotional meetings during which line employees were cautioned that they were not to enter the space beneath the conveyor. At first, the causal factor for this incident was recorded as the unsafe act of the employee. Later, questions were posed about the significance of the production scheduling glitch and the design of the conveyor. It was realized that if parts had not fallen off the conveyor, there would have been no enticement for the worker to retrieve them. Then, the design of the conveyor was considered the primary causal factor, and the design was modified.

**Case 2**

After several fatiguing hours of work on a maintenance project, it was time to lock out and tag out the electrical power, for which a detailed procedure was in place. An employee, feeling the pressure to get the job done immediately so that production could be re-commenced, chose not to follow the procedure. He was electrocuted.

The incident investigation report recorded the causal factor as “employee failed to follow the established lockout/tagout procedure.” Later, it was determined that the distance to the power shut off was 216 feet. In that work situation, where fatigue had become a factor, it was judged that the design of the lockout/tagout system whereby the power shut off was not immediately accessible “encouraged” the employee’s
risky behavior. This error-provocative situation became the focal point about which a review of the accessibility of all power disconnects took place.

Case 3

Packages weighing in excess of 25 pounds were handled by workers several hundred times a day. Operations involved twisting, turning, and bending. Numerous workers compensation claims had been filed for back injuries. Assumptions were made that “improper lifting” by employees was the causal factor needing attention. Over time, focused training was given and back belts were used.

Not until automatic tilt tables were provided, along with other steps to redesign the work, were the ergonomic stresses — and the workers compensation cases — reduced.

Training and personal protective equipment were not proper solutions for this situation, and the temporary “fixes” cost far more than would have been expended if the issues were addressed in the original design processes.

A MACRO VIEW OF DESIGN IMPLICATIONS

Although the scenarios just previously given are post-incident, their purpose is to develop an awareness of the workplace or work methods design implications on safety, and of the benefits that could be achieved if hazards are properly addressed in the design process.

If the design of the work is overly stressful or error-provocative, or if the immediate work situation encourages riskier actions than the prescribed work methods, the causal factors for incidents that occur are principally systemic. To identify the causal factor in such situations primarily as an “employee error” or as an “unsafe act” would be wrong, inappropriate, and ineffective.

Consider a bit further how designing for safety relates on a macro basis to the reality of injury and illness experience. To demonstrate the relevancy, excerpts have been taken from Table 4 in Lost-Worktime Injuries and Illnesses: Characteristics and Resulting Time Away from Work, 2000 — an April 10, 2002 U.S. Department of Labor publication.

What is important here? For every event or exposure type listed in this exhibit, a review of the initial design practices would be beneficial in achieving injury and illness reduction.
United States Department of Labor—Bureau of Labor Statistics

USDL 02–196 April 12, 2002

Lost-Worktime Injuries and Illnesses:

Characteristics of Injuries and Resulting Time Away From Work, 2000

This study pertains to the 1,477,800 injuries and illnesses that occurred in private industry in 2000 requiring recuperation away from work beyond the day of the incident. Numbers of events or exposure types are given in the Bureau of Labor statistics report. This author computed percentages for each event or exposure category. Because of rounding, percentages do not add up to 100.

Table 4. Number of nonfatal occupational injuries and illnesses involving days away from work by selected injury and illness characteristics, 2000

<table>
<thead>
<tr>
<th>Event or Exposure Leading to Injury or Illness</th>
<th>Percent Distribution Cases in 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact with objects and equipment</td>
<td>30.0</td>
</tr>
<tr>
<td>Struck by object</td>
<td>15.2</td>
</tr>
<tr>
<td>Struck against object</td>
<td>7.3</td>
</tr>
<tr>
<td>Caught in equipment or object</td>
<td>5.1</td>
</tr>
<tr>
<td>Other</td>
<td>2.4</td>
</tr>
<tr>
<td>Falls to lower level</td>
<td>6.4</td>
</tr>
<tr>
<td>Falls on same level</td>
<td>13.5</td>
</tr>
<tr>
<td>Slip, trip, loss of balance — without fall</td>
<td>3.6</td>
</tr>
<tr>
<td>Overexertion</td>
<td>30.1</td>
</tr>
<tr>
<td>Overexertion in lifting</td>
<td>17.4</td>
</tr>
<tr>
<td>Other</td>
<td>12.7</td>
</tr>
<tr>
<td>Repetitive motion</td>
<td>4.6</td>
</tr>
<tr>
<td>Exposure to harmful substances</td>
<td>4.7</td>
</tr>
<tr>
<td>Transportation accidents</td>
<td>4.9</td>
</tr>
<tr>
<td>Fires and explosions</td>
<td>0.3</td>
</tr>
<tr>
<td>Assaults and violent acts by person</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>99.3</td>
</tr>
</tbody>
</table>

BENEFITS TO BE OBTAINED, IN ADDITION TO SAFETY

Many companies have applied the principles of safety through design, and their successes have impacted favorably on productivity and cost efficiency, in addition to safety. Their successes became evident in the work that culminated in the creation of an Institute for Safety Through
Design by the National Safety Council. This is the Institute’s Mission statement.

To reduce the risk of injury, illness, and environmental damage by integrating decisions affecting safety, health, and the environment in all stages of the design process.

For the preparation of the proposal recommending that an Institute for Safety Through Design be created, a collection was made of actual cases describing initiatives taken by safety professionals to resolve injury problems by redesigning operations that also resulted in improvements in productivity and cost efficiency. An overwhelming number of examples of preoperational, operational, and post-incident situations were submitted. Several of those cases are cited in Chapter 19, “Applied Ergonomics: Significance and Opportunity.”

As the brochure of the Institute for Safety Through Design indicates, if hazards are properly addressed in the design processes, the benefits to society would be

- Significant reductions of injuries, illnesses, and damage to the environment, and their attendant costs
- Productivity improvement
- Decreases in operating costs
- The avoidance of design shortcomings and expensive retrofitting

A good example of the benefits that can be achieved from applying a safety through design concept is described in these excerpts from an article titled “Sound Advice for a Quieter Workplace” that appeared in the magazine Safety + Health. For this article the subcaption is “Companies take a proactive stance against noise with engineering controls.”

Over months and years, the total costs of replacing equipment and the annual testing of every exposed employee can become significant, both in dollars and in time. Finally, when everyone is wearing hearing protection, *errors and delays in communication might cause costly losses in quality and productivity.* [Italics added.]

The limited effectiveness of administrative controls and testing has led many companies to the conclusion that engineering controls offer the most reliable and lasting way to reduce workplace noise.

The most effective time to apply engineering controls is before a noise source ever comes into the workplace. Establish noise standards and work closely with suppliers at the time machinery is specified and ordered. Ford’s
noise standard, SX-1, has been in effect for more than 20 years and is routinely included in the specifications for new and rebuilt machinery.

[When a Ford plant was reconstructed] noise was eliminated by design. Ford’s efforts have paid off. Recent tests that equipped 300 employees in the plant with noise dosimeters showed none were being exposed to noise above 85 dBA. Of 700 employees in the new plant, fewer than 60 are required to wear hearing protection or undergo testing. Any company that buys equipment can specify maximum noise levels for new purchases.

BEING ANTICIPATORY AND PROACTIVE

During my discussions with Dr. Thomas A. Selders in developing a definition of the practice of safety, he offered this critique: The principal shortcoming in what safety professionals do is that they seldom are in a position to anticipate hazards and give counsel on their avoidance. Dr. Selders’ point was that our activity did not start soon enough in the decision stream, that it was not proactive.

Willie Hammer addressed the need to anticipate, avoid, or control hazards in the design process in his *Handbook of System and Product Safety*. This is what he writes:

The system safety (and product safety) concept is predicated on this principle: The most effective means to avoid accidents during system operation is by eliminating or reducing hazards and dangers during design and development [p. 5].

Hammer’s statement applies to every aspect of safety, whatever it is called. His premise spells opportunity for safety professionals to provide counsel in the design process on a proactive basis, to anticipate hazards, and to give advice on their avoidance, elimination, or control.

ON “HUMAN ERROR” AND DESIGNING FOR SAFETY

For many incidents resulting in back injuries, strains and sprains, cumulative trauma disorders, and others, employees were adhering to the prescribed work procedure when the incident occurred. Typically, an incident investigation report would show that an unsafe act, a human error, was the principal incident cause.

If the employee was following the prescribed procedure, surely the focus in determining causal factors after an incident occurs should be on the design of the prescribed work methods. It would be inappropriate in
such a situation to indicate that the principal cause of the incident was an employee unsafe act, when the employee was doing precisely what was expected.

One of my purposes here is to suggest that, often, a causal factor identified as an “employee error” or an “unsafe act” may actually be “programmed” into the prescribed work methods. That occurs when the design of the work is overly stressful, or error-provocative, or encourages riskier actions than desired. If the work is so designed, it is reasonable to assume that a performance deviation is principally a systemic problem rather than a task performance problem.

Alphonse Chapanis is exceptionally well known in ergonomics and human factors engineering circles. He is often quoted concerning the gains to be made by addressing the capabilities and limitations of workers in the design process, thereby avoiding the design of work that is error-provocative.

These are excerpts from his chapter titled “The Error-Provocative Situation” in the book *The Measurement of Safety Performance*:

- Many situations are error provocative . . . the evidence is clear that people make more errors with some devices than they do with others.
- Given a population of human beings with known characteristics, it is possible to design tools, appliances, and equipment that best match their capacities, limitations and weaknesses.
- The improvement in system performance that can be realized from the redesign of equipment is usually greater than the gains that can be realized from the selection and training of personnel.
- Design characteristics that increase the probability of error include a job, situation, or system which:
  a. Violates operator expectations;
  b. Requires performance beyond what an operator can deliver;
  c. Induces fatigue;
  d. Provides inadequate facilities or information for the operator;
  e. Is unnecessarily difficult or unpleasant; or
  f. Is unnecessarily dangerous.
- A good systems engineer can usually build a nearly infallible system out of components that individually may be no more reliable than a human being. The human factors engineer believes that with sufficient ingenuity nearly infallible systems can be built even if one of the components is a human being [p. 111].

A central point in Dr. Chapanis’ work is that: “The improvement in system performance that can be realized from the redesign of equipment
is usually greater than the gains that can be realized from the selection and training of personnel.”

Trevor Kletz, in his book *An Engineer’s View of Human Error*, states that:

Almost any accident can be said to be due to human error and the use of the phrase discourages constructive thinking about the action needed to prevent it happening again; it is too easy to tell someone to be more careful [p. 182].

Kletz also suggests that we should do away with the term “human error” [p. 181]. His focus, in the Introduction to his book, has a significant bearing on the purpose of this chapter:

The theme of this book is that it is difficult for engineers to change human nature and, therefore, instead of trying to persuade people not to make mistakes, we should accept people as we find them and try to remove opportunities for error by changing the work situation, that is, the plant or equipment design or the method of working. Alternatively, we can mitigate the consequences of error or provide opportunities for recovery.

A second objective of the book is to remind engineers of some of the quirks of human nature so that they can better allow for them in design [p. 1].

In his book, Kletz reviewed several accidents that “at first sight were due to human error” and discussed how, in reality, they could have been prevented through (a) improved design, construction, and maintenance, (b) improved design of work methods, and (c) better management.

I now conclude that an engineer who is to design the workplace, work methods, and products must — I repeat, must — be learned in ergonomics. Why? Without a thorough understanding of the capabilities and limitations of people, and their penchant for unpredictable behavior, the design engineer could not effectively anticipate stressful or error-provocative behavior — or quirky behavior — and design systems that compensate for, or are tolerant of, possible human error.

Having so stated, I want to make sure that I do not imply that designing for safety is limited to ergonomics. Designing for safety applies to all injury and illness types.

**DESIGNING FOR SAFETY DURING MAINTENANCE**

My experience over many years has been that, in relation to their share of the employment population, maintenance workers had higher lost workday case rates (i.e., more severe injuries). To determine whether others
had similar experiences, I polled 21 safety directors for their comments: 18 said that their companies had similar results; three said that theirs did not.

Nearly all of those 18 safety directors had their own tragic stories to tell about maintenance people having incidents resulting in severe injuries. And in each case, questions could be asked about the absence of safety considerations in the design of the work methods that resulted in maintenance work being so risky.

Not one of us could say that we had historically done a good job of exploring the implications of workplace or work methods design during investigations of incidents involving maintenance personnel. Nor could one of those 18 safety directors recall a helpful study on the subject. Yet, all of us recognized the significance of the higher lost workday case rates that maintenance personnel have had.

A limited search for literature that addresses designing for safety during maintenance came up short. There is a relevant paragraph or two in some books on maintenance or maintainability. This subject should be given a high priority so that the knowledge required about designing for safety during maintenance is developed, published, and promoted.

But perhaps the results of a study on this subject will be published in time. In 2002, data collected by a very large manufacturing company on severe injuries, many of which occurred to maintenance personnel, prompted research on its high-hazard jobs.

**CONCLUSION**

Safety practitioners can create frequent opportunities to influence the design process, to their great advantage. To do that effectively requires:

- Application of an incident causation model that properly balances causal factors deriving from less than adequate policies, standards, or procedures that impact on design management, operations management, and task performance
- An understanding of hazards
- An understanding of risk
- Knowledge of hazard analysis and risk assessment methods
- Awareness of designing for safety concepts
- Ability to demonstrate to senior management, design personnel, and purchasing personnel the benefits to be obtained from designing at minimum risk
The next chapter is to assist safety professionals who want to become involved in the design processes by providing guidelines for designing for safety.

REFERENCES


INTRODUCTION

Assume that a safety professional wants to influence an organization’s culture as it impacts on the design of the workplace and work methods, or products. A first step could be to search for readily available guidelines on the concept of designing for safety: That search may not be productive.

I have not located a resource that sets forth in concept form the principles to be applied in designing for safety. Standards, regulations, specifications, design handbooks, and checklists that establish the minimums for specific design subjects are plentiful, and they are very important. But, a concept of designing for safety must go far beyond the application of the minimums set forth in standards and guidelines.

Trevor Kletz in Plant Design for Safety: A User-Friendly Approach gives an example of a design concept that goes far beyond standards and guidelines. Kletz proposes that designers establish a goal when designing for safety to achieve a “user-friendly” occupational setting. Consider his theme. (It also applies to product design.)

In all industries errors by operators and maintenance workers and equipment failures are recognized as major causes of accidents, and much thought has been given to ways of reducing them or minimizing their consequences. Nevertheless, it is difficult for operators and maintenance workers to keep up an error-free performance all day, every day. We may keep up a tip-top
performance for an hour or so while playing a game or a piece of music, but we cannot keep it up continuously [p. 1].

Designers have a second chance, opportunities to go over their designs again, but not operators and maintenance workers. Plants should therefore be designed, whenever possible, so that they are “user friendly,” to borrow a computer term, so that they can tolerate departures from ideal performance by operators and maintenance workers without serious effects on safety, output, or efficiency [p. 1].

It is the theme of this book that, instead of designing plants, identifying hazards, and adding on equipment to control the hazards or expecting operators to control them, we should make every effort to choose basic designs and design details that are user friendly [p. 4].

What needs to be agreed upon in an organization is a well-understood concept, a way of thinking, that is translated into a process that effectively addresses hazards and risks in the design process, a way of thinking that is universally applied by all who have involvement with designing.

**PRINCIPAL RESOURCES**

These guidelines are to provide safety professionals and design engineers with concepts to be applied in designing for safety. In their development, considerable extension was required of the bits and pieces taken from several sources, two of which are most significant.

One is the *Air Force System Safety Handbook*, a revision of which was published in July 2000. It is an adaptation of *Standard Practice for System Safety*, Department of Defense, known as MIL-STD-882D, 2000. And the second is William J. Haddon’s energy release theory as set forth in his papers, such as “The Prevention of Accidents” and “On the Escape of Tigers: An Ecological Note.”

Military Standard 882D is the document containing the general system safety program requirements for contractors to the Department of Defense. The Air Force System Safety Handbook is an extension of those general requirements. (Other branches of the military services have their own system safety guides.) I consider these publications to be valuable resources. As I extract from them, I hope that safety generalists will agree that their premises are applicable to their fields of endeavor.

Haddon’s energy release theory proposes that quantities of energy, means of energy transfer, and rates of transfer are related to the types of incidents that occur, the probability of their occurrence, and the severity of their outcomes. Haddon also addressed the significance of avoiding unwanted exposures to harmful environments. Designing to avoid
unwanted energy flows and unwanted exposures to harmful environments should reduce both (a) the probability of harmful or damaging incidents occurring and (b) the severity of their outcomes.

ULTIMATE PURPOSE

The ultimate purpose of applying concepts of safety through design to systems, the workplace, work methods, and products is to achieve safety — that state for which the risks are judged to be acceptable.

GENERAL PRINCIPLES AND DEFINITIONS

For the practice of safety, the term design process applies to

- Facilities, hardware, equipment, tooling, selection of materials, operations layout and configuration, energy controls, environmental concerns
- Work methods and procedures, personnel selection standards, training content, work scheduling, management of change procedures, maintenance requirements, and personal protective equipment needs
- Products for business and industry, and consumer use

Those who are involved in the design process must have an understanding of the concept of risk. Risk is expressed as a combination of the probability of a hazards-related incident occurring and the severity of harm or damage that could result.

As a matter of principle, for an operation to proceed, its risks must be acceptable, or tolerable if you prefer.

Minimum risk is to be sought with respect to new technology, materials, and designs and in designing new production methods.

Minimum risk is achieved when all risks deriving from hazards are at a realistic minimum. Minimum risk does not mean zero risk, which is unattainable.

In determining minimum risk, decision factors will be design objectives, the practically of risk reduction measures and their costs, and their probable acceptance by users.

If a system (the facilities, equipment, and work methods), or a product is not designed to minimum risk, superior results with respect to safety cannot be attained, even if management and personnel factors approach the ideal.

In the design and redesign processes, the two distinct aspects of risk must be considered:
• Avoiding, eliminating, or reducing the probability of a hazards-related incident occurring
• Minimizing the severity of harm or damage, if an incident occurs

All risks to which this concept applies derive from hazards. There are no exceptions.

Thus, hazards must be the focus of design efforts to achieve a state for which the risks are judged to be acceptable.

Hazards are most effectively and economically avoided, eliminated, or controlled in the design or redesign processes.

Both the technology and human activity aspects of hazards must be addressed. Hazards are defined as the potential for harm or damage to people, property, or the environment; hazards include the characteristics of things and the actions or inactions or persons.

If a hazard is not avoided, eliminated, or controlled, its potential may be realized, and a hazards-related incident may occur that has the potential to, but may or may not, result in harm or damage, depending on exposures.

With respect to workstations, tools, equipment, and operating methods, design and engineering applications are the preferred measures for preventing hazards-related incidents since they are more effective.

Hazard probability is defined as the aggregate of the likelihood that the potentials of hazards will be realized and that a hazards-related incident will occur. Hazard probability is to be described in probable occurrences per unit of time, events, population, items, or activity.

Hazard severity is defined as the aggregate of the worst credible outcomes of a hazards-related incident, considering the exposure.

Exposure includes the people, the property, and the environment that could be harmed or damaged if a hazards-related incident occurs.

A risk assessment is an analysis that addresses both the probability of a hazards-related incident occurring and the expected severity of its adverse effects.

OBJECTIVES
Safety, consistent with goals, is to be designed into all systems, processes, the workplace, the work methods, and products in a proactive, cost-effective manner.

Risk assessment is to be an integral part of the design process.

A fundamental design purpose is to have processes and products that are error-proof, or error-tolerant.

Hazards must be identified and evaluated, and then avoided, eliminated, or controlled so that the associated risks are at an acceptable level, throughout the entire life cycle of processes, equipment, and products.
Consideration is to be given early in the design process to the risks attendant in the eventual disposal of processes and products.

Requirements for minimum risk are to be established and applied in the acquisition or acceptance of new materials, technology, or designs, and prior to the adoption of new production, test, or operating techniques.

Actions taken to identify and eliminate hazards and to reduce their attendant risks to an acceptable level are to be documented.

Retrofit actions required to improve safety are to be minimized through the timely inclusion of safety features during research, technology development, and in purchasing and acquisition.

Simplicity of design is to be attained — the simplest design consistent with functional requirements and expected service conditions. Systems, equipment, and products are to be capable of operation, maintenance, and repair in their operational environment by personnel with a minimum of training.

When design or work methods changes are made, a management of change system is to be in place that includes identification and analysis of hazards so that an acceptable risk level is maintained.

Significant safety data representing lessons learned are to be documented and disseminated to interested personnel.

ORDER OF DESIGN PRECEDENCE

To achieve the greatest effectiveness in hazard avoidance, elimination, or control, the following order of precedence is to be applicable in all design and redesign processes.

Top Priority: Design for Minimum Risk

From the very beginning, the top priority is that hazards are to be eliminated in the design process. If an identified hazard cannot be eliminated, the associated risk is to be reduced to an acceptable level through design decisions.

Second Priority: Incorporate Safety Devices

As a next course of action, if identified hazards cannot be eliminated or their attendant risks adequately reduced through design selection, the risks are to be reduced to an acceptable level through the use of fixed, automatic, or other protective safety design features or devices. Provisions are to be made for periodic functional checks of safety devices.
GUIDELINES: DESIGNING FOR SAFETY

Third Priority: Provide Warning Devices
When identified hazards cannot be eliminated or their attendant risks reduced to an acceptable level through initial design decisions or through the incorporated safety devices, systems are to be provided that detect the hazardous conditions and include warning signals to alert personnel of the hazards.

Warning signals and their application are to be designed to minimize the probability of incorrect personnel reactions and shall be standardized within like types of systems.

Fourth Priority: Develop and Institute Operating Procedures and Training
Where it is impractical to eliminate hazards or reduce their associated risks to an acceptable level through design selection, incorporating safety devices, or warning devices, relevant operating procedures and training shall be used.

However, operating procedures and training, or other warning, caution, or written advisory forms, are not to be used as the only risk reduction method for critical hazards. Acceptable procedures may include the use of personal protective equipment.

It should be understood that tasks and activities judged to be essential to safe operation may require special training and certification of personnel proficiency.

For many design situations a combination of these principles will apply. But, a lower level of priority is not to be chosen until practical applications of the preceding level or levels are exhausted. First and second priorities are more effective because they reduce the risk by design measures that eliminate or adequately control hazards. Third and fourth priorities rely on human intervention.

GENERAL DESIGN REQUIREMENTS: A GENERIC THOUGHT PROCESS FOR HAZARD AVOIDANCE, ELIMINATION, OR CONTROL
Using Haddon’s theory as a base, considering comments of others on his work, and making extensions representing my thinking, “A Generic Thought Process for Hazard Avoidance, Elimination or Control” was developed.

This thought process pertains to all three elements of the practice of safety: the preoperational mode, the operational mode, and the post-incident mode. Some aspects pertain to either or both unwanted energy
flows and unwanted exposures to harmful environments. In offering this outline, it is strongly emphasized that

- The Order of Design Precedence previously given is to prevail.
- Ergonomics design principles are to apply, so that the work methods prescribed are not error-provocative or overly stressful.
- The two distinct aspects of risk are to be considered in the design and redesign processes,
  - avoiding, eliminating, or reducing the *probability* of a hazards-related incident occurring and
  - minimizing the *severity* of harm or damage, if an incident occurs.

1. Avoid introduction of the hazard: Prevent buildup of the form of energy or hazardous materials.
   - Avoid producing or manufacturing the energy or the hazardous material.
   - Use material handling equipment rather than manual means.
   - Don’t elevate persons or objects.

2. Limit the amount of energy or hazardous material.
   - Seek ways to reduce actual or potential energy input.
   - Use the minimum energy or material for the task (voltage, pressure, chemicals, fuel storage, heights).
   - Consider smaller weights in material handling.
   - Store hazardous materials in smaller containers.
   - Remove unneeded objects from overhead surfaces.

3. Substitute, using the less hazardous.
   - Substitute a safer substance for a more hazardous one: When hazardous materials must be used, select those with the least risk throughout the life cycle of the system.
   - Replace hazardous operations with less hazardous operations.
   - Use designs needing less maintenance.
   - Use designs that are easier to maintain, considering human factors.

4. Prevent unwanted energy or hazardous material buildup.
   - Provide appropriate signals and controls.
   - Use regulators, governors, and limit controls.
   - Provide the required redundancy.
   - Control accumulation of dusts, vapors, mists, et cetera.
• Minimize storage to prevent excessive energy or hazardous material buildup.
• Reduce operating speed (processes, equipment, vehicles).

5. Prevent unwanted energy or hazardous material release.
• Design containment vessels, structures, elevators, material handling equipment to appropriate safety factors.
• Consider the unexpected in the design process, to include avoiding the wrong input.
• Protect stored energy and hazardous material from possible shock.
• Provide fail-safe interlocks on equipment, doors, valves.
• Install railings on elevations.
• Provide nonslip working surfaces.
• Control traffic to avoid collisions.

6. Slow down the release of energy or hazardous material.
• Provide safety and bleed off valves.
• Reduce the burning rate (using an inhibitor).
• Reduce road grade.
• Provide error-forgiving road margins.

7. Separate in space or time, or both, the release of energy or hazardous materials from that which is exposed to harm.
• Isolate hazardous substances, components, and operations from other activities, areas, and incompatible materials, as well as from personnel.
• Locate equipment so that access during operations, maintenance, repair, or adjustment minimizes personnel exposure (e.g., hazardous chemicals, high voltage, electromagnetic radiation, cutting edges).
• Arrange remote controls for hazardous operations.
• Eliminate two-way traffic.
• Separate vehicle from pedestrian traffic.
• Provide warning systems and time delays.

8. Interpose barriers to protect the people, property, or the environment exposed to an unwanted energy or hazardous material release.
• Insulation on electrical wiring
• Guards on machines, enclosures, fences
• Shock absorbers
• Personal protective equipment
• Directed venting
• Walls and shields
• Noise controls
• Safety nets

9. Modify the shock concentrating surfaces.
• Padding low overheads
• Rounded corners
• Ergonomically designed tools and products
• “Soft” areas under playground equipment

HAZARD ANALYSIS AND RISK ASSESSMENT

A hazard analysis and risk assessment method must be used in determining risk and the hazards management actions to be taken. A good hazard analysis/risk assessment model will enable decision makers to understand and categorize the risks and to determine the methods and costs to reduce risks to an acceptable level. Chapter 14 addresses “Hazard Analysis and Risk Assessment.”

APPROPRIATION REQUESTS, PROJECT REVIEWS, CONTRACT SPECIFICATIONS

An organization’s appropriation proposal system for new projects or major alterations should include a design review procedure that includes hazard identification and analysis and risk assessment. One purpose of addressing hazards in the design process is to avoid retrofitting, which may be excessively costly or impossible when construction projects are in progress or new equipment does not meet the requirements of good hazards management.

When contract specifications clearly set forth safety requirements, the probability of that sort of problem occurring is reduced. Some safety professionals have convinced their managements that they should be participants in specification writing.

Having a well-crafted checklist for project reviews and for the development of contract specifications would be beneficial to engineers and safety professionals. A sample checklist follows which can serve as a base for the development of a checklist suitable to an organization. It is to serve as a guide only. To suit the checklist needs of any organization, additions, deletions, and modifications would be made.
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Project Review — Contract Specification Checklist

Walking/Working Surfaces
1. Will pedestrian aisles and forklift aisles be ample?
2. In the aisles, are people and vehicles adequately separated?
3. Will adequate exits and egress paths be provided?
4. Have logistics been studied to provide safe and efficient flow of people and materials?
5. Will the construction texture of walking surfaces be nonslip?
6. Will the floors be designed to stay dry?
7. Will water and process flows be designed to keep off the walkway?
8. Will the floors be sloped and drained?
9. Will utilities and other obstructions be routed off the walking surfaces?
10. Will the design allow future utility expansion, not having to cross floors?

Mechanical Safety
11. Will machines be properly guarded?
12. Will machines be properly interlocked?
13. Will machines be properly equipped for connecting equipment or conveyors?
14. Will hot surfaces be insulated?

Electrical Safety
15. Will the electrical system meet OSHA/NEC standards?
16. Is the design flexible enough to safely allow future service expansion?
17. Will the design allow safe use of temporary systems?
18. Will grounding and proper fuses or circuit breakers be provided?
19. Will ground fault interruption be provided for wet areas?
20. Will hard wiring be provided where needed?
21. Will emergency power be provided for critical systems?

Fire Protection
22. Will National Fire Codes and insurance requirements for fire walls, doors, exits be met?
23. Will the building have adequate external fire zones?
24. Will emergency vehicle access be adequate?
25. Will flame arresters be installed where needed on equipment vents?
26. Will fire hydrants be adequate?
27. Will small hose stand pipes be adequate?
28. Will sufficient hose racks be provided?
29. Will fire extinguishers be of appropriate types and adequate?
30. Will risers and post valves be accessible?
31. Will the location of flammables be appropriate?
32. For flammables, will storage rooms and cabinets meet NFC and insurance requirements?
33. For flammable liquid dispensing, will grounding, bonding, and ventilation be adequate?
34. Will special fire suppression systems be provided?
35. Has containment of fire suppression water been addressed?
36. Will fire sensors, pull stations, and alarms be adequate?
37. Has the project been reviewed by insurance company personnel?

**Emergency Safety Systems**

38. Will reliable emergency power be provided for critical and life support systems?
39. Will remote or self-actuating valves be installed where necessary?
40. Will emergency lighting and exit lighting be adequate?
41. Will emergency safety showers and eyewash stations be adequate and properly placed?
42. Will adequate first-aid stations, spill carts, and emergency stations be provided?

**Chemical, Biological, Radiological**

43. Have all materials in this category been identified and inventoried?
44. Have the physical properties of the individual chemicals been identified?
45. Are the reactive properties known for chemicals that will be combined or mixed?
46. Have Material Safety Data Sheets been obtained for all materials?
47. Have adequate provisions been made for chemical release, fire, explosion, and reaction?
48. Have measures been taken to minimize the quantities of hazardous chemicals stored?
49. Is the storage of hazardous chemicals below ground to be avoided?
50. Is storage tank location such as to minimize facility damage in a catastrophic event?
51. Is adequate storage tank diking provided?
52. Will emergency ventilation be provided for accidental releases?
53. For extraordinary releases, will special ventilation, relief, and deluge systems be provided?
54. Will the normal use of chemicals allow operating without personal protective equipment?
55. Will the design of bulk loading/unloading facilities contain anticipated leaks and spills?

**Pressure Vessels**
56. Will pressure vessels be designed to ASME and insurance company requirements?
57. Will vessels containing flammables or combustibles meet OSHA (1910:106) and NFC standards?
58. Will pressure relief valves be correctly sized and set, and suitable for intended use?
59. Will discharge of relief devices be directed safely?
60. Will needed vacuum breakers be installed?
61. Are products compatible with the composition of the vessels?

**Ventilation**
62. Will local ventilation effectively capture contaminants at the point of discharge?
63. Will room static pressures be progressively more negative as the operation becomes “dirtier”?
64. Will ventilation system provide a margin of safety if the system fails?
65. Will emergency power be provided on critical units?
66. Will the ventilation equipment be remote and/or “quiet”?
67. Will spray booths and degreasers meet OSHA standards?
68. Will laboratory or contaminated air be totally exhausted?
69. If contaminated air is cleaned and reused, is its safety assured?
70. Will the make up air to hoods be adequate?
71. Have flow patterns been established to prevent exposure to personnel?
72. Will a glove box or process containment be provided for carcinogens or mutagens?
73. Is an adequate facility provided for radiation or biological hazards?
74. Does the ventilation meet ASHRAE standards?

**Ergonomics—Workstation and Work Methods Design**

75. Do material handling designs consider employee capabilities and limitations?
76. Do material handling designs promote the use of hoists, scissor jacks, or drum carts?
77. Has constant lifting been eliminated or minimized in work methods design?
78. Have routine operations been designed to avoid crawling, stooping, or overreaching?
79. Has the need for stairs or ladders been reduced or eliminated?
80. Does the design safely accommodate routine servicing and cleaning?
81. Will there be adequate clearance around equipment for servicing?
82. Will controls be efficiently located in a logical and sequential order?
83. Will indicators be easy to read, either by themselves or in combination with others?
84. Has adequate attention been given to lighting, heat, cold, noise, and vibration?

**Environmental**

85. Have waste products been identified and a means of disposal established?
86. Will provisions be made for responding to chemical spills (containment, cleanup, disposal)?
87. Is there an existing spill control plan for chemicals?
88. Have all waste streams been identified?
89. Are adequate pretreatment facilities provided for process waste streams?
90. Will an adequate storage area be available for wastes held prior to treatment or disposal?

91. Will waste storage areas have adequate isolation, or containment for spills?

92. Will hazardous wastes be disposed of at approved treatment, storage, and disposal facilities?

93. Is special equipment or specially trained personnel provided for treatment operations?

94. Has the acquisition of permits been addressed for the treatment or disposal of waste streams?

95. Have state or local requirements for permitting been evaluated and factored into the project?

96. Can the facility meet regulations for reporting spills or the storage of chemicals?

97. Have adequate provisions been made for cleaning the process equipment?

98. Have provisions been made for a catastrophic release of chemicals?

99. Have provisions been made for any necessary demolition and the resulting waste?

100. Have requirements for remediation at the site prior to construction been addressed?

101. Will all feasible measures for waste minimization be implemented?

102. Have the processes that generate air pollution been evaluated for minimization potential?

103. Will adequate air pollution controls be installed (scrubbers, fume hoods, dust collectors)?

104. Has handling and cleaning of air pollution control systems been addressed?

**Wastewater**

105. Have the processes that generate wastewater been evaluated for minimization potential?

106. Will indoor spills be protected from reaching drains?

107. Will outdoor spills be protected from reaching storm water drains and sewer manholes?

108. Are adequate water disposal systems available?

109. Will pretreatment methods be necessary and provided?
110. Will the discharges of domestic and industrial wastewater be in accord with regulations?

A MODEL POLICY/PROCEDURE STATEMENT ON SAFETY THROUGH DESIGN

In a few organizations, policy/procedure statements have been issued specifying that hazards are to be addressed early on by design work groups, with safety professionals being participants in design discussions.

To serve as a reference, an example of a policy/procedure statement on safety in the design process follows. Its intent is to announce that hazards are to be addressed during early design concept stages, and as an integral part of a concurrent engineering program.

Safety in the Design Process: An Example of a Policy/Procedure Statement

It is our continuing policy to provide employees with a safe work environment and to ensure a proper treatment of environmental hazards deriving from our operations.

To meet this objective, it is necessary for personnel having design responsibilities to consider hazards during the early concept stages when developing new products, manufacturing processes, technology, and facilities that may impact on occupational safety and health and on the environment.

It is most cost effective to design for safety, health, and environmental considerations upstream where the ability to influence is greatest. In addition to reducing risk, the concept of “Safety in the Design Process” has also been demonstrated to

- Increase worker productivity.
- Improve people and processing flexibility.
- Facilitate uptime.
- Reduce costs.
- Reduce hazards in service and maintenance activities.
- Achieve effective environmental controls, upstream.

Conversely, the cost of secondary engineering to retrofit for hazards impacting on safety, health, and environmental needs after the initial design and deployment of the manufacturing process is excessive, and it often includes burdensome constraints on our manufacturing and production systems.
During the early conceptual stages for product and process development, anticipating service and maintenance tasks and identifying employee exposures are critical first steps in developing the safeguarding and engineering controls necessary for protecting the employee. That same concept applies for environmental controls. It includes (a) designing to avoid or control hazards and (b) designing in the necessary safeguarding protection for operators and supporting maintenance personnel—considering both planned and unplanned service of the equipment and facility.

Engineering design should strive for elimination of hazards. Only when elimination, substitution, or engineering controls are not feasible should reliance on physical barriers, warning systems, training, and personal protective equipment be considered.

The concept of Safety in the Design Process requires a coordinated effort between the engineering and the safety, health, and environmental communities. Our bulletin xyz establishes when safety, health, and environmental studies are necessary in the consideration of new products, technology, and manufacturing processes. Please review current and future programs to ensure that safety, health, and environmental issues are considered in the early stages of concept and design.

Safety, health, and environmental personnel are to assist as technical resources in achieving our Safety in the Design Process goals.

A MODEL PROCEDURE GUIDE FOR SAFETY THROUGH DESIGN

How would an organization put into practice a policy requiring that hazards be addressed in the design process? As was the case with policy statements, very few procedure statements exist that could serve as references. An adaptation follows of such a procedure guide. It is to serve as a reference only: It will not be suitable for any organization without modification.


Purpose. To provide operations, engineering, and design personnel with guidelines and methods to foresee, evaluate and control hazards related to occupational safety and health and the environment when considering new or redesigned equipment and processes.

Scope and Definitions. This guideline is applicable to all processes, systems, manufacturing equipment, and test fixtures regardless of size or
materials used. These conditions will be necessary for an exemption from design review:

- No hazardous materials are used (as defined by 29CFR 1910.1200).
- Operating voltage of equipment is <15 volts, and the equipment will be used in nonhazardous atmospheres and dry locations.
- No hazards are present that could cause injury to personnel (e.g., overexertion, repetitive motion, error-prone situations, falls, crushing, lacerations, dismemberment, projectiles, visual injury, etc.).
- Pressures in vessels or equipment are <2 psi.
- Operating temperatures do not exceed 100°F/38°C.
- No hazardous wastes as defined by 40CFR 26 & 262 and/or 331 CMR 30 are generated.
- No radioactive materials or sealed source devices are used.

If other exemptions are desired, they are to be cleared by the safety, health, and environmental professional.

**Phase I: Precapital Review.** This review is to be completed prior to submission of a project request or a request for equipment purchase, in accord with the capital levels outlined in Bulletin 246. Precapital reviews are crucial for planning facilities needs such as appropriateness of location, power supply, plumbing, exhaust ventilation, et cetera. Process and project feasibility are determined through this review. A complete “What-If” hazard analysis, in accord with Bulletin 135, is to accompany the request. Noncapital projects should also be reviewed utilizing these procedures, but a formal “What-If” hazard analysis is not required.

**Phase II: Installation Review.** This review requires a considerably more detailed hazards and failure analysis relative to equipment design, production systems, and operating procedures. Detailed information is documented, including equipment operating procedures, a work methods review giving emphasis to ergonomics, control systems, warning and alarm systems, et cetera. A “What-If” system of hazard analysis may be used and documented. Other methods of hazards analysis will be applied if the hazards identified cannot be properly evaluated through the “What-If” system. The project manager shall be responsible for establishing a hazard review committee and for managing its functions.

**Hazard Review Committee.** This committee will conduct all phases of design review for equipment and processes. In addition to the project
manager, members will include the safety, health, and environmental professional, the facilities engineer, the design engineer, the manufacturing engineer, and others (financial, purchasing) as needed. For particular needs, outside consultants for equipment design or hazard analysis may be recommended by the safety, health, and environmental professional.

“What-If” Hazard Analysis. This hazard assessment method utilizes a series of questions focused on equipment, processes, materials, and operator capabilities and limitations, including possible operator failures, to determine that the system is designed to a level of acceptable risk. Users of the “What-If” method would identify possible unwanted energy releases or exposures to hazardous environments. Bulletin 135 contains procedures for use of a “What-If” checklist. For some hazards, a “What-If” checklist will be inadequate and other hazard analysis methods may be used.

Responsibilities

Project Manager. For all phases of the design review, the project manager will be responsible, from initiation to completion. That includes initiation of the design review, forming the design review committee, compiling and maintaining the required information, document distribution, setting meeting schedules and agendas, and preparing the final design review report. The project manager will be responsible for coordination and communication with all outside design, engineering, and hazard analysis consultants.

Department Manager. Department managers will see that design reviews are completed for capital expenditure or equipment purchase approvals, and prior to placing equipment or processes in operation, as required under “Installation Review.” Signatures of department managers shall not be placed on asset documents until they are certain that all design reviews have been properly completed, and that their findings are addressed.

Design Engineer. Whether an employee or a contractor, the design engineer shall provide to the project manager and to the review committee documentation including

- Detailed equipment design drawings
- Equipment installation, operation, preventive maintenance, and test instructions
- Details of and documentation for codes and design specifications
- Requirements and information needed to establish regulatory permitting and/or registrations
For all of the foregoing, information shall clearly establish that the required consideration has been given to safety, health, and environmental matters.

Safety, Health, And Environmental Professional. Serving as a member of the hazard review committee, the safety, health, and environmental professional will assist in identifying and evaluating hazards in the design process and provide counsel as to their avoidance, elimination, or control. Special training programs for the review committee may be recommended by the safety, health, and environmental professional. Also, consultants may be recommended who would complete hazards analyses, other than for the “What-If” system.

Administrative Procedures. In this section, the administrative procedures would be set forth, such as the amount of time that, prior to submission of a capital expenditure or equipment purchase request, is to be allowed the hazard review committee for its work, information distribution requirements, advance notice time requirements for installation review meetings, procedures to ensure that findings of hazards analyses are addressed, and how differences of opinion of hazard review committee members are to be resolved.

CONCLUSION

Safety professionals are encouraged to venture into safety through design. Opportunities there for accomplishment and recognition are great.

REFERENCES


INTRODUCTION

System safety professionals have achieved notable successes, and generalists in the practice of safety can learn valuable lessons from them. In *MORT Safety Assurance Systems*, William G. Johnson made the following comments, with which I agree, about accomplishments that could not have been achieved without applying system safety concepts.

The system safety programs used in aerospace, nuclear, and military projects provided a well-ordered guide to some requirements for a superlative effort. Indeed, they are a route to accomplishing things which would otherwise be beyond human reach [p. 127].

Those accomplishments are a matter of fact, and they are immense. Anyone who has an understanding of the complexity of the hardware, the demands on the personnel, and the attendant risks must marvel at the success of a space shot. Space travel could not have been achieved without application of the principles of system safety.

I believe that generalist safety practitioners will improve the quality of their performance by acquiring knowledge of what system safety is all about. I do not say that those generalists must become specialists in system safety, although trends indicate that they will be expected to apply at least the fundamentals of system safety: hazard analysis and risk assessment.
INFLUENCES ENCOURAGING ADOPTION OF SYSTEM SAFETY CONCEPTS

I refer to the 1998 version of the American Society of Safety Engineers’ paper titled “Scope and Functions of the Professional Safety Position.” And I quote very briefly from that paper, which is an excellent and current position description for the safety professional:

**Scope and Functions of the Professional Safety Position**

The major areas relating to the protection of people, property and the environment are:

A. Anticipate, identify and evaluate hazardous conditions and practices.
B. Develop hazard control designs, methods, procedures and programs.
C. Implement, administer and advise others on hazard controls and hazard control programs.
D. Measure, audit and evaluate the effectiveness of hazard controls and hazard control programs.

Note that according to item A, the safety professional is to “anticipate hazards.” And item B indicates that safety professionals are to “develop hazard control designs.”

To be in a position to anticipate hazards, one must be involved in the design process. To effectively participate in the design process, the safety professional must be skilled in hazard analysis and risk assessment techniques. Influencing the design process and using hazard analysis and risk assessment techniques to achieve acceptable risk levels are the bases upon which system safety is built.

Enterprising safety practitioners will pay attention to the hazard identification and hazard control design aspects of ASSE’s “Scope and Functions of the Professional Safety Position,” to their advantage. Just in the past few years, a broader recognition has emerged concerning the value of addressing hazards in the design process.

Joe Stephenson got it right in *System Safety 2000* when he wrote:

Safety is achieved by doing things right the first time, every time. If things are done right the first time, every time, we not only have a safe operation but also an extremely efficient, productive, cost-effective operation [p. 10].

For new products, facilities, equipment, and processes, and for their subsequent alteration, the time and place to efficiently and effectively avoid, eliminate, or control hazards is in the design or redesign process.
Participating in the design process presents opportunities for upstream involvement by safety professionals, using system safety concepts.

Also, there has been an extended recognition that, after hazards have been identified and analyzed and risks have been assessed, taking engineering actions is the preferred course of action to avoid, eliminate, or control hazards. That extended recognition derives from several sources, among which is the involvement of safety professionals in:

- Applied ergonomics
- Meeting European requirements whereby risk assessments are to be made on goods that are to go into workplaces in the European Community countries
- Applying the requirements of newly issued guidelines and standards or works in progress that propose or require risk assessments (B11.TR3, Robotics, Lockout/Tagout, Aviation Ground Safety, Semiconductors)
- Meeting the requirements for hazards analysis in OSHA’s standard for Process Safety Management of Highly Hazardous Chemicals and in EPA risk management program requirements
- Quality management


A development at the National Safety council is another indicator of the awareness that has developed with respect to the societal benefits that can be obtained if hazards are addressed in the design process. In 1995, the Council created an Institute for Safety Through Design, with the following being two of its stated purposes:

- To have the concepts of designing for safety included in courses taken by engineering students
- To develop course materials on designing for safety for the thousands of engineers now employed

I have been a member of the Institute’s advisory committee from its start. In principle, what we have been proposing is that engineers have knowledge of and apply system safety concepts, but we did not refer
to them as such. Colleagues who are specialists in system safety often reminded me of that difference. This chapter encourages safety practitioners to become skilled in the basics of system safety, but it does not suggest that the term *system safety* communicates well.

**DEFINING SYSTEM SAFETY**

Unfortunately, the term *system safety* does not convey a clear meaning of the practice as it is applied. Published definitions of system safety are of some help in understanding the concept, but they do not communicative clearly. To move this discussion forward, and to give indications of the differences in the definitions of system safety, I quote from five sources.

Joe Stephenson, in *System Safety 2000*, gives the following definition of system safety:

> Simply put, system safety is the name given to the effort to make things as safe as is practical by systematically using engineering and management tools to identify, analyze, and control hazards [p. 12].

In *System Safety Engineering and Management*, 2nd edition, Harold E. Roland and Brian Moriarty ask, What is system safety? In response to their own question, they give two meaningful comments and then establish the system safety objective:

> The system safety concept is the application of special technical and managerial skills to the systematic, forward-looking identification and control of hazards throughout the life cycle of a project, program, or activity. The concept calls for safety analyses and hazard control actions, beginning with the conceptual phase of a system and continuing through the design, production, testing, use, and disposal phases, until the activity is retired [p. 8].

> The system safety concept involves a planned, disciplined, systematically organized and before-the-fact process characterized as the identify-analyze-control method of safety [p. 9].

System Safety Objective: *A safety objective such that each person will live and work under conditions in which hazards are known and controlled to an acceptable level of potential harm* [p. 12].

Richard G. Pearson and Mahmoud A. Ayoub gave the following view of the systems approach in “Ergonomics Aids Industrial Accident and Injury Control”:
By systems approach, we mean a conscientious, systematic effort to design an effective system, such as a production plant, giving due consideration to the interaction among humans, machines, and the environment. From the ergonomics viewpoint, prime consideration is given to human performance and safety considerations. A cardinal principle of ergonomics is that since everything is designed ultimately for human use or consumption, the characteristics of humans should be considered from the very beginning of the design cycle.

Systems evaluation should be a continuous process during the design, development, installation, operation, and maintenance of an industrial manufacturing system [p. 18].

In System Safety and Risk Management, A Guide for Engineering Educators, Pat L. Clemens and Rodney J. Simmons write as follows:

What Is System Safety? System safety has two primary characteristics: (1) it is a doctrine of management practice that mandates that hazards be found and risks controlled; and (2) it is a collection of analytical approaches with which to practice the doctrine [p. I-3].

In the U.S. Air Force System Safety Handbook, the definition of system safety is simply stated:

System Safety. The application of engineering and management principles, criteria, and techniques to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle [p. viii].

Using those definitions as a base, and with some extensions, I present the following for consideration by safety generalists to emphasize what system safety encompasses and to relate system safety to the workplace and work methods and to the safety of products.

The System Safety Idea

1. System safety is hazards and design based.

2. Hazard analysis is the most important safety process in that, if that fails, all other processes are likely to be ineffective [Johnson, p. 245].

3. Hazards are most effectively and economically anticipated, avoided, or controlled in the initial design processes, or in the redesign of existing systems.
4. All hazards-related incidents result from interaction of elements in a system.

5. Applied system safety requires a conscientious, planned, disciplined, and systematic use of special engineering and managerial tools.

6. On an anticipatory and forward-looking basis, hazards are to be known, avoided, eliminated, or controlled so that systems can be practically designed to attain minimum risk.

7. Applying specifically developed hazard analysis and risk assessment techniques is a necessity in system safety applications.

8. System safety concepts promote the establishment of policies and procedures that are to achieve an effective, orderly and continuous hazards management process for the design, development, installation, and maintenance, of all facilities, materials, hardware, equipment, tooling, and products, and for their eventual disposal.

9. In the system design process, consideration is to be given to the interactions among humans, machines and the environment, and the capabilities and limitations of people and their penchant for unpredictable behavior.

10. Applied system safety is to attain that state for which the risks are judged to be acceptable.

I am aware that my outline of “The System Safety Idea” does not fit precisely with any of the several definitions of system safety published. It encompasses most, and goes beyond several. I hope that it’s of interest to more generalists in the practice of safety than are now applying system safety concepts. I am confident that the application of system safety concepts in the business and industrial setting would result in significant reductions in injuries and illnesses.

System safety is hazards-focused, as are all the subsets of the practice of safety, whatever they are called. System safety commences with hazard identification and analysis. Do that poorly, and all that follows is misdirected. Applications of the hazard analysis and risk assessment methods developed in the evolution of system safety have been successful. The generalist in safety practice ought to know more about them. As a minimum, generalist safety practitioners should be knowledgeable about these methods: Preliminary Hazard Analysis; What-If Analysis; and Failure Modes and Effects Analysis. (See Chapter 14, “Hazard Analysis and Risk Assessment.”)
A SYSTEM SAFETY APPLICATION OUTLINE

Work done by Ernest Levins, who was Director of Safety at McDonald–Douglas in Santa Monica, helps in thinking about system safety and how the concepts can be applied in the workplace setting. What Levins wrote is expressed in uncomplicated and easily understood terms.

In an article titled “Search I—Fourth Installment, Locating Hazards Before They Become Accidents,” Levins gave his views on an effective hazard analysis scheme, which follows. (Although the following is taken from a 1970 publication, a review of subsequent literature indicates that it has not been bettered.)

**Seven Steps to Follow**

1. Define the system in space and time—including its objectives, the location of its interfaces with other systems of interest, and the analytical limits of resolution within the system (may vary, depending on the analyst’s interests).

2. Specify the identifiable undesired outcomes, states, or conditions within the defined system.

3. Select the key undesired system-characteristic outcomes that serve as the basis for decision—by comparing them with some index of criticality (e.g., negligible, marginal, critical, catastrophic); record the results.

4. Determine the possible modes of occurrence of the selected undesired outcomes.

5. Evaluate the likelihood of occurrence of the possible modes of occurrence. This can be done with logic alone; failure rate data are not needed in most industrial systems. An estimate of the mission-success can even be made on the basis of events being “likely” or “unlikely” to occur.

6. From the foregoing, decide if the system design is adequate to prevent failure; and, if not, what design changes are required to improve relative safety of the system.

7. Analyze any system revision as above, and repeat as often as necessary until the optimum design is achieved [p. 21].

Levins speaks of “relative safety” and “optimum design.” What do those terms imply? Design goals are not to attain a risk-free system, which is unattainable. In arriving at the optimum design, judgments will
be made concerning the probability of hazard realization, the severity of harm or damage that could result, the cost of risk reduction, performance requirements, and scheduling. Safety professionals must realize that resources required to identify, evaluate, and eliminate every hazard will never exist.

Levins does suggest that some of the judgments necessary can be made with logic alone. That’s important. System safety concepts can be implemented in many cases without applying extensive and time-consuming hazard analysis and risk assessment methods. But, logic alone will not be adequate for all hazards. For some hazards, applying the hazard analysis and risk assessment methods specifically developed in the evolution of system safety will be necessary.

HOW SYSTEM SAFETY EVOLVED

A bit of history on the evolution of system safety will give an insight into its origins, the need for the hazard analysis and risk assessment techniques which were developed, and the place that system safety has attained. Authors don’t agree on when or where it all started. But, all the historical references on system safety do relate to the military or to aeronautics.

In the literature there are many citations of adverse accident experience in the military branches, which are said to have given impetus to the development of system safety concepts. The following is an example taken from “Why System Safety” by Charles O. Miller, a former Director of the Bureau of Aviation Safety at the National Transportation Safety Board:

Statistics show that far more aircraft, and indeed more pilots, were lost in stateside operations during (World War II) than ever were in combat. In 1943, for example, something like 5,000 aircraft were destroyed stateside, against 3,800 in the war proper.

Then, shortly after World War II, in the period 1946 to 1948, people in the military were astonished by a new accident peak. Thus, the war experience, plus the immediate postwar experience, resulted in a call to the technical community for help [p. 28].

But, in his Handbook of System and Product Safety, Willie Hammer says that

Oddly enough, it was more the concern with unmanned systems, the intercontinental ballistic missiles (ICBMs), that led to the development of the system safety concept [p. 4].
C. W. Childs, in “Industrial Accident Prevention Through System Safety,” gives this brief history of the origins of system safety:

In the early stages of missile development, it was necessary to assemble thousands of subsystems and millions of component parts in such a manner as to be virtually free or at least “forgiving” of mistakes or failures. The management and engineering disciplines at this point in time were not sophisticated or rigid enough to assure such a concept.

Consequently, there were some very spectacular accidents and the engineering disciplines of reliability and quality control were tasked to provide a greater measure of mission success through elaborate quality assurance and reliability analyses and testing. Despite this, accidents continued at a higher rate than was considered acceptable and the new discipline of system safety was developed to bring the accident preventive experience into the systems engineering processes.

Since that time, some methods and techniques have been developed which not only resulted in decreased accident rates for complex flight systems, but are now being used to prevent accidents in the industrial environment [p. 7].

And, great successes were achieved. But, I do wish that Childs’ latter statement—that system safety concepts which were applied in developing complex flight systems were being used to prevent accidents in the industrial environment—could be substantiated more than I have been able to do.

There were many developments to advance system safety in the military branches and at the National Aeronautical and Space Administration (NASA), commencing in the 1960s. Several governmental standards have been issued on system safety, following the intent of what is known as MIL-STD-882. Its most recent modification, made in 2000, is titled the Standard Practice for System Safety: Department of Defense and is identified as MIL-STD-882D.

Each branch of the U.S. military has its own system safety guides, some of which are substantive extensions of 882D. For example, 882D contains 26 pages. The previously mentioned Air Force System Safety Handbook, a 2000 publication, is a 152-page document.

**WHY SYSTEM SAFETY CONCEPTS HAVE NOT BEEN WIDELY ADOPTED**

At least one other author expected a more widespread adoption of system safety concepts, beyond the use by the military and aerospace personnel, and nuclear facility designers. He also had to recognize that
it wasn’t happening. In *The Loss Rate Concept in Safety Engineering*, R. L. Browning wrote the following:

As every loss event results from the interactions of elements in a system, it follows that all safety is “systems safety”. The safety community instinctively welcomed the systems concept when it appeared during the stagnating performance of the mid-1960s, as evidenced by the ensuing freshet of symposia and literature. For a time, it was thought that this seemingly novel approach could reestablish the continuing improvement that the public had become accustomed to; however, this anticipation has not been fulfilled.

Now, almost two decades later, although systems techniques continue to find application and development in exotic programs (missiles, aerospace, nuclear power) and in the academic community, they are seldom if ever met in the domain of traditional industrial and general safety [p. 12].

Although there were countless seminars and a proliferation of papers on system safety, the generalist in the practice of safety seldom adopted system safety concepts. In response to his own question, Why this rejection?, Browning said that traditional safety is predicated on absolutes, “safe” or “unsafe,” while the concepts of measurable and acceptable risk are fundamental to system safety. Also, he expressed the view that system safety literature and seminars on system safety may have turned off generalist safety professionals because of the “exotica” they usually presented. I believe that to be so. Nevertheless, Browning went on to build *The Loss Rate Concept in Safety Engineering* on system safety concepts. He also gave this encouragement:

> We have found through practical experience that industrial and general safety can be engineered at a level considerably below that required by the exotics, using the mathematical capabilities possessed by average technically minded persons, together with readily available input data [p. 13].

And it is appropriate to recognize that system safety concepts were foundational in the development of MORT (management oversight and risk tree). References to system concepts are frequent in Johnson’s *MORT Safety Assurance Systems* and in other literature on MORT.

There is a reality in Browning’s observations: System safety literature is loaded with governmental jargon and can easily repel the uninitiated. It makes more of highly complex hazard analysis and risk assessment techniques requiring extensive knowledge of mathematics and probability theory than it does of concepts and purposes. Some system safety literature does give the appearance of exotica. And using some of the methodologies for the analysis of hazards of lesser significance would be cost prohibitive.
PROMOTING THE USE OF SYSTEM SAFETY CONCEPTS

With the hope of generating a further interest by generalist safety professionals in the basics of system safety, I suggest that they concentrate on those basic concepts through which gains can be made in an occupational or product design setting and avoid being repulsed by the more exotic hazard/risk assessment methodologies. Ted Ferry said it well in the Preface to System Safety 2000, by Joe Stephenson:

Professional credentials or experience in “system safety” is not required to appreciate the potential value of the systems approach and system safety techniques to general safety and health practice [p. ix].

To paraphrase Browning, all hazards-related incidents result from interactions of elements in a system. Therefore, all safety is system safety. Therein lies an important idea.

Others have said that the system is what’s important and that system safety purposes could be met, in many instances, with sound knowledge of safety practice along with intuition.

In Safety Management, John V. Grimaldi and Rollin H. Simonds wrote that:

System safety analyses require the imaginative construction of every conceivable situation that could arise [p. 253].

A reference to system analysis may merely imply an orderly examination of an established system or subsystem [p. 287].

Applying system safety as “an orderly examination of an established system or subsystem” to identify, analyze, avoid, eliminate, or control hazards can be successful in the less complex situations, without using elaborate analytical methods.

For safety generalists who take an interest in system safety concepts, I offer this short reading list:

**Recommended Reading and an Internet Resource**

- Also, as a primer, an article by Pat Clemens titled “A Compendium of Hazard Identification & Evaluation Techniques for System Safety Application,” in which comments are made on 25 analytical methods.
- **System Safety 2000** by Joe Stephenson. This book begins with a history of and the fundamentals of system safety. Then, the author moves into system safety program planning and management, along with system safety analysis techniques. About half of the book is devoted to those techniques. A safety generalist would find it a good and not too difficult read.

- **Basic Guide to System Safety** by Jeffrey W. Vincoli. These two sentences are taken from the Preface. “It should be noted from the beginning that it is not the intention of the *Basic Guide to System Safety* to provide any level of expertise beyond that of novice. Those practitioners who desire complete knowledge of the subject will not be satisfied with the information contained on these pages.” Jeff Vincoli fulfilled his purpose. He has written a basic book on system safety that will serve the novice well.

- **System Safety Engineering and Management**, 2nd edition, by Harold E. Roland and Brian Moriarty. This is a good book. It provides an extensive review of the concepts of system safety, along with their methods of application. An overview of a system safety program is given, and the descriptions of several analytical techniques are valuable. It covers system safety extensively, including those analytical methods for which quite a bit of knowledge about mathematics is necessary.

- **The Loss Rate Concept in Safety Engineering** by R. L. Browning. This is a little but good book, to which I have referred several times. Browning believes that one can apply system safety concepts in an industrial setting without necessarily becoming exotic. He builds on The Energy Cause Concept, and he works through qualitative and quantitative analytical systems.

- **Managing Risk: Systematic Loss Prevention for Executives** by Vernon L. Grose. A system approach is taken by Grose for hazard identification, the writing of scenarios concerning them, and judgments made by “juries” of qualified personnel that consider the scenarios as to probability of occurrence, severity of outcome, and the cost of risk control. Rankings, which are non-numerically quantified, are given to risks according to a “Hazard Totem Pole.” Grose is leery of the “numerologists.” Reading this book would be a good learning experience.

- **Air Force System Safety Handbook**, Air Force Safety Agency. If a safety practitioner wanted extensive detail on the technology of system safety and how it is made to work in the military, this publication is a good reference.
• An Internet Resource. Jacobs Engineering Group Inc. is one of the world’s largest and most diverse providers of professional technical services. Jacobs Sverdrup is its technology company, and its staff is extensively involved in system safety. Many of its publications are available on the Internet and are downloadable, free, in accord with “Terms of Use.” Freely providing this resource and literature for interested persons is an impressive public service. I was encouraged by Pat Clemens of Jacobs Sverdrup to provide access information.

Access is as follows: www.sverdrup.com; Safety and Quality; System Safety Practices. The following appears on the System Safety page:

You’ll find presentation material here for classroom use or for self-instruction. There are also workshop problems, and there’s our Jacobs Sverdrup System Safety Scrapbook of ideas on the principles of system safety practice. You’ll also find four bibliographies of texts pertinent to this field, as well as a System Safety and Risk Management Guide for Engineering Educators. All of these materials undergo revisions from time to time, so revisit the site often to see new and important items.

In its entirety, this provides a notable resource. For example, these are the publications listed under “Presentation Materials”:

• Concepts in Risk Management
• A Brief Overview of Selected System Safety Analytical Approaches
• Working with the Risk Assessment Matrix
• Preliminary Hazard Analysis
• Energy Flow/Barrier Analysis
• Failure Modes and Effects Analysis
• Fault Tree Analysis
• Making Component Failure Probability Estimates
• Combinatorial Failure Probability Analysis Using MIL-STD-882
• Event Tree Analysis
• Cause-Consequence Analysis
• Risk Acceptance and Strategy Selection in Technology Activities
• Failure Information Propagation Modeling
• Guidelines for Writing Operating Procedures
• Human Factors and Operator Error
• Weighted Scoring Decision-Making
• Sneak Circuit Analysis
Two names appear as authors of the foregoing: P. L. Clemens and R. R. Mohr. Pat Clemens is a colleague of long standing. We have interesting discussions on system safety and don’t always agree. Understandably, some may take exception to specifics in the documents Jacobs Sverdrup has made available. Nevertheless, a review of those documents pertinent to the needs of individual safety practitioners will be an educational experience.

CONCLUSION

In this chapter, it was my purpose to (a) recognize the many successes that have been achieved through the application of system safety concepts, (b) establish that fundamental system safety concepts can be applied by generalists in safety practice, (c) outline “The System Safety Idea,” and (d) encourage generalists who have not adopted system safety concepts in their practices to commence the inquiry and education to do so.

I sincerely believe that we generalists in safety practice can learn from system safety successes and be more effective in our work through adopting system safety concepts. Their application in the occupational and product safety settings would result in significant reductions in injuries and illnesses.

REFERENCES


INTRODUCTION

Applied ergonomics has become a major element in the practice of safety. Because of the prominence of musculoskeletal injuries within the universe of occupational injuries and illnesses, safety practitioners must achieve broad knowledge in applied ergonomics. As ergonomics emerged to attain the prominence it now has, opportunities arose for achievement, recognition, and professional satisfaction far beyond what has been typical for safety professionals.

Successes from many ergonomics applications that were initiated to resolve injury and illness problems have also achieved increases in productivity and reductions in costs. That gets management attention. Safety professionals who attain such successes stress the possible economic gains from ergonomics applications, far more than what has been traditional. Also, there is a greater awareness now that ergonomics is fundamentally design-based and that effective ergonomics applications require a focus on workplace and work methods design.

SIGNIFICANCE OF ERGONOMICS WITHIN WORKPLACE SAFETY

What is the significance of ergonomics-related incidents within the universe of workplace injuries and illnesses? A colleague in an insurance
company said that, for a group of workers compensation claims valued at over one billion dollars, ergonomics-related claims were 50% of the number of claims and represented 60% of the costs. Because of variations in the risks in individual industries, estimates will differ on what percentage of injuries and illnesses are ergonomically related, and the percentages differ by occupation. An April 10, 2002 Bureau of Labor Statistics (BLS) news release pertaining to the year 2000 says:

Sprain and strain was, by far, the leading nature, or physical effect, of injury and illness in every major industry division, ranging from over 33 percent in agriculture, forestry, and fishing to over 50 percent in services and in transportation and public utilities [p. 3].

Table 4 in the BLS report is titled “Number of nonfatal occupational injuries and illnesses involving days away from work by selected injury or illness characteristics and industry division, 2000.” For private industry as a whole, strains and sprains, carpal tunnel syndrome, and tendonitis were 46.3% of total cases. Similar figures are commonly expressed.

For example, Dr. Franklin Mirer, Director of the UAW Health and Safety Department, says that for about 700,000 auto workers, over 50% of all incidents reported are musculoskeletal. And the costs for musculoskeletal injuries tend to run high, especially for serious back injuries.

Discussions were held with several safety directors to determine how they would respond to estimates of 50% of the number of workers compensation claims and 60% of total claims costs being ergonomics-related. There was general agreement that those estimates were sound, but two cautions were expressed: Estimates are applicable if the statistical sample is large enough; and variations by industry could be significant.

A professor in an industrial engineering department who is responsible for courses on ergonomics was asked to comment on these numbers. He said they were close to his assumptions.

Understandably, applied ergonomics has become a major element in the practice of safety, and effective safety practitioners will sense the opportunity that provides and acquire extensive knowledge in the field.

Unfortunately, ergonomics has been narrowly and inappropriately perceived by some to include only cumulative trauma disorders. Opportunities for risk reduction and improving productivity and cost efficiency are lost if ergonomics concepts are not applied to all aspects of workplace and work methods design presenting excessive biomechanical stresses — cumulative or instantaneous.

As a case in point, back injuries are a debilitating and costly segment of workers compensation claims. Preventing back injuries requires
eliminating work that is excessively stressful by designing jobs to fit the capabilities and limitations of the worker. That’s applied ergonomics!

This thinking should be extended to include all incidents involving bodily reaction and overexertion, as well as all other aspects of work that are overly stressful or error-provocative.

Assume that on a macro and best-information-available basis, estimates previously cited are close—that is, that 50% of workplace injuries and illnesses and 60% of workers compensation costs are ergonomics-related. Then, those who have responsibilities in occupational safety and health must have broad involvement in ergonomics.

DEFINING ERGONOMICS

I had previously defined ergonomics as the art and science of designing the work to fit the worker. Because of lessons learned in past years, I now use this definition:

Ergonomics is the art and science of designing the work to fit the worker—to achieve optimum productivity and cost efficiency, and minimum risk of injury.

In some places, that “art and science” has been called human factors engineering. Dr. Alphonse Chapanis gave this definition of human factors engineering in his article “To Communicate the Human Factors Message, You Have to Know What the Message Is and How to Communicate It.”

Human factors engineering is the application of human factors information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use [p. 2].

In the same article, Dr. Chapanis expressed these views concerning the relationship between human factors engineering and ergonomics:

I don’t intend to enter into an extended discussion about the differences between human factors and ergonomics. Frankly, I don’t think the differences, such as they are, are important. So, though I shall be using the words human factors and human factors engineering in this article, I mean them to apply equally to ergonomics and the practice of ergonomics [p. 2].

Ergonomics and human factors engineering have become synonymous terms. In this chapter, ergonomics will be used exclusively, and it will also mean human factors engineering.
WHY DEFINE ERGONOMICS TO INCLUDE PRODUCTIVITY AND COST EFFICIENCY

For an occupational setting, this is an appropriate extrapolation of what Dr. Chapanis wrote: the outcome of applied human factors engineering is to make the physical aspects of the workplace and work methods safe, comfortable, and effective for human use.

Ergonomics developed out of the need to make the work being done less stressful and more comfortable, and that’s a laudable goal. But, finding an emphasis in ergonomics texts or articles written as recently as 1998 that also suggests applying ergonomics principles to improve productivity and cost efficiency would be an exception. That has changed substantively in the past few years.

To give emphasis to the transitions that have recently taken place in applied ergonomics, I asked a renowned ergonomics professional to comment on them. What Dr. Paul S. Adams wrote to me in May 2002 follows:

Evolving Ergonomics: Changes in Process Drivers

by

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Occupational ergonomics has evolved significantly in recent years, especially with regard to why ergonomics is applied and how it is sold.

Throughout the 1990’s, numerous government entities, including Canadian Provincial Ministries of Labour and both U.S. Federal and State OSHA’s, attempted to come to grips with what appeared to be an epidemic of work-related musculoskeletal disorders (MSDs). The American National Standards Institute and other standards organizations joined the bandwagon, with arguably limited effect. In 2001, a newly elected U.S. Congress and President cancelled a controversial OSHA Ergonomics Program Standard before its effective date.

The activity and debate preceding the 2000 publication of an OSHA ergonomics standard affected all ergonomics stakeholders. Although the regulatory stick was rescinded, many business executives became aware of this heretofore unfamiliar field, discovered ergonomic problems in their organizations through this exercise, and realized these problems were costing them money and human resources. Organized labor was confronted with the prospect of gaining regulatory support, but losing numerous physically
WHY DEFINE ERGONOMICS TO INCLUDE PRODUCTIVITY AND COST EFFICIENCY

demanding jobs to automation and job exportation. The research community was challenged by significant scientific gaps in our understanding of MSDs, which were exposed during numerous debates.

Traditionally, industrial ergonomics has been primarily a “health and safety” issue. This process driver remains, as Workers’ Compensation and health insurance premiums have risen sharply in recent years. For many employers, MSDs account for 60% or more of their total Workers’ Compensation bill. This financial hemorrhaging has increased awareness of the problem, and safety professionals have been asked to focus efforts on reducing these disproportionately expensive cases.

With much of the OSHA debate focusing on the value of ergonomic programs, many astute business leaders began to look at the business effects of ergonomically “bad jobs” in their organizations. For some, this appears to have resulted in a shift of the drivers behind ergonomic processes and programs.

First, it can be difficult to attract and retain quality workers for ergonomically bad jobs, especially when the unemployment rate is low as it was in the late 1990’s. Jobs that cause discomfort are typically plagued with high turnover and absenteeism, especially when alternative employment is readily available. In addition, jobs with high physical demands are often difficult to fill, as the pool of physically capable prospects may be extremely small during periods of low unemployment. In their quest to create “preferred places of employment” and expand the pool of acceptable applicants, Human Resource managers have become open to approaches that reduce job requirements. Ergonomics reduces task demands.

Another significant driver for implementing ergonomic processes has been “lean manufacturing” and “six-sigma” strategies. Lean manufacturing strives to reduce and eliminate all forms of waste, thereby improving production efficiency and reducing costs. Six-sigma strategies are intended to improve competitiveness by increasing process quality. Unfortunately, failure to consider the human factor appropriately in these efforts can compromise, and even jeopardize the ability of these programs to meet their objectives.

Oftentimes, well-intentioned lean manufacturing “improvements” increase worker task demands. Increased physical demands, coupled with workforce aging, cause many workers to respond in ways that result in turnover, absenteeism, or reported MSDs. Similarly, poorly designed six-sigma projects may demand higher levels of vigilance, signal detection, and cognitive processing capabilities than workers can successfully manage. This can result in increased anxiety and reduced job satisfaction.

Ergonomics is not fundamentally discordant with lean manufacturing and six sigma however. Rather, applying sound ergonomic principles as integral aspects of these projects usually enhances their value. Eliminating process
steps usually eliminates movements, which reduces stress and strain on the worker and associated MSD risk. Enhancing process controls and capabilities often relegates mundane tasks to computers and shifts the more complex decision-making appropriately to the worker. Following some poor results due to worker/task mismatches, some process managers are now recognizing the value of integrating ergonomics into their lean manufacturing and six-sigma efforts. By helping managers understand the importance of considering human capabilities, ergonomists are beginning to sell their services as a means for both preventing failure and for better utilizing human resources.

Business pressures, ranging from attracting and retaining good employees to minimizing operating costs, are now providing opportunities to sell ergonomics as much more than a strategy to reduce occupational injuries and illnesses. Whether implemented reactively (solving existing problems) or proactively, good ergonomics is clearly good economics. However, the principle of lean manufacturing to minimize waste can only be achieved through early identification of potential ergonomic issues and applying ergonomics in the design phase of new and revised production processes. Retrofitting ergonomic solutions wastes precious capital.

In recent years, industry leading companies have begun to realize the benefits of integrating safety and ergonomics into design, and this has created opportunities for training design professionals on ergonomics, and for highly skilled ergonomists to work alongside process and equipment designers. This trend is likely to accelerate as more organizations follow this lead and begin to experience the benefits of incorporating ergonomics prior to fabrication. One should also expect engineers trained in ergonomics to apply their new understanding of human capabilities on projects intended to improve productivity. Evidence of this is the growing pressure on equipment suppliers to produce machines capable of being operated by a diverse labor pool, and maintained quickly by employees with limited troubleshooting skills and lower strength capabilities.

While a highly competitive business climate is encouraging the use of ergonomics for economic reasons, there is also an underlying social change that is affecting how ergonomic processes are executed. Worker expectations appear to be changing. Generation “Xers” no longer accept pain or discomfort as “part of the job”, and they appear to be more willing to report discomfort than their older coworkers. Perhaps more importantly, this new generation of workers expects to be directly involved in decisions affecting their workplace. To keep pace, ergonomics training typically entails less lecture and more hands-on participation. This social change has also contributed to the emergence of “Macro-ergonomics”. Macro-ergonomics holistically addresses worker characteristics in the production system with the goal of optimizing organizational efficiency. Again, this expanded view of the human in the work environment is not a total departure of ergonomics
from the realm of health and safety, but rather a broadened perspective on matching the work to the human in a way that increases value and minimizes costs.

Case histories are now prevalent describing ergonomics applications that were initiated to resolve injury and illness problems and also achieved improvements in productivity and cost efficiency, and sometimes quality. Emphasizing the possible productivity and cost-efficiency gains from applied ergonomics gets management attention. Relating ergonomics to safety, productivity, and quality as an integrated whole spells opportunity for safety professionals who seek to be perceived as supporting entity goals and who want to build solid job security. Indications of that evidence are cited in the following history.

I served as chair of a committee at the National Safety Council whose efforts resulted in the Council creating an Institute For Safety Through Design. In the exploratory work to establish the basis for a proposal to create the Institute, I needed to collect actual cases where initiatives undertaken by safety professionals to resolve injury and illness problems also resulted in improved productivity and cost efficiency.

Eleven safety directors were asked for help. Much to my surprise, everyone agreed to send me success stories. That was an important indicator of how their jobs had changed. They were into productivity, cost efficiency, and performance measurement much more than I expected.

Nine of the 11 safety directors actually responded with case studies. (Anyone who has done volunteer work will appreciate that such a response was remarkable.) More surprising was the number of success stories they sent me. I knew that I could use but five or six cases in the proposal being developed. They sent me 22, and they offered more if I needed them.

As I relate a few of those cases, keep this in mind: Safety professionals initiated the studies because of injury experience; and productivity improved and costs were reduced.

**A Computer Manufacturer**

An electronic panel drilling machine was difficult to operate. A study indicated that workers had to bend and reach to perform tasks, and operator comfort, product quality, and performance suffered. As a result of the study, new machines designed for better body mechanics were acquired. In the first year, labor costs were reduced by $270,000 and yield increased $420,000. Productivity was improved. Injuries were reduced.

**An Aircraft Manufacturer**

An assembly operation required standing on a platform to get visual and physical access to parts being assembled. Shoulder strain injuries resulted
from installing operations, done above shoulder level. Work methods were redesigned. An assembly stand mounted on a hydraulic height-adjustable cart permitted drilling, riveting, and installing parts in a hands-free operation performed below shoulder height, with good visual and physical access. No more strain injuries occurred. Production increased from two to four units a week. Estimated annual cost saving was $52,800.

A Copier Manufacturer

For a copier production entity, the design of the assembly operation included numerous highly repetitive tasks. It was estimated that this entity had workers compensation costs 2.5 times higher than the corporate average. A redesign study revealed how repetitive tasks could be minimized and hazards could be reduced and how simplifications could be made in product design (reduction in the number of parts, and standardization of parts for multiple use), with a substantial reduction in production costs.

A Construction and Farming Equipment Manufacturer

On a backhoe assembly line, the design of the work, done within the operator’s cab, required taking stressful and awkward positions and repetitive hand tool use. Back injuries were frequent, and none but the youngest employees would accept assignment to the work. Wage rate ergonomic team members and the ergonomics coordinator proposed a new design that permitted the work to be done prior to installation of components in the cab, allowing the assembler to work in a good upright position. A major reduction in production time resulted, and hazards were notably reduced.

A Computer Chip Maker

Because of the very high cost of constructing chip fabrication facilities, achieving cost-effective design solutions through proactive design activity is essential. Great benefits were achieved when the application of sound engineering criteria resulted in human-compatible designs for manual material handling, workstations, controls and displays, and maintainability. It was found that the costs of implementing solutions in the early design stages have an additional equipment cost impact of 0–5%, versus the 10–20% of costs for retrofitting to achieve the same ends.

Several case study contributors were enthused about the improved perception that managements had of them because their work also influenced productivity and cost efficiency.

Experience now indicates that it should be the exception when an ergonomics analysis is proposed only for safety purposes.
What is needed is an integrated ergonomics task analysis system that addresses productivity, cost efficiency, safety, and sometimes quality — all in one study. That would be unique. In support of that idea, consider these excerpts from the web page for ergoweb, taken from a January 2001 entry quoting Dr. Peter Budnick, a professional ergonomist and CEO of ErgoWeb:

The three primary risk factors that contribute to MSDs, explains Budnick, are posture, force and repetition. One of these, or a combination of two or all of them—is at the root of most problems in the workplace, whether it's health, production, or quality.

Luckily, ergonomics is becoming an easier sell. Study after study concludes that a properly implemented ergonomics program can reduce workers compensation costs, absenteeism and turnover while increasing production efficiency, product quality and worker morale. It's a competitive business strategy that is separating the early adaptors from the pessimistic proponents of “the way things were.” [http://www.ergoweb.com]

What sort of professional recognition can be attained from successes in applied ergonomics? Consider this real-world situation. A generalist in safety became proficient in applied ergonomics before ergonomics became as fashionable as it is now. To convince management of the efficacy of his ergonomics proposals, his practice for the situations requiring expensive work modification was to produce cost–benefit data using only potential injury and illness cost savings in the benefit side of the equation.

The design and engineering staff recognized that many of the ergonomics risk reduction actions taken as a result of the proposals made by the safety professional had also improved productivity and reduced costs. This safety professional was advised by design engineers that, for his ergonomics proposals, he no longer needed to make cost–benefit studies. They said that they would undertake to justify the expense to accomplish what he proposed by determining the expected productivity and cost-efficiency improvements, with injury cost savings data being worked into their computations.

Furthermore, because of his demonstrated capability, this safety professional was asked to participate as a member of the design team working on a new production facility, the understanding being that he was to see that they designed things right.
APPLIED ERGONOMICS CONSIDERATIONS FOR MANUAL MATERIAL HANDLING

For as long as statistics have been compiled, manual material handling incidents have been prominent both as to frequency of occurrence and severity of injury within the universe of occupational injuries and illnesses. Many safety professionals now take a different approach to determining causal factors for manual material handling incidents when making incident investigations and analyses, having recognized the import of applied ergonomics.

As a case in point, reviews made of incident analyses compiled in previous years resulted in the conclusion that, too often, improper lifting by an employee was given as the principal incident causal factor when, in reality, the basic causal factor was work methods design. Improper lifting had been programmed into the work procedure.

Consider this example. Bags weighing 70 pounds are at floor level on pallets. Workers slit open the bags, lift them to shoulder height, and pour the contents into hoppers. Speed, stooping, and twisting are required. Back injuries are frequently reported. Causal factors recorded in investigation reports are always improper lifting by the employee. Always, the corrective action is to reinstruct the worker in proper lifting techniques. For remedial action, another employee training program would be conducted on how to lift safely. The solution to this problem obviously is work methods redesign. No amount of training or reinstruction or behavior modification could be an adequate solution. Yet, safety professionals accept that this scenario relates often to the actuality of past investigations, analyses, and corrective actions proposed.

Safety professionals cannot escape the fact that many of the corrective measures proposed in the past to reduce the number of overexertion incidents, particularly back injuries, were not effective. Improving employee selection, training, and behavior are ineffective solutions to work methods design problems. (It’s recognized that, in certain situations, they are the only measures that can be taken.)

Negative findings of the National Institute for Occupational Safety and Health (NIOSH) concerning the use of employee selection techniques and training to prevent manual lifting injuries have not been disputed. They are reported in the book *Work Practices for Manual Lifting*. These are some of the findings:

No significant reduction in low back injuries was found by employers who used medical histories, medical examinations, or low back x-rays in selecting the worker for the job.
And, unfortunately, no controlled epidemiological study has validated any of the contemporary theories on (lift techniques).

Also, the importance of training and work experience in reducing hazards is generally accepted in the literature. The lacking ingredient is largely a definition of what the training should be and how this early experience can be given to the naive worker without harm.

More important than proper selection and training in the long-term prevention of accidents and injuries relating to lifting, is providing a safe ergonomics environment in which to work [pp. 3 and 6].

There is a need for debate and a learned paper on manual lifting techniques, reflecting NIOSH research and other studies that put past practices in doubt. Valid guidelines for training on manual material handling should be included in the paper.

PARTICIPATING IN THE DESIGN PROCESS

I believe that the greatest strides forward with respect to safety, health, and the environment are being made through the design process. Several safety professionals who recently participated in design discussions in their companies, a new venture for them, were euphoric when telling of their experiences. They expressed an added sense of accomplishment. That’s understandable.

Without question, the content of professional safety practice is undergoing a necessary and vital transition. To prepare for the needs and opportunities presented by this evolution, basic ergonomics-related knowledge and skill, as follows, should be acquired by the safety professional who would participate in design decisions.

- Working knowledge of engineering principles is necessary to communicate successfully with engineers who make workplace and work practice design decisions.
- An understanding is requisite of the broad range of human physical and psychological variations that employees bring to the workplace, which is the subject of anthropometry.
- Knowledge of the application of mechanical principles for the analysis of forces on body parts will be necessary, and can be obtained through a study of biomechanics.
- Appreciation is needed of the shortcomings of designing a fixed and inflexible workplace to average characteristics, which is the all-too-typical design practice.
• Through the foregoing, knowledge and skill would be attained concerning what constitutes good workstation and work practice design.

Courses on ergonomics are available in great number. Some are in appropriate depth in relation to needs and opportunities. Others are superficial. Considering the impact that ergonomics is having and will have on the content of professional safety practice, the courses of study taken should be substantive.

Acquiring an adequate library of ergonomics-related texts has also become requisite. A recommended listing follows, moving from the basic and necessary to the more complex, the last being a design reference.

  A safety professional interested in back injury prevention must be familiar with these NIOSH publications.

  Putz-Anderson’s book is an excellent primer and is a must as a reference. Contributors have been prominent in the development of ergonomics concepts. It is well-written. Its approach to prevention is sound.

• *Musculoskeletal Disorders (MSDS) and Workplace Factors: A Critical Review of Epidemiological Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*, National Institute for Occupational Safety and Health
  The title describes the content of this 590-page text.

  National Safety Council’s ergonomics guide provides a basic outline that is helpful in getting started on an ergonomics program.

• *Ergonomics: How to Design for Ease and Efficiency*, 2nd edition, K. H. E. Kroemer
  This book does a good job of presenting ergonomic design considerations in an easy-to-understand way.

• *Ergonomic Design for People at Work*, Volumes 1 and 2, Human Factors Section at Eastman Kodak
  Both of these volumes, for which Suzanne H. Rodgers was the Technical Editor, are practical and easily followed.

Considering the number of times this book is quoted, *Fitting the Task to the Man: A Textbook of Occupational Ergonomics* has obviously proven its value as a resource.

- *The Ergonomics Edge—Improving Safety, Quality, and Productivity*, Dan MacLeod
  I quote from the Introduction to MacLeod’s book. “The goal of this book is to convince you that every business strategy should include improving the user-friendliness of both the workplace and the end product.”

  This is a follow-up work by Macleod that is worthy of attention.

- *The Practice and Management of Industrial Ergonomics*, David C. Alexander

- *Fundamentals of Industrial Ergonomics*, B. Mustafa Pulat

- *Human Factors Design Handbook*, W. E. Woodson
  *The Practice and Management of Industrial Ergonomics*, *Fundamentals of Industrial Ergonomics*, and *Human Factors Design Handbook* are used in ergonomics courses in engineering curricula. Woodson’s book is what the title implies, a design handbook.

For all of these texts, a common theme is apparent: Design the job to fit the worker’s capabilities and limitations.

**UNDERTAKING AN ERGONOMICS INITIATIVE**

What is the preferred order of priority when instituting an ergonomics initiative? To begin with, the data gathering necessary to identify jobs, operations, and departments that present workstation or work practice problems would be done through:

1. Reviews of incident investigation reports and OSHA 200 log
2. Reviews of workers compensation and group insurance claims for ergonomics-related incidents
3. Discussion with the personnel staff concerning high-turnover jobs and jobs with excessive absenteeism
4. Seeking comments from supervisors on stressful jobs
5. Encouraging employees to identify jobs for which they have experienced work-related pain or discomfort
6. Walk-through tours of the facility to locate jobs that
   • require a great deal of strength or power,
   • require considerable stretching, bending or stooping,
   • require considerable lifting,
   • require the worker to assume awkward positions,
   • are extremely repetitive,
   • may present excessive vibration exposure from power tool usage,
   • are performed at a rapid pace,
   • present environmental discomfort (temperature, contaminants, lighting, et cetera),
   • prompt employee-generated work changes (benches, wraps on tool handles, cheater bars used on wrenches and valves, padding on chairs, footrests),
   • are monotonous, or
   • involve multiples of the preceding considerations.

After making such a study, hazards would be analyzed and priorities established for the actions to be taken. In setting priorities, consideration would be given to

   • The most stressful jobs
   • The probability that severe injuries may result from doing particular jobs
   • Workstations that can be easily modified
   • Workstation changes that require capital expenditures

In selecting individual tasks for treatment, the following excerpts from Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs give good guidance:

There is seldom a simple, single change to be made. More often there are numerous overlapping problems involving some combination of high production demand, faulty work methods, awkward work station layouts or ill-fitting tools. Furthermore, what may be an effective ergonomic intervention for controlling cumulative trauma at one workplace may be totally inappropriate at a sister plant with a different work population. Perfect solutions are rarely available and design decisions often involve compromises and trade-offs.
Perhaps the most cautious way to proceed is to administer an ergonomic intervention with the same degree of care as one would use with any new remedy. One should:

1. Perform a thorough examination (job analysis) first to determine the specific problem;
2. Evaluate and select the most appropriate intervention(s) (the assistance of an expert may be useful here);
3. Start conservative treatment (implement the intervention), on a limited scale if possible.
4. Monitor progress; and
5. Continue to adjust or refine the scope of the intervention as needed [p. 86].

After analyzing the data gathered, a communication to management proposing an ergonomics initiative would be prepared. That communication should include a plan that addresses the following elements and how they would be incorporated within the overall safety processes in place.

1. Management commitment and involvement
2. Responsibility and accountability
3. Engineering involvement
4. Purchasing liaison
5. Employee involvement
6. Worksite analysis
7. Engineering modifications
8. Administrative controls
9. Personal protective equipment
10. Training
   - Engineers — first training priority
   - Supervisors
   - Employees
11. Medical management
12. Documentation, monitoring, feedback
   - Engineering revisions
   - Work practice revisions
   - Enforcement of safe work practices
   - Record keeping, analysis, and review
Safety professionals should recognize that a significant change in direction is being proposed to management when a new ergonomics initiative is suggested. Knowing how to manage to achieve change successfully would serve well in this endeavor.

When introducing an ergonomics initiative, it is important that the infrastructure be in place to respond properly to the work orders that surely will be generated by an increased awareness of ergonomics concepts. Assume that the initiative receives management support and, in time, an employee awareness and education program is conducted. If maintenance and engineering personnel are not equipped to act on proposals for workstation and work practice changes made by employees in a reasonable time, employee enthusiasm will surely be dampened and the credibility of the ergonomics initiative will be damaged.

Only a few years ago, the conventional thinking among many safety professionals was that applied ergonomics would not be a prominent aspect of safety practice, their assumption being that expenditures for ergonomics improvement would be excessive in relation to the benefits that could be obtained.

History has proven that many work practice improvements can be made without great expense. An example of a revision in material handling methods that can be made with minimum expense is described in the paper titled “Dynamic Comparison of the Two-Hand Stoop and Assisted One-Hand Lift Methods” by Cook, Mann, and Lovested. That paper resulted from a study made at the University of Iowa to test an alternative one-hand lift method developed to address parts picking in a warehouse setting.

Countless success stories are being told by safety professionals about the suggestions for ergonomics workplace improvements made by first-line employees. Many of those suggestions are easily accomplished, inexpensive, and effective. Employees must be actively involved in ergonomics, and their participation should be considered a valuable asset.

Learning from recent history, some cautions are offered with respect to the introduction of an ergonomics initiative. First, the initial thrust should be to educate and obtain the involvement and direction of upper management. Having obtained upper management involvement and direction, the next course of action should be to train engineering and maintenance personnel in ergonomics fundamentals. That is the first training priority, and it should be done before awareness and training programs are run for supervisors and line employees. It is folly to assume that engineering personnel, even though they may be degreed engineers, have basic ergonomics knowledge.
To repeat, the infrastructure should be in place to handle what could be a flood of work orders when supervisors and line employees become participants in the ergonomics initiative.

A GIVEN ERGONOMICS APPLICATION MAY NOT ALWAYS BE SUCCESSFUL

A comment previously quoted from the book edited by Vern Putz-Anderson and titled *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs* is repeated here:

Furthermore, what may be an effective ergonomic intervention for controlling cumulative trauma at one workplace may be totally inappropriate at a sister plant with a different work population. Perfect solutions are rarely available and design decisions often involve compromises and trade-offs [p. 86].

My experience supports the premise that what seems to be a sound ergonomics solution may not always produce the desired results. In the previous quotation, mention is made of a different work population, and that could be an important factor. Another has to do with the psychosocial atmosphere. An article on that subject by William M. Montante appeared in the June 1999 issue of *Professional Safety*, the title of which is “The Psychosocial Zone” (p. 20). Montante’s article represents important work and is recommended reading. It received a technical paper award from the American Society of Safety Engineers. This is his premise:

A growing body of research and experience is advancing the understanding that psychosocial and work organization factors affect the reporting of upper extremity musculoskeletal disorders, and that those psychosocial factors must be considered.

Consider these two examples, within the writer’s experience. At one location of a large company, several employees had operations for carpal tunnel syndrome although the risk factors in the work being done did not indicate carpal tunnel exposures. But, it had become a mark of social stature to have the operation, and one surgeon was willing to accommodate the workers.

In another situation, after much complaining by a group of workers about workstations, expenditures were made for the very best in ergonomics layout and equipment. The appropriate training was provided. The complaints and the run of minor claims did not stop. With the help
of human relations analysts, it was determined that the group had come to glory in the grousing and that no matter what was done to accommodate them, they would continue to complain. Over time, they were split up and assigned to different departments.

Montante also addresses the need to bring employees into discussions as changes are considered to encourage a buy-in for what eventually gets done. He concludes:

Accept the fact that the human being is one part of a complex work system—that a complex interaction exists among the physical, psychological, psychosocial and work organization factors. Facing on one aspect, while ignoring others, will lead to an incomplete solution at best—one that treats only symptoms, not root causes.

So, accept the fact that, on occasion, the ultimate solution for an ergonomics situation may require going beyond the typical preventive measures.

**OSHA AND ERGONOMICS**

In April 2002, OSHA announced a four-element plan with respect to ergonomics, partially in response to congregational demands after a previously issued ergonomics standard was rescinded by the new administration. This plan consists of

- Voluntary guidelines for specific industries and tasks
- Enforcement pertaining to ergonomic hazards through application of the general duty clause in the OSHA Act (Section 5(a)(1))
- Compliance assistance to help workplaces reduce and prevent ergonomic injuries
- Ergonomics research, led by a new national advisory committee to help OSHA identify research gaps

What sort of guidelines can be expected? It seems logical to presume that their requirements cannot be less than OSHA’s only official Guidelines on ergonomics. In August 1990, OSHA issued “Ergonomics Program Management Guidelines for Meatpacking Plants.” Reference is made in the Introduction to those Guidelines to a 1989 OSHA issuance titled “Safety and Health Program Management Guidelines.”

Ergonomics guidelines for meatpacking duplicate much of the language in the safety and health program management guidelines. Their structures are alike. There is a pattern here.
“Ergonomics Program Management Guidelines for Meatpacking Plants” are generic and generally applicable (although they are a bit much on the medical side). Their Table of Contents follows, with only two phrases removed. In the original Table of Contents, “for the Meat Industry” follows “Examples of Engineering Controls” in Item III. B; in Item III. C, “in Meatpacking Establishments” follows “Medical Management Program.”

I. MANAGEMENT COMMITMENT AND EMPLOYEE INVOLVEMENT
   A. Commitment by Top Management
   B. Written Program
   C. Employee Involvement
   D. Regular Program Review and Evaluation

II. PROGRAM ELEMENTS
   A. Worksite analysis
   B. Hazard Prevention and Control
      1. Engineering Controls
      2. Work Practice Controls
      3. Personal Protective Equipment
      4. Administrative Controls
   C. Medical Management
   D. Training and Education
      1. General Training
      2. Job-Specific Training
      3. Training for Supervisors
      4. Training for Managers
      5. Training for Engineers and Maintenance Personnel

III. DETAILED GUIDANCE AND EXAMPLES
   A. Recommended Worksite Analysis Program for Ergonomics
      1. Information Sources
      2. Screening Surveys
      3. Ergonomic Job Hazard Analysis
      4. Periodic Ergonomic Surveys
   B. Hazard Prevention and Control: Examples of Engineering Controls
      1. Work Station Design
      2. Design of Work Methods
3. Tool Design and Handles

C. Medical Management Program for the Prevention and Treatment of Cumulative Trauma Disorders
   1. General
   2. Trained and Available Health Care Providers
   3. Periodic Workplace Walkthrough
   4. Symptoms Survey
   5. Compile a List of Light-Duty Jobs
   6. Health Surveillance
   7. Employee Training and Education
   8. Encourage Early Reporting of Symptoms
   9. Protocols of Health Care Providers
   10. Evaluation, Treatment, and Followup of CTDs
   11. Recordkeeping — OSHA Recordkeeping Forms
   12. Monitor Trends

Since these Guidelines are generic and generally applicable, and since they are an official OSHA document, it does not seem probable that other voluntary guidelines to be issued by OSHA for specific industries will require less in ergonomics management. But, another OSHA document may influence the additional guidelines to be issued.

In 1990, unpublished and unofficial “Ergonomics Program Management Recommendations for General Industry” were written at OSHA. They are labeled “Internal Draft — Not for Public Release.” Including Attachments and a Bibliography, they fill 94 double-spaced pages. About 36 of the 94 pages are devoted to the specifics of medical management.

Overall, the Recommendations seem excessive. Nevertheless, they are thought-provoking, and they are educational. They give an indication of the thinking of some individuals on what should be included in an ergonomics Standard. The Recommendations duplicate a good part of the previously mentioned “Safety and Health Program Management Guidelines.” They include much detail on ergonomics methodology in the form of a specification Standard.

Excerpts representing about one-eighth of the document are included as Addendum A to this chapter since they embody the management elements of a good ergonomics initiative.

MEETING THE CHALLENGE

It should be the goal of safety professionals to be sought for their counsel by those who make workplace and work practice design decisions.
Becoming qualified in ergonomics partially prepares safety professionals for that role. Ergonomics, as it continues to emerge and have great influence on the practice of safety, has compelled many safety professionals to again become students. That’s necessary to meet the challenge and to maintain a practice of safety at a professional level.

(See also Addendum B for additional resources.)

REFERENCES


ADDENDUM A: EXCERPTS FROM OSHA’S UNPUBLISHED AND UNOFFICIAL ERGONOMICS PROGRAM MANAGEMENT RECOMMENDATIONS FOR GENERAL INDUSTRY

Introduction

Effective management of worker safety and health includes protection from all work-related hazards whether or not they are regulated by specific government standards.

The Occupational Safety and Health Act of 1970 (OSH Act) clearly states that the general duty of all employers is to provide their employees with a work place free from recognized hazards.

In recent years, there has been a dramatic increase in the occurrence of injuries and illnesses due to ergonomic hazards.

The incidence and severity of [ergonomic-related] work place injuries and illnesses demand that effective programs be implemented to protect workers from these hazards. These [programs] should be a part of the employer’s overall safety and health management program.

In January 1989 [OSHA] published voluntary, Safety and Health Program Management Guidelines, which are recommended to all employers as a foundation for their safety and health programs and as a framework for their ergonomics programs.

In addition, OSHA has developed the following general industry ergonomics program management recommendations. [This program] is divided into two primary sections: a discussion of the importance of management
commitment and employee involvement, followed by a recommended program with four major elements — worksite analysis, hazard prevention and control, medical management, and training and education.

The science of ergonomics seeks to adapt the job to the worker by designing tasks within the worker’s capabilities and limitations.

Experience has shown that instituting programs in ergonomics has significantly reduced the incidents of [ergonomics-related] disorders and, often, improved productivity.

I. Management Commitment and Employee Involvement

Commitment and involvement are complementary and essential elements of a sound safety and health program. Commitment by management provides the organizational resources and motivating force necessary to deal effectively with ergonomic hazards.

Employee involvement and feedback through clearly established procedures are likewise essential, both to identify existing and potential hazards and to develop and implement effective ways to abate such hazards.

A. Commitment by Top Management. The implementation of an effective ergonomics program includes a commitment by the employer to provide the visible involvement of top management. An effective program should have a team approach with top management leading the team, and including the following:

1. Management involvement demonstrated through the priority placed on eliminating the ergonomic hazards.
2. A policy which places safety and health on the same level of importance as production.
3. Commitment to assign and communicate responsibility.
4. Commitment to provide adequate authority and resources.
5. Commitment to ensure that [all are held] accountable for carrying out [their] responsibilities.

B. Employee Involvement. An employer should provide for and encourage employee involvement in the ergonomics program and in decisions which effect the worker safety and health, including the following:

1. An employee complaint or suggestion procedure which allows workers to bring their concerns to management and provide feedback without fear of reprisal.
2. A procedure which encourages prompt and accurate reporting of potential CTD’s [and other ergonomics-related injuries].

3. Safety and health committees which receive information on ergonomic problem areas.

4. Ergonomic teams or monitors with the required skills.

**C. Written Program.** Effective implementation requires a written program for job safety, health, and ergonomics that is endorsed and advocated by the highest level of management and that outlines the employer’s goals and plans. The written program should be communicated to all personnel.

**D. Regular Program Review and Evaluation.** Procedures and mechanisms should be developed to evaluate the implementation of the ergonomics program and to monitor progress accomplished.

The results of management’s reviews should be a written progress report and program update, which should be shared with all responsible parties and communicated to employees.

**II. Program Elements**

An effective ergonomics program should include the following four components: worksite analysis, hazard prevention and control, medical management, and training and education.

**A. Worksite Analysis.** Worksite analysis provides for both the identification of problem jobs and risk factors associated with problem jobs. The first step is to determine what jobs and work stations are the source of the greatest problems. Thus, a systematic analysis program should be initiated by reviewing injury and illness reports.

The second step is to perform a more detailed analysis of those work tasks and positions previously determined to be problem areas for their own specific ergonomic risk factors.

The analysis should be routinely performed by a qualified person.

The analyst(s) should keep in mind the concept of multiple causation [i.e.] the combined effect of several risk factors. jobs, operations, or work stations that have multiple risk factors have a higher probability of causing [ergonomics-related] disorders.

**B. Hazard Prevention and Control.** Ergonomic hazards are prevented primarily by effective design of a job or job site. An employer’s program should establish procedures to correct or control ergonomic hazards.
using appropriate engineering, work practice, and administrative controls, coordinated and supervised by an ergonomist or a similarly qualified person.

Administrative controls reduce an employee’s exposure to tasks with ergonomic hazards by schemes such as rotation to less stressful jobs, reduced production demand or quotas, and increased rest breaks.

Engineering controls, where feasible, are the preferred method of control. The primary focus of an ergonomics program is to make the job fit the person, not force the person to fit the demands of the job. This can be accomplished by redesigning the work stations, work methods, work tools, and work requirements to reduce or eliminate excessive exertion, repetitive motion, awkward postures, and other risk factors.

1. Engineering Controls

A. PRINCIPLES OF WORK METHODS. Work methods, including workstations and tools, should be designed to reduce [ergonomics] exposure . . . .

The first step is to identify the present problems, and a task analysis should follow.

B. PRINCIPLES OF WORK STATION DESIGN. Work stations should be designed to accommodate the vast majority of the persons who work at a given job. Because workers vary considerably, it is not adequate to design for the average worker.

Work stations should be easily adjustable and designed for each specific task so that they are comfortable and are appropriate for the job performed.

Specific attention should be paid to static loading of muscles, work activity height, reach requirements, force requirements, sharp or hard edges, thermal conductivity of the work surface, proper seating, support for the limbs, work piece orientation, work piece holding, and layout.

C. TOOL AND HANDLE DESIGN. Proper attention should be paid to the selection and design of tools and workstation layouts to minimize the risk of cumulative trauma disorders [and other ergonomics-related injuries].

D. BACK INJURY PREVENTION. While most back disorders result from cumulative trauma or gradual insult to the back over time, some injuries are caused by a sudden excessive load or fall. These disorders are by far the largest single category of all lost-time injuries, and have enormous financial implications.

Historically, back injury prevention has focused primarily on problems of materials handling. Common preventive measures were:
• Training workers how to lift “safely”
• Restricting the weights lifted to some maximum
• Selecting the “strongest” workers for the “heavy work”

Scientific research, industrial studies, and compensation statistics have demonstrated that these approaches have been ineffective in reducing and controlling the problem. It is now recognized that effective back injury prevention requires ongoing effort with long term commitment to:

• Redesigning existing workplaces, jobs and equipment
• Providing training and education for all members of an organization on the causes and means of preventing back injuries as well as proper individual body mechanics.

It should be noted that there are a number of specific risk factors that may act alone or in combination to increase the risk of back disorders. A list of relevant job and workstation considerations — which is by no means inclusive — follows:

• Workplace and work station layout
• Actions and movements
• Working posture and work positions
• Frequency and duration of manual handling activities
• Load considerations

2. **Work Practice Controls.** An effective program for hazard prevention and control also includes procedures for safe and proper work which are understood and followed by managers, supervisors, and workers. Key elements of a good work practice program for ergonomics include proper work techniques, employee conditioning, regular monitoring, feedback, maintenance, adjustments, modifications, and enforcement.

3. **Personal Protective Equipment (PPE).** Potential ergonomic hazards should be considered when selecting PPE.

4. **Administrative Controls.** A sound overall ergonomics program includes administrative controls that reduce the duration, frequency, and severity of exposure to ergonomic hazards.
   a. Examples of administrative controls include the following:

   • Reducing the total number of repetitions
   • Providing rest pauses to relieve fatigued muscles
• Increasing the number of employees assigned to the task
• Using job rotation, with caution and as a preventive measure, not in response to symptoms of cumulative trauma disorders

b. Effective programs for facility, equipment, and tool maintenance to minimize ergonomic hazards include the following measures:

• A preventive maintenance program for mechanical and power tools and equipment
• Performing maintenance regularly
• Effective housekeeping programs

C. Medical Management. An effective medical management program for cumulative trauma disorders is essential to the success of an employer’s total ergonomic program.

The major components of a medical management program for the prevention and treatment of cumulative trauma disorders are:

1. Periodic Workplace Walkthrough
2. Symptoms Survey
3. Identification of Restricted Duty Jobs
4. Health Surveillance
5. Employee Training and Education
6. Accurate Recordkeeping
7. Periodic Program Evaluation

[Editorial Note: In the Recommendations from which these excerpts were taken, 36 pages of proposals and comments follow the preceding list of the major components of a medical management program.]

D. Training and Education. The last major program element for an effective ergonomic program is training and education to ensure that employees are sufficiently informed about the ergonomics hazards to which they may be exposed and thus are able to participate actively in their own protection.

A training program should include the following individuals:

• All effected employees
• Engineers and maintenance personnel
• Supervisors
• Managers
ADDENDUM B

As of May 2002, for the years 1996 through 2001, the National Safety Council library listed 867 articles and books referring to ergonomics. A selection of nineteen of them follows. The articles were chosen for the variety of the subjects covered.

A Comparison of Accident Analysis Techniques for Safety — Critical Man—Machine Systems
Author: Kontogianis T/ Leopoulos V/ Marmaras N

A Comprehensive Lifting Model: Beyond the NIOSH Lifting Equation
Author(s): Hidalgo J/ Genaidy A/ Karwowski W
Source: Ergonomics V.40 NO. 9, PP. 916–927, Sep 1997

A Quantitative Model of Work-Related Fatigue: Background and Definition
Author(s): Dawson D/ Fletcher A
Source: Ergonomics V.44 NO. 2, PP. 144–163, 10 Feb 2001

Analyzing Human Error in Aircraft Ground Damage Incidents
Author(s): Wenner CA/ Drury CG

Beyond Debate: Award-Winning Ergonomics Programs
Author(s): Nash JL

Can Ergonomics Cure “Human Error”?
Author(s): Labar G
Source: Occupational Hazards V.58 NO. 4, PP. 48–51, Apr 1996

Embedding Ergonomics in Hospital Culture: Top-Down and Bottom-Up Strategies
Author(s): Hignett S
Source: Applied Ergonomics V.32 NO. 1, PP. 61–69, Feb 2001

Ergonomic Assessment & Design: Key to Reducing Back Injuries
Author(s): Oakley JS/ SMITH SM
Ergonomics Efforts Work: Some Employers Seeing Big Payoffs
Author(s): Fletcher M
Source: Business Insurance V.34 NO. 5, PP. 1,13, 31 Jan 2000

Ergonomics Is Driving Quality
Author(s): Fernberg PM

Ergonomic Job Measurement System
Author(s): Ridyard D/ TAP0P L/ WYLIE L
Source: Professional Safety V.46 NO. 1, PP. 29–32, Jan 2001

Ergonomics: Reducing Health & Safety Concerns and Improving Productivity
Author(s): Wynn M

Guidelines for Occupational Musculoskeletal Load as a Basis for Intervention: A Critical Review
Author(s): Westgaard RH/ WINKEL J
Source: Applied Ergonomics V.27 NO. 2, PP. 79–88, Apr 1996

Improving Productivity Through Ergonomic Design
Author(s): Kerst J
Source: Today’s Chemist at Work V.7 NO. 5, PP. 38–40,42, May 1998

Incorporating Ergonomics Into the Concurrent Engineering of a New Warehouse
Author(s): Parker M

NIOSH’S Publications on Video Display Terminals, 3RD. ED
Author(s): No Author
Source: National Institute for Occupational Safety & Health, Cincinnati, OH, 132PP. Sep 1999

Office Ergonomics Programs: A Case Study of North American Corporations
Author(s): Moore JS  

Ridding Production Work of Strain & Pain  
Author(s): Brown SF  

Task Design, Psycho-Social Work Climate and Upper Extremity Pain Disorders — Effects of an Organizational Redesign on Manual Repetitive Assembly Jobs  
Author(s): Christmansson M/ Friden J/ Sollerman C  
ON QUALITY MANAGEMENT
AND THE PRACTICE
OF SAFETY

INTRODUCTION

There is a remarkable kinship between the principles of quality management and the principles for the practice of safety. Safety professionals involved in soundly based quality management initiatives have opportunities for professional growth and recognition beyond the usual, since that participation allows them to assist in solving problems that impact broadly on quality, productivity, and cost efficiency, as well as safety.

Safety professionals who have responsibilities in quality management have become aware that the processes to be improved to achieve superior quality are the same processes out of which injuries, illnesses, property damage, and environmental incidents occur. And, having had to acquire a new body of knowledge, they speak an additional language.

Surely, American industry has been on a drive to attain recognition for the quality of its products and services. As an example, receiving The Malcolm Baldrige National Quality Award, given by the United States Department of Commerce, has become a mark of prestige. In 2001, entities interested in the award or in improving their quality management systems requested over 73,000 copies of the award Criteria from the Department of Commerce.

To assist those who had been using the Baldrige Criteria and wanted to evaluate how much progress had been made in their organizations, a
self-assessment questionnaire was made available in 2001 by the National Institute of Standards and Technology, an agency of the Department of Commerce. Its title is: *Are We Making Progress?*

To establish the similarities between the principles of quality management and the principles for the practice of safety, this chapter will

- Explore the theoretical ideal for quality management and safety management
- Review the Criteria for Performance Excellence for the Malcolm Baldrige National Quality Award and relate the Criteria to safety management principles
- Comment on the work of Deming, Crosby, Juran, Gryna, and Winn, as well as on that of Brown, Hitchcock, and Willard
- Give emphasis to Six-Sigma quality management concepts
- Establish that quality management and safety initiatives succeed or fail for the same reasons
- Reflect on my own experience

**ON THE THEORETICAL IDEAL**

A statement in *Why TQM Fails and What to Do About It* by Graham Mark Brown, Darcy E. Hitchcock, and Marsha L. Willard provides a basis for review to determine how near operations are to achieving the theoretical ideal for quality, or safety, management. If the following quotation is read with “safety” replacing “quality,” where safety has been inserted in square brackets, the substance of the statement remains sound.

> When TQM [safety] is seamlessly integrated into the way an organization operates on a daily basis, quality [safety] becomes not a separate activity for committees and teams but the way every employee performs his or her job responsibilities [p. 79].

Some organizations, according to Brown et al., maintain that “they don’t have a total quality management program; rather, they have a culture change initiative.” Also, Brown et al. say “Others insist that TQM is a macrochange strategy. The intent of these companies is to integrate TQM so completely into the organization that it is virtually indistinguishable.”

The theoretical ideal is reached when quality or safety is seamlessly integrated into an organization’s culture and the way it operates on a
daily basis. When that seamless integration is attained, separately identi-
ified quality or safety programs would not be needed since all required
actions would be blended into daily operations. This theoretical ideal
establishes a model toward which an organization should strive. But,
until the ideal is achieved, quality and safety programmatic elements will
be necessary.

**RELATIONSHIP OF THE CRITERIA FOR PERFORMANCE
EXCELLENCE FOR THE MALCOLM BALDRIGE NATIONAL
QUALITY AWARD TO REQUISITES FOR EFFECTIVE SAFETY
MANAGEMENT**

It became apparent in the 1980s that American businesses needed to
improve the quality of their products and services to be more compet-
titive in world markets. A Federal Government initiative toward that end
created The Malcolm Baldrige National Quality Award through Public
Law 100–107 — The Malcolm Baldrige National Quality Improvement
Act of 1987. The award is named for Malcolm Baldrige, whose man-
agerial excellence as Secretary of Commerce from 1981 to 1987 was
recognized as contributing to long-term improvement in efficiency and
effectiveness in government. The American Society for Quality (formerly
the American Society for Quality Control) assists in administering the
Award Program.

The introductory and explanatory text in the award Criteria is revised
annually. As the guiding statements have evolved, they relate even more
so to what is highly desirable for safety management. The latest such
issuance is titled the 2002 Criteria for Performance Excellence for the
Malcolm Baldrige National Quality Award. The criteria are an excellent
guide for superior quality management.

Consider the following excerpts from those Criteria as they relate to
safety management (meaning the management of safety, health, and envi-
ronmental affairs). The excerpts are cited with minimum comment by this
author because they speak for themselves as being desirable for safety
management guidance.

**Visionary Leadership**

Your leaders should ensure the creation of strategies, systems, and methods
for achieving excellence, stimulating innovation, and building knowledge
and capabilities. The values and strategies should help guide all activi-
ties and decisions of your organization. Senior leaders should inspire and
motivate your entire workforce and should encourage all employees to
contribute, to develop and learn, to be innovative, and to be creative.
Senior leaders should serve as role models through their ethical behavior and their personal involvement in planning, communications, coaching, development of future leaders, review of organizational performance, and employee recognition. As role models, they can reinforce values and expectations while building leadership, commitment, and initiative throughout your organization.

**Management by Fact**

A major consideration in performance improvement and change management involves the selection and use of performance measures or indicators. *The measures or indicators you select should best represent the factors that lead to improved customer, operational, and financial performance. A comprehensive set of measures or indicators tied to customer and/or organizational performance requirements represents a clear basis for aligning all activities with your organization’s goals.* Through the analysis of data from your tracking processes, your measures or indicators themselves may be evaluated and changed to better support your goals.

(Chapter 24, “Measurement of Safety Performance,” discusses performance measurement. The guidance given in the citation above is pertinent as measurement methods are selected.)

**Public Responsibility and Citizenship**

An organization’s leaders should stress its responsibilities to the public and the need to practice good citizenship. These responsibilities refer to basic expectations of your organization related to business ethics and protection of public health, safety, and the environment includes your organization’s operations, as well as the life cycles of your products and services. Also, organizations should emphasize resource conservation and waste reduction at the source.

Planning should anticipate adverse impacts from production, distribution, transportation, use, and disposal of your products. Effective planning should prevent problems, provide for a forthright response if problems occur, and make available information and support needed to maintain public awareness, safety, and confidence.

For many organizations, the product design stage is critical from the point of view of public responsibility. Design decisions impact your production processes and often the content of municipal and industrial wastes. Effective design strategies should anticipate growing environmental concerns and responsibilities.

(Similarly, the design of the systems in which employees work to make a product or provide a service is critical to employee safety and health.)
Keeping in mind both the preceding excerpts from the Baldrige Award guidelines and the following outline, also taken from the Award guidelines, it is obvious that the similarities to good safety management are striking.

2002 Criteria for Performance Excellence—Item Listing

P Preface: Organizational Profile
  P.1 Organizational Description
  P.2 Organizational Challenges

2002 Categories/Items

1 Leadership
   1.1 Organizational Leadership
   1.2 Public Responsibility and Citizenship

2 Strategic Planning
   2.1 Strategy Development
   2.2 Strategy Deployment

3 Customer and Market forces
   3.1 Customer and Market Knowledge
   3.2 Customer Relationships and Satisfaction

4 Information and Analysis
   4.1 Measurement and Analysis of Organizational Performance
   4.2 Information Management

5 Human Resource Focus
   5.1 Work Systems
   5.2 Employee Education, Training, and Development
   5.3 Employee Well-Being and Satisfaction

6 Process Management
   6.1 Product and Service Processes
   6.2 Business Processes
   6.3 Support Processes

7 Business Results
   7.1 Customer Focused Results
   7.2 Financial and Market Results
   7.3 Human Resource Results
   7.4 Organizational Effectiveness Results

To a large extent, the management processes in which the safety professional has an interest are identical with those of interest to personnel
responsible for quality. Whether or not an organization is seeking the Baldrige Award, if the purposes of its quality management endeavors are similar to those set forth in the preceding citations, there is ample opportunity for involvement by safety professionals.

Though the term *customer* does not often appear in safety literature, safety professionals should understand that they have two categories of customers: (a) customers within operations, and (b) customers external to operations who might be affected by them.

Excerpts follow from the Baldrige Award Criteria for only a few of its categories. In substance, they represent ideals for safety, health, and environmental management.

1.1 Organizational Leadership

How do senior leaders set and deploy organizational values, short- and longer-term directions, and performance expectations? How do senior leaders review organizational performance and capabilities to assess organizational success, competitive performance, progress relative to short- and longer-term goals, and the ability to address changing organizational needs?

1.2 Public Responsibility and Citizenship

How do you address the impacts on society of your products, services, and operations? How do you accomplish ethical business practices in all stakeholder transactions and interactions?

4.1 Measurement and Analysis of Organizational Performance

Describe how your organization provides effective performance management systems for measuring, analyzing, aligning, and improving performance at all levels and in all parts of your organization. How do you select and align measures/indicators for tracking daily operations and overall organization performance? What analyses do you perform? How do you communicate the results?

5.1 Work Systems

How do you organize and manage work and jobs to promote cooperation, initiative/innovation, your organizational culture, and the flexibility to keep current with business needs? How do you motivate employees to develop and utilize their full potential?

5.2 Employee Well-Being and Satisfaction

How do you improve workplace health, safety, and ergonomics? How do employees take part in improving them? How do you determine the key factors that affect employee well-being, satisfaction, and motivation?
6.1 Product and Service Processes

What are your design processes for products/services and their related production/delivery systems and processes? How do you incorporate new technology, including e-technology, into products/services and into production/service delivery systems? How do you coordinate and test your design and production/delivery systems and processes? What are your key performance measures/indicators used for the control and improvement of these processes?

7.2 Human Resources Results

Summarize your organization’s key human resource results, including employee well-being, satisfaction, and development and work system performance.

If what is expected in an organization for quality management resembles the Baldrige Award Criteria, it would seem prudent for safety professionals to be extensively involved. Obviously, the Criteria have a close resemblance to the requisites of good safety management.

LEARNING FROM DEMING, JURAN, AND GRYNA

*Out of the Crisis* by W. Edwards Deming is a major reference for this chapter. I admit to being a disciple of Deming. That will be evident. I will also take excerpts from *Quality Planning and Analysis* by Joseph M. Juran and Frank M. Gryna, which I highly recommend. Although the literature on quality management is voluminous, the work of Deming and Juran and Gryna still has great influence.

Although Deming achieved world renown in quality assurance, as I reviewed his writings it occurred that he might regard such a designation as rather narrow in relation to what his work is intended to do. In *Out of the Crisis*, Deming outlined his management theory in a “Condensation of the 14 Points of Management.” His position was that his theory must be applied if American industry is to be successful in the world market. Within that theory is his framework for attaining superior quality.

Many authors have quoted Deming’s “14 Points,” sometimes with deviations that are difficult to understand. These are Deming’s “14 Points,” directly and entirely as he wrote them in *Out of the Crisis*.

**Condensation of the 14 Points of Management**

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.

6. Institute training on the job.

7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia,
abolishment of the annual or merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody’s job [p. 23].

Some companies have built their quality improvement programs on much of what Deming has proposed. But I do not know of an organization that has adopted all of Deming’s 14 points, some of which are controversial. But, Deming’s disciples are rabid followers, as the following example indicates.

Rafael Aguayo is the author of *Dr. Deming — The American Who Taught the Japanese About Quality*. In the Introduction, he wrote the following about a course he had taken, led by Dr. Deming:

Deming proceeded to destroy every important notion of management I had been taught. He showed me that the important things I had learned in business school were wrong. Not only were they wrong, but they led to inferior results, poor quality, and customer dissatisfaction [p. xi].

Deming would do away with all performance reviews, in any form, and performance incentives. In two places in his 14 points, he records his opposition to management by objectives. Those premises have not been prominently adopted.

Nevertheless, a great deal of what Deming outlines as management theory is directly related to the principles and practices to be applied in attaining successful hazards management. From *Out of the Crisis, Dr. Deming — The American Who Taught the Japanese About Quality*, and *The Deming Management Method*, a book by Mary Walton who was a Deming colleague, I have selected particularly relevant points that associate closely with the practice of safety. These points also reflect this author’s experiences.

**Wherever the word “quality” appears in the following summary, “safety” can be comfortably substituted.**

- Quality begins in the boardroom.
- Significant improvement in quality requires a change in the corporate culture.
- A long-term commitment by management and knowledge of what actions must be taken are necessary to measurably improve quality.
- Management support alone will not be sufficient: Personal management action and leadership are required. Management obligations cannot be delegated.

- Only management can initiate improvement in quality and productivity. Workers are helpless to change the systems in which they work. On their own, they can achieve very little.

- Everybody has customers. If a person is not aware of who the customers are, that person does not understand the job.

- Quality must be built in at the design stage, where teamwork is fundamental. When processes are in place, revisions are costly.

- Quality is achieved from a continuing improvement in processes.

- Quality comes not from inspection but from improvement of the process. The old way: Inspect bad quality out. The new way: Build good quality in.

- Inspection to improve quality is performed too late in the system. Mass inspection is ineffective and costly. (There are exceptions to this dictum—e.g., bank statements.)

- Fundamental changes in the system can significantly reduce variations; adjustments in an existing system will not significantly reduce variations.

- Managers have a tendency to put responsibility on workers that is beyond their control. People work in the system created by management and which only management can change.

- Employees are not a part of the decision-making for things such as plant layout, lighting, heating, ventilation, product design, process selection and design, determination of work methods, and equipment and materials purchasing. Why should they be held responsible for quality?

- Decisions to improve a system should relate to statistical knowledge and thinking. Basing decisions on timely and accurate data is critical. Intelligent decisions can be made only when the data are accurate and properly interpreted. Relying only on data, though, can lead to difficulty.

- Meeting established specifications ensures maintaining the present status. It does not result in improvement.

- Understanding the distinction between a stable system and an unstable system is essential. A statistical chart, with points properly charted, indicates whether or not a system is stable.
Much of what Deming proposes represents a set of principles that a safety professional can easily support. They emphasize:

- A culture change being necessary to achieve significant improvement in quality
- Building quality into systems, in the beginning
- A constant seeking of error reduction and reducing cycle time
- A continuing improvement of processes and systems
- Placing responsibility for the greatest part of what can be done to attain improvement on management
- Not expecting from employees what they cannot do
- A proper use of statistics

CROSBY: A DIFFERENT APPROACH

Philip B. Crosby sets forth a markedly different concept in *Quality Is Free*. His program is prominently used, and some safety professionals say that its adoption has done some good, but I wonder about its staying power. I have difficulty with it, as I do with hazards management initiatives that do not recognize the importance of design and engineering decisions; do not emphasize the necessity of management involvement with respect to continuing process improvement; and expect more of employees than they can accomplish.

While there are references to design in *Quality Is Free*, the book’s argument requires a stretch to conclude that product and process design and management direction and involvement concerning continuous process improvement are important. Crosby presents a program outline that is similar to many safety program outlines. It expects more than can be achieved. It has several rah-rah aspects, with pledges and commitments from employees.

Eventually, the program focuses on Zero Defects, a theme not now in vogue in very many places. The concept supporting the Zero Defects program concerns me. Crosby wrote this:

The Zero Defects concept is based on the fact that mistakes are caused by two things: lack of knowledge and lack of attitude. Lack of knowledge can be measured and attacked by tried and true means. But lack of attention is a state of mind. It is an attitude problem that must be changed by the individual [p. 171].

Those premises focus on the employee, on the employee’s lack of knowledge and lack of attitude — not on the system put in place by management.
Though the Crosby program commences with management commitment, senior management is not very prominent thereafter. It is also my impression that *Quality Is Free* expects too much of a quality assurance group and that its emphasis may be more on being in conformance than on reducing performance ranges through improved product and process design. This is the Crosby program outline (p. 175).

### QUALITY IMPROVEMENT THROUGH DEFECT PREVENTION

<table>
<thead>
<tr>
<th>Step</th>
<th>Purpose</th>
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</thead>
<tbody>
<tr>
<td>1. Management Commitment</td>
<td>To make it clear where management stands on quality</td>
</tr>
<tr>
<td>2. The Quality Improvement</td>
<td>To run the quality improvement program</td>
</tr>
<tr>
<td>Team</td>
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<tr>
<td>3. Quality Measurement</td>
<td>To provide a display of current and potential nonconformance problems in a manner that permits objective evaluation and corrective action</td>
</tr>
<tr>
<td>4. The Cost of Quality</td>
<td>To define the ingredients of the cost of quality, and explain its use as a management tool</td>
</tr>
<tr>
<td>5. Quality Awareness</td>
<td>To provide a method of raising the personal concern felt by all personnel in the company toward the conformance of the product or service and the quality reputation of the company</td>
</tr>
<tr>
<td>6. Corrective Action</td>
<td>To provide a systematic method of resolving forever the problems that are identified through previous action steps</td>
</tr>
<tr>
<td>7. Zero Defects Planning</td>
<td>To examine the various activities that must be conducted in preparation for formally launching the Zero Defects program</td>
</tr>
<tr>
<td>8. Supervisor Training</td>
<td>To determine the type of training that supervisors need to actively carry out their part of the quality improvement program</td>
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### Step Purpose

9. **ZD Day [Zero Defects Day]**
   To create an event that will let all employees realize, through a personal experience, that there has been a change.

10. **Goal Setting**
    To turn pledges and commitments into action by encouraging improvement goals for themselves and their groups.

11. **Error-Cause Removal**
    To give the individual employee a method of communicating to management the situations that make it difficult for the employee to meet the pledge to improve.

12. **Recognition**
    To appreciate those who participate.

13. **Quality Councils**
    To bring together the professional quality people for planned communication on a regular basis.

14. **Do It Over Again**
    To emphasize that the quality improvement program never ends.

Safety professionals could have an interest in certain aspects of a quality improvement program based on Crosby’s program and would want to be active participants in them. An article by James C. Manzella titled “Achieving Safety Performance Excellence Through Total Quality Management” favorably references Crosby’s work.

But safety professionals should be cautious about the emphasis placed on expecting improvements to be initiated by employees, and about the absence of emphasis on management’s responsibility for the system put in place and for its continuous improvement.

### SIX SIGMA

What is Six Sigma? It presents an outstanding quality assurance standard. Envision a normal distribution chart, a bell curve. Variability from the mean, the center point of the distribution, is measured in units called sigma, which is defined as the standard deviation. At plus or minus three sigma, three standard deviations, 99.7% of a population would be included. In a manufacturing process using a three-sigma standard, approximately 2700 parts per million could be defective.
If a quality performance standard of Six Sigma is achieved, at plus or minus six standard deviations from the mean, it can be expected that no more than 3.4 parts per million will be defective. Four-sigma capability is ten times better than three-sigma capability; five sigma is 30 times better than four sigma; and six sigma is seventy times better than five sigma. One can appreciate the stretch in the quality standard adopted.

Although Six Sigma had its beginnings as a quality performance standard, some safety professionals have sensed its value and promoted its adoption. As an example of the relevant articles that appeared in the safety literature on Six Sigma, I cite a paper by Tom Rancour and Mike McCracken titled “Applying Six Sigma: Methods for Breakthrough Safety Performance.” This is how the article commences.

From Board rooms to manufacturing floors, organizations around the world are using quality improvement tools to bring about dramatic changes in their operations. The ultimate goal is to gain competitive advantage by meeting or exceeding customer requirements while controlling costs.

Today’s safety professionals need to delight customers—employees—by tapping into those same quality tools and using them to continuously improve safety processes. This article reviews Honeywell’s Six Sigma Safety Approach for detecting and eliminating safety defects through re-engineering processes for enhanced employee protection and business results [p. 29].

After this introduction, the authors give the background to the development of the Six-Sigma concept, which they acknowledge was initiated by the senior management at Motorola. (Motorola was the 1988 winner of the Malcolm Baldrige National Quality Award.) The authors go on to indicate that “Six Sigma has been embraced by many other companies, most notably General Electric and Honeywell.”

Motorola outlines “The Six Steps to Six Sigma,” which, paraphrased, are as follows:

- Identifying the product or service you create or provide
- Identifying the customer and what the customer considers important
- Identifying your needs to create the product or service and to satisfy the customer
- Defining the process for doing the work
- Mistake-proofing the process
- Measuring and analyzing, thus ensuring continuous process improvement
When taking a course on Six Sigma at Motorola University, I was much impressed with the strong emphasis on defining and designing the process for doing the work, mistake-proofing the system, and continuous improvement methods (seeking failure-free methods, standardizing procedures, work simplification, work aids, and training). That emphasis reflects the literature issued by Motorola on Six Sigma which states that defects in the manufacturing process are caused by insufficient manufacturing process control, design margin, or bad material. This places emphasis on product design and on the design and control of the manufacturing process.

Motorola has been highly successful in its quality control endeavors. Several of my safety colleagues have said that their companies visited Motorola for benchmarking purposes. Often, they say that it would take several years for their companies to achieve a quality culture that matches what exists there.

WHY QUALITY AND SAFETY INITIATIVES FAIL

Some quality management ventures, predictably, have not been successful. Brown, Hitchcock, and Willard, in *Why TQM Fails and What to Do About It*, comment on the reasons for the failures and offer counsel on how to achieve success. Their text will be of interest to many safety professionals. This comes from the preface of their book.

Much has been written recently about the failures of total quality management (TQM), as if it is just another management fad in decline, following in the grand tradition of quality of work life programs, quality circles, and the like. Many TQM efforts have not yielded the expected results [and] there are common causes for those failures [p. v].

Some Directors of Human Relations whose counsel I sought when quality management became prominent expressed concern that it would turn out to be a fad, just as had many other management panaceas. Why were they concerned? They knew that the fundamentals were not being put in place for the culture change necessary to attain the laudable goals set for quality. Comments of those Human Relations Directors on how employees viewed the new quality management undertakings fit closely with these excerpts from Brown et al.

Seasoned American employees have seen many programs come and go. They are familiar with the distinguishing characteristics of a three-initial name and the accompanying slogans, signs, banners, bumper stickers, pins, and promises [p. 74].
Employees remember that programs of the past were introduced with similar fanfare, and consequently, they see TQM as yet another program with slogans and banners [p. 75].

But, Brown et al. also said “total quality management is even more critical now than it was 10 years ago.” Why do initiatives to improve quality management often succeed or fail? For the same reasons that some undertakings to improve the level of safety succeed or fail. I offer these six premises as near absolutes.

1. Major improvements in quality or safety will not be achieved unless a culture change takes place at all levels of employment, unless major changes occur in the system of expected behavior throughout an organization. Unfortunately, a culture change is not easily accomplished. A colleague has speculated that the time required for the culture change necessary to achieve superior quality or safety is directly related to the age of an organization: The older the organization, the more difficult it is to achieve a culture change.

2. If achieving short-term goals is management’s performance measure, the initiative will fail. Management must be committed to long-term goals and accountability measures and must understand that attaining the culture change necessary may take years.

3. Assessing that which is necessary to achieve customer satisfaction, and preference, must be a continuing and never-ending effort.

4. Systems and processes must be designed to attain superior quality and safety if that is the performance level desired.

5. There must be a continuous improvement initiative, a constant seeking of error reduction, the goal of which is to mistake-proof systems and processes.

6. Operating procedures must be exceptionally well crafted, recognizing the capabilities and limitations of people, so as to give operating personnel a reasonable chance to achieve the desired quality or safety levels.

What results can be expected if quality initiatives, intended to attain uncommon achievements, are not soundly based? These excerpts, from Out of the Crisis, are about “A typical path of frustration.” They also apply to safety.

A program of improvement sets off with enthusiasm, exhortations, revival meetings, posters, pledges. Quality becomes a religion. Quality as measured by results of inspection at final audit shows at first dramatic improvement,
better and better by the month. Everyone expects the path of improvement to continue along the dotted line.

Instead, success grinds to a halt. What has happened? The rapid and encouraging improvement seen at first came from removal of special causes, detected by horse sense. All this was fairly simple. But as obvious sources of improvement dried up, the curve of improvement leveled off and became stable at an unacceptable level.

It takes about two years for people to discover that their program that started off with exhortations, posters, pledges, and revival meetings has come to a dead end. Then, they wake up; we’ve been rooked [p. 322].

Deming also stated that “with a sound program the curve of improvement of quality and productivity does not level off” [p. 324].

Gary L. Winn, in an article titled “Total Quality? The ‘New’ Paradigm Seems Out of Reach for Safety Managers,” commented on the abandonment of quality programs by some American companies and then addressed the difficulty of achieving a culture change.

Why would a company which invested heavily in the Deming or similar Japanese quality methods be willing to call it quits so soon? The answer may be found in a careful reading of Deming and corroborated by satisfied practitioners in the field.

First, Deming warns that the changes necessary to commit a company to the path of total quality are so far reaching that it may take upper management a year to fully understand the implications, much less implement them. To implement a full gamut of these changes, literally every existing practice must change, and everyone must change. These irreversible modifications to tools, habits, systems and styles are cultural changes, and the successful changes are incredibly pervasive [p. 53].

EMPHASIZING SYSTEM AND PROCESS DESIGN

Over time, the level of quality or safety achieved will relate directly to the caliber of the initial design of products, processes and work methods, and their redesign as continuous improvement is sought.

I plead for an acceptance of what Deming wrote about the import of management setting the stage for design decisions. Deming stressed, again and again, that processes must be designed, or redesigned, to achieve superior quality if such performance is desired, and that superior quality cannot be attained otherwise. And the same principle applies to safety.

For examples of what Deming intended concerning his statement that “quality must be built in at the design stage”, I will use the third and
fifth points in the previously cited “Condensation of the 14 Points of Management.” This is the third point.

Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place [p. 28].

To do as Deming proposed requires addressing the quality levels to be attained in the design process. Similarly, Juran and Gryna, in *Quality Planning and Analysis*, speak of “Error Proofing the Process,” and I quote from them.

An important element of prevention is the concept of designing the process to be error free through “error proofing” (the Japanese call it pokayoke or bakayoke). A widely used form of error proofing is the design (or redesign) of the machines and tools (the hardware) so as to make human error improbable or even impossible [p. 347].

Chapters in Juran and Gryna cover, in depth, “Designing for Quality” and “Designing for Quality — Statistical Tools.”

This is Deming’s fifth premise, in the “Condensation of the 14 Points of Management.”

Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs [p. 49].

The following quotations from Deming’s explanation of this fifth premise, taken from *Out of the Crisis*, are important.

A theme that appears over and over in this book is that quality must be built in at the design stage. It may be too late, once plans are on their way. We repeat here that the quality desired starts with the intent, which is fixed by management. The intent must be translated into plans, specifications, tests, in an attempt to deliver to the customer the quality intended, all of which are management’s responsibility [p. 49].

For the paragraphs quoted from *Out of the Crisis*, wherever the word “quality” appears, “safety” can replace it with a good fit. Management “fixes” the level of quality or safety desired, and that “fixing” is a derivation of the organization’s culture.

Deming makes a strong case for not expecting from employees what they are not capable of doing. Conversely, it would be folly not to empower employees to achieve up to their capabilities.
Problems that are in the system can only be corrected by a redesign of the system, by management. If system design and work methods design are the problems, the capability of employees to help is principally that of problem identification.

**ON STATISTICAL PROCESS CONTROLS**

Safety professionals involved in quality management have had to become informed on statistical process control methods. I suggest that a broader application of those methods by our profession to measure safety performance would be beneficial.

Deming principles, or other soundly based quality management concepts, cannot be applied without the use of statistical control methods: cause-and-effect diagrams, control charts, run (trend) charts, Pareto charts, flow charts, check sheets, histograms. Juran and Gryna are very good on this subject. So also are Cyrus Derman and Sheldon M. Ross in *Statistical Aspects of Quality Control*.

Deming believed that statistical methods should be used as a guide to understanding accidents and to their reduction. The following is quoted from *Out of the Crisis* on reducing accident frequency:

> The first step in reduction of the frequency of accidents is to determine whether the cause of an accident belongs to the system or to some specific person or set of conditions. Statistical methods provide the only method of analysis to serve as a guide to the understanding of accidents and to their reduction [p. 314].

But, I offer a caution concerning an excessive reliance on statistical control methods for the practice of safety, as did Deming on the excessive reliance on statistical controls in quality management. Low-probability incidents resulting in severe consequences would seldom appear on control charts. Thus, the plottings on a chart indicating that a system is in control can be deluding as to the potential for events occurring that could result in severe harm or damage. Dangerous assumptions could be made by those who are falsely comforted by a control chart indicating that a system is in control.

**CONCLUSION**

This chapter is intended to be a primer on quality assurance concepts and to establish that they have a remarkable kinship with the principles for the
practice of safety. I believe that involvement by safety professionals in soundly based quality management initiatives presents opportunities for professional growth and recognition, beyond the usual.

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INTRODUCTION

Looking ahead a few years, safety practitioners can expect the issuance of an occupational safety management standard that will impact on their knowledge and skill needs and what employers expect of them. Developments in the recent past are precursors of that occurring, and a selection of those developments will be reviewed in this chapter, along with their possible influence. Those developments are

- Authorization by the American National Standards Institute (ANSI) for the creation of a Secretariat to develop a standard pertaining to Occupational Health and Safety systems
- Issuance by the International Labour Office, Geneva, of a significant document titled “Guidelines on occupational safety and health management systems — ILO/OSH 2001”
- Issuance by the International Organization for Standardization, a worldwide organization of national standards bodies, of
ANSI, AND THE DEVELOPMENT OF A SAFETY STANDARD

Under the auspices of the American National Standards Institute, the American Industrial Hygiene Association serves as the secretariat for the Accredited Standards Committee for Occupational Health and Safety Systems. A working group has been established which has become identified as the ANSI Z10 committee. Its scope is to

Develop a standard of management principles and systems to help organizations design and implement deliberate and documented approaches to continuously improve their occupational health and safety (OHS) performance. The standard will enable organizations to integrate OHS management into their overall business management systems; it will focus on principles that are broadly applicable to organizations of all sizes, not on detailed specifications. The standard will be compatible with relevant OHS, environmental, and quality management standards (e.g. ISO 9000 and 14000) and with approaches to OHS management in common use in the US.

Safety practitioners should appreciate the significance of the creation of the Z10 committee and, presumably, the issuance of a safety management standard. Some participants on the committee, reflecting on the progress achieved, believe that the standard being developed will incorporate many of the advances made in occupational safety management throughout the world. These participants say that safety management guides and standards have been collected from several worldwide sources. At least some Z10 committee members have all of the previously listed European issuances.

HOW AN ANSI STANDARD WOULD IMPACT ON THE PRACTICE OF SAFETY

By its very existence, a standard for occupational safety management systems carrying the approval of the American National Standards Institute takes on considerable significance. Such a standard becomes the minimum against which the adequacy of the safety management systems in place is measured. Membership on the Z10 committee broadly represents the interests of employers, labor, government, and the public. Assuredly, the standard will be much publicized.

Assume that the issued standard contains provisions believed by the writers to represent good safety management. Then presume that some of those provisions are not addressed in an entity’s safety systems in place. The persons responsible for operations in that entity would serve their interests well by taking the actions necessary with respect to the
absent systems. For many locations, the improvements necessary may be substantive. Upon issuance of the standard, safety practitioners should observe whether it contains provisions that prompt the acquisition of additional knowledge and skill (for example, in hazard analysis and risk assessment).

Members of the Z10 committee have said that the draft document to be submitted for public comment in the normal course of standard development will be representative of what has been learned about good safety management, and will be somewhat beyond the safety management guidelines issued in previous years that were then considered acceptable. An example of such previous issuances are the Safety and Health Program Management Guidelines published by the Occupational Safety and Health Administration (OSHA) in 1989.

A document titled Guidelines on occupational safety and health management systems and identified as ILO/OSH 2001 was issued by the International Labour Office, Geneva, in June 2001. This is truly an international document with far-reaching consequences. For general industry, it is now the world’s model.

In the listing of participants and observers involved in developing the guideline, 21 countries were represented: 10 from Europe, 1 from Africa; 2 from South America, 4 from North America, and 4 from the Far East. The United States had representation from the Occupational Safety and Health Administration, the Industrial Hygiene Association, and the Motorola Company.

Objectives for the Guidelines state that they should contribute to safety at a national level (legislation) and at an organizational level. The latter is to be addressed here. With what would one compare the ILO/OSH Guidelines? The previously mentioned Safety and Health Program Management Guidelines issued by OSHA will serve that purpose.

On January 26, 1989, OSHA published Safety and Health Program Management Guidelines in the Federal Register. Those Guidelines became the basis for determining whether a location qualified for OSHA’s Voluntary Protection Program. At the time of their issuance, they were thought by many to represent a sound safety management system that balances design and engineering, operational, and task performance practices. The Guidelines are performance-oriented.

Verbatim excerpts from the OSHA Guidelines appear as an Addendum to this chapter. Although brief, the excerpts maintain the substance of the
OSHA Guidelines. For comparison purposes, the ILO/OSH Guidelines can be downloaded at


Requirements in the ILO/OSH Guidelines are more precise and extensive than those in OSHA’s Guidelines. For example, the ILO/OSH Guidelines contain the following verbiage with respect to management responsibility.

Occupational safety and health, including compliance with the OSH requirements pursuant to national laws and regulations, are the responsibility of the employer.

The employer and senior management should allocate responsibility, accountability and authority for the development, implementation and performance of the OSH management system and the achievement of the relevant OSH objectives. [A list of 13 management-related “structures and processes” follow this statement.]

OSHA does place responsibility for safety on the employer in the Occupational Safety and Health act of 1970 (OSHAAct) through the general duty clause, Section 5. It specifies that

Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees [and] shall comply with occupational safety and health standards promulgated under this Act.

In the OSHA Guidelines, one purpose of which was to assist employers in fulfilling their responsibilities under the general duty clause, this is the sort of language used:

OSHA urges all employers to establish and to maintain programs which meet these guidelines in a manner which addresses the specific operations and conditions of their worksites.

Employers are advised and encouraged to institute and maintain in their establishments a program which provides systematic policies, procedures, and practices that are adequate to recognize and protect their employees from occupational safety and health hazards.

Of particular note in the ILO/OSH Guidelines are the requirements for
• Hazard prevention, for which OSHA has a comparable section
• Management of change, procurement, contracting, performance monitoring and measurement, and audit—which do not appear in the OSHA Guidelines.

A comparison of the ILO/OSH and the OSHA provisions for hazard prevention indicates that the ILO/OSH Guidelines are somewhat more detailed. They relate to both hazards and the risks that derive from them, and set forth actions to be taken in what originated in the United States as a hierarchy of controls, applied in an order of effectiveness.

**ILO/OSH Guidelines**

**Hazard prevention and control measures**

Hazards and risks to workers’ safety and health should be identified and assessed on an ongoing basis. Preventive and protective measures should be implemented in the following order of priority:

a. eliminate the hazard/risk;
b. control the hazard/risk at source, through the use of engineering controls or organizational measures;
c. minimize the hazard/risk by the design of safe work systems, which include administrative control measures;
d. where residual hazards/risks cannot be controlled by collective measures, the employer should provide for appropriate personal protective equipment, including clothing, at no cost and should implement measures to ensure its use and maintenance.

Hazard prevention and control procedures or arrangements should be established and should:

a. be adapted to the hazards and risks encountered by the organization;
b. be reviewed and modified if necessary on a regular basis;
c. comply with national laws and regulations, and reflect good practice; and
d. consider the current state of knowledge, including information or reports from organizations, such as labor inspectorates, occupational safety and health services, and other services as appropriate.

**OSHA Safety and Health Program Management Guidelines**

**Hazard prevention and control** are triggered by a determination that a hazard or potential hazard exists. Where feasible, hazards are prevented by effective design of the job site or job. Where it is not feasible to eliminate them, they are controlled to prevent unsafe and unhealthful exposure.
Recommended Actions

1. So that all current and potential hazards, however detected, are corrected or controlled in a timely manner, establish procedures for that purpose, using the following measures:
   - Engineering techniques where feasible and appropriate;
   - Procedures for safe work which are understood and followed, as a result of training, positive reinforcement, and, if necessary, enforcement through a clearly communicated disciplinary system;
   - Provision of personal protective equipment; and
   - Administrative controls, such as reducing the duration of exposure.

2. Provide for facility and equipment maintenance, so that hazardous breakdown is prevented.

3. Plan and prepare for emergencies, and conduct training and drills.

4. Establish a medical program.

Mention is made of planning for emergencies and medical facilities in other sections of the ILO/OSH document.

For the management of change provision in the ILO/OSH Guideline, this is the principle requirement:

A workplace hazard identification and risk assessment should be carried out before any modification or introduction of new work methods, materials, processes or machinery. Such assessment should be done in consultation with and involving workers and their representatives, and the safety and health committee, where appropriate.

Note that risk assessments are to be made: They are not required in any OSHA document.

OSHA’s Safety and Health Program Management Guidelines do not contain a provision for management of change. OSHA’s Final Rule for Process Safety Management of Highly Hazardous Chemicals does contain such a provision. Hazard identification is required by that provision. Safety directors in chemical companies have said that it was difficult to obtain compliance with the management of change provision because making the reviews and evaluations necessary runs contrary to age-old practices. To achieve success, they had to achieve a culture change.

This is what is said with respect to the audit provision in the ILO/OSH document:

Arrangements to conduct periodic audits are to be established in order to determine whether the OSH management system and its elements are in place, adequate, and effective in protecting the safety and health of workers
and preventing incidents. An audit policy and programme should be developed which includes a designation of auditor competency, the audit scope, the frequency of audits, audit methodology and reporting. Audits should be conducted by competent persons internal or external to the organization who are independent of the activity being audited.

This audit provision is extensive. If a similar provision appears in the upcoming ANSI standard, the impact on how safety practitioners spend their time will be substantial.

Overall, the ILO/OSH Guidelines are quite a piece of work. It will be interesting to observe how many of its provisions are incorporated into the document eventually issued by the Z10 committee. The ILO/OSH Guidelines cannot be ignored.

SAFETY ASPECTS — GUIDELINES FOR THEIR INCLUSION IN STANDARDS: ISO/IEC GUIDE 51

Why cite these Guidelines? They have import since they were issued by the International Organization for Standardization and they are illustrative of the international acceptance of terminology to be used in the writing of safety standards. This is the scope of Guide 51:

Scope

This Guide provides standards writers with guidelines for the inclusion of safety aspects in standards. It is applicable to any aspect related to people, property or the environment, or a combination of one or more of these.

Some of the subjects discussed in the ISO/IEC Guidelines are

- Terms and definitions
- Use of the words “safety” and “safe”
- The concept of safety (“Safety is achieved by reducing risk to a tolerable level”)
- Achieving tolerable risk
- Safety aspects in standards

In the document being prepared by the Z10 committee, there will be a section listing terms and definitions, as is the case typically in ANSI standards. Members of the Z10 committee cannot ignore the content of the ISO/IEC Guidelines. Furthermore, the standards writers will be faced with establishing the risk level to be achieved by application of the standard.
SAFETY OF MACHINERY — PRINCIPLES OF RISK ASSESSMENT, ISO 14121

The purpose of ISO 14121 would have to be considered by those developing an occupational safety and health standard. This is an international standard, the purpose of which is to “establish general principles for the procedure known as risk assessment.”

How did it come to be? Under the auspices of the Central Secretariat, European Committee for Standardization, European Standard EN 292 was issued in 1991. Its title is “Safety of machinery — Basic concepts, general principles for design.” It has two parts: Part 1 carries the subtitle “Basic terminology, methodology”; Part 2 is subtitled “Technical principles and specifications.”

In Part 1, one of the provisions is that hazards are to be identified and risks are to be assessed. To assist machinery designers in fulfilling that requirement, a standard known as EN 1050 was written. As stated in the Scope, “This International Standard gives guidance on the information required to allow risk assessments to be carried out.” In 1999, the ISO issued 14121, which is a verbatim copy of EN 1050.

In the administration of these standards, it is required that most products sold in the European community bear a “CE” mark. By affixing the “CE” mark, a manufacturer indicates that the product complies with all applicable directives. As a practical matter, risk assessments are to be made for a great deal of the equipment that goes into European workplaces, and the manufacturers have to attest that they have been made.

Many American manufacturers who sell workplace equipment to European buyers have had to gear up with personnel and training to make the necessary risk assessments. At trade shows, it is common to see advertising material indicating that the equipment displayed carries a “CE” mark.

How the Z10 committee addresses the subject of employers requiring that risk assessments be made by suppliers of the equipment to be brought into workplaces will be interesting to observe. Requiring such risk assessments serves the interests of employers and employees in a very important way: They minimize the possibility of bringing hazards into the workplace, which results in having a safer operation. Also, the high cost of retrofitting is avoided.

CONCLUSION

In time, a safety management standard will be issued in the United States, and the European influence on its content will be noteworthy. Over the last 10 years, at least, the Europeans have been the leaders in advancing
the state of the art in safety and health management. Those who want a standard written in the United States to represent the state of the art will have to consider the documents to which reference is made here.

Safety practitioners will serve their interests well if they anticipate the possible content of such a standard in light of worldwide developments and sharpen their skills accordingly.

REFERENCES


Scope and Application
This guideline applies to all places of employment covered by OSHA, except those covered by 29 CFR 1926, which is the construction safety standard.

Introduction
Effective management of worker safety and health protection is a decisive factor in reducing the extent and severity of work-related injuries and illnesses.

Effective management addresses all hazards whether or not they are regulated by government standards.

OSHA urges all employers to establish and to maintain programs which meet these guidelines in a manner which addresses the specific operations and conditions of their worksites.

The Guidelines — General
Employers are advised and encouraged to institute and maintain in their establishments a program which provides systematic policies, procedures, and practices that are adequate to recognize and protect their employees from occupational safety and health hazards.

An effective program includes procedures for the systematic identification, evaluation, and prevention or control of general workplace hazards, specific job hazards, and potential hazards which may arise from foreseeable conditions.

An effective program looks beyond specific requirements of law to address all hazards.

Written guidance ensures clear communication of policies and priorities and consistent and fair application or rules.

[Next in the Guidelines comes item (b), Major Elements, of which there are four. In a separate item (c) in the Guidelines, Recommended Actions are set forth for each of the Major Elements. In these excerpts, the applicable Recommended Actions follow Major Elements, directly.]

Major Element 1
Management commitment and employee involvement are complementary. Management commitment provides the motivating force and
resources and applies its commitment to safety and health protection with as much vigor as to other organizational purposes.

Employee involvement provides the means through which workers develop and/or express their own commitment to safety and health protection, for themselves and for their fellow workers.

**Recommended Actions.** State clearly a worksite policy on safe and healthful work and working conditions, so that all personnel with responsibility understand the priority of safety and health protection in relation to other organizational values.

Establish and communicate a clear goal for the safety and health program and objectives for meeting that goal.

Provide visible top management involvement.

Provide for and encourage employee involvement.

Assign and communicate responsibility so that [all] know what performance is expected of them.

Provide adequate authority and resources.

Hold managers, supervisors and employees accountable.

Review program operations at least annually to evaluate their success so that deficiencies can be identified [and] objectives can be revised.

**Major Element 2**

**Worksite analysis** involves a variety of worksite examinations, to identify not only existing hazards but also conditions and operations in which changes might occur to create hazards.

Effective management actively analyzes the work and worksite, to anticipate and prevent harmful occurrences.

**Recommended Actions.** Conduct comprehensive baseline worksite surveys for safety and health and periodic comprehensive update surveys.

Analyze planned and new facilities, processes, materials, and equipment.

Perform routine job hazard analyses.

Provide for regular site safety and health inspections.

Provide a reliable system for employees to notify management personnel [of perceived hazards] without fear of reprisal.

Provide for investigation of accidents. Analyze injury and illness trends.

**Major Element 3**

**Hazard prevention and control** are triggered by a determination that a hazard or potential hazard exists. Where feasible, hazards are prevented by
effective design of the job site or job. Where it is not feasible to eliminate them, they are controlled to prevent unsafe and unhealthful exposure.

**Recommended Actions**

1. So that all current and potential hazards, however detected, are corrected or controlled in a timely manner, establish procedures for that purpose, using the following measures:

   Engineering techniques where feasible and appropriate;
   Procedures for safe work which are understood and followed, as a result of training, positive reinforcement, and, if necessary, enforcement through a clearly communicated disciplinary system;
   Provision of personal protective equipment; and
   Administrative controls, such as reducing the duration of exposure.

2. Provide for facility and equipment maintenance, so that hazardous breakdown is prevented.

3. Plan and prepare for emergencies, and conduct training and drills.

4. Establish a medical program.

**Major Element 4**

**Safety and health training** addresses the safety and health responsibilities of all personnel concerned.

**Recommended Actions.** Ensure that all employees understand the hazards to which they may be exposed and how to prevent harm to themselves and others from exposure to these hazards.

So that supervisors will carry out their safety and health responsibilities effectively, ensure that they understand those responsibilities and the reasons for them, including:

   Analyzing the work to identify hazards;
   Maintaining physical protection in their work areas;
   Reinforcing employee training on hazards [and] on needed protective measures, through continual performance feedback and, if necessary, through enforcement of safe work practices; and
   Ensuring that managers understand their safety and health responsibilities as described under Management Commitment and Employee Involvement, so that the managers will effectively carry out those responsibilities.
ON SAFETY, HEALTH, AND ENVIRONMENTAL AUDITS

INTRODUCTION

In an article published in the October 1998 issue of Professional Safety and titled “What Measures Should We Use, and Why?,” Dan Petersen questions the value of “packaged audits,” giving examples of studies that show that audit results did not always correlate to a firm’s accident experience. There is a history of that sort of thing with respect to “packaged audits” in which an audit guide is used that may not be sufficiently relative to the actual safety practices and needs in the entity being audited. Petersen concluded that “the self built audit—one that accurately measures performance of a firm’s own safety system—was viewed as the answer.” To construct such an audit, Petersen says, a firm must define:

1. Safety system elements
2. The relative importance of each (weighting)
3. Questions to determine what is happening (p. 38)

This is meaty stuff. All elements in a safety management system, while necessary, do not equally impact on those hazards that present the greatest potential for harm, whether measured by incident frequency or severity of injury. Obviously, the safety management elements included, and those emphasized, in an audit system should relate to the hazards that an entity
really has to deal with. Keep in mind that hazards include both the characteristics of things and the actions or inactions of people.

To determine what is really happening, an auditor must explore the safety management systems in place, what is expected of them, and which systems are effective or ineffective in controlling an entity’s risks. That, in effect, results in culture appraisal.

**SHORTCOMINGS IN SAFETY AUDIT CONTENT**

There are some considerations that are supra to the individual elements in safety management systems. I have concluded that most safety, health, and environmental management system audits, intended to measure the quality of hazards management in place, are deficient in purpose and content. I include in that observation the guidelines used for the audits I drafted for individual client needs, the many audit reports I reviewed, and a study of several audit systems.

To begin with, the principal purposes of an audit and what it is to achieve are seldom understood. More specifically, shortcomings exist in our assessments of

- An organization’s culture regarding safety
- The reality of management commitment
- Design and engineering practices
- Procedures in place to identify hazards that could be the causal factors for low probability–high consequence incidents

Also, we could do a better job of giving advice on (a) prioritizing risks, (b) the actions proposed to reduce risk, and (c) alternative remediation solutions and their costs.

**A SELF-REVIEW OUTLINE**

To those who make audits or are responsible for their being made, I offer this self-review outline. It asks the questions that I believe should be resolved to make safety audits more effective.

1. For your purposes, what is the appropriate definition of an audit?
2. What is the *principal* purpose of the audits to be made?
3. How is senior management commitment to safety evaluated?
4. Does the audit system designed relate closely to the hazards and risks in the entity to be audited?

5. With respect to procedures to avoid bringing hazards into the workplace, does the audit system include an examination of the management practices for the design of the workplace, the work methods, and the environmental system, and the purchasing standards?

6. Does the audit system require
   a. prioritizing risks and the recommendations submitted to reduce risk and
   b. giving counsel on alternative actions for risk reduction, the costs for each alternative, and the risk reduction expected?

7. Upon completion of an audit, can the auditor or audit team give reasonable (but not absolute) assurance to management that
   a. the actual quality of safety management has been measured,
   b. the principal hazards have been identified and assessed, and
   c. the principal management actions necessary to reduce risk are being proposed?

**DEFINITION OF AN AUDIT**

To begin with, I suggest that safety professionals agree on a definition of a safety, health, and environmental management system audit. Several writers have provided definitions and addressed what information the audit should provide. Their views differ.

In *Safety Auditing*, Donald W. Kase and Kay J. Wiese say:

> Safety auditing, as we will develop it in this work, is a structured and detailed approach to reducing and controlling the seriousness of accidents. And, safety auditing is a method whereby management can receive a continuing evaluation of its safety effectiveness [p. xiii].

In *Safety Audits, A Guide for the Chemical Industry*, issued by the Chemical Industries Association Limited, it is implied that the major objective of a safety audit is to determine the effectiveness of a company’s safety and loss prevention measures. It is also proposed that whatever the objectives, it is important that they be clearly defined.

In an article titled “Measuring the Health of Your Safety Audit System,” Robert M. Arnold, Jr. listed seven benefits that a safety audit system should provide. These two are pertinent to this discussion.
It offers a precise evaluation of an organization’s safety performance.

It establishes the organization’s capability to forecast the potential for loss-producing events [p. 28].

According to William E. Tarrants, editor of *The Measurement of Safety Performance* and author of several of its chapters:

One must recognize that the main function of a measure of safety performance is to describe the safety level within an organization ... in effect, then, measures of safety performance must ... describe where and when to expect trouble and must provide guidelines concerning what we should do about the problem [p. 49].

Borrowing from these definitions and reflecting on my experience, I give the following definition:

A management system safety audit is a structured approach to provide a detailed evaluation of safety effectiveness, a diagnosis of safety and health problems, a description of where and when to expect trouble, and guidelines concerning what should be done to improve safety effectiveness.

That’s a laudable description. A safety audit that met all of those criteria would truly be professional and serve hazards management needs very well. But, do our safety audits really do all that? Most audit systems do not fulfill all of the requirements of that definition. Comments will be made here on the shortcomings.

**PRINCIPAL PURPOSE OF A SAFETY MANAGEMENT SYSTEM AUDIT**

Kase and Wiese drew the appropriate conclusion when they wrote in *Safety Auditing: A Management Tool* that

Success of a safety auditing program can only be measured in terms of the change it effects on the overall culture of the operation, and enterprise that it audits [p. 36].

An organization’s culture determines the probability of success of a safety, health, and environmental process. All that takes place or doesn’t take place in that process is a direct reflection of the organization’s culture.

The paramount goal of a safety management system audit is to influence the organization’s culture concerning safety — that is, its system of
expected behavior that determines the quality of safety to be obtained. Such a safety audit report is an assessment of the outcomes of the safety-related decisions made over the long term. Those outcomes are determined by assessing what really takes place with respect to the existing or nonexisting policies, standards, procedures, and operating systems. A safety audit report, in effect, is an audit of an entity’s safety culture.

Hazards noted, physical or operational, are to be viewed as being representative of possible deficiencies in management systems. A management that wants to achieve a change in culture is best served if the deficiencies noted and the proposals made in audit reports for improvement principally effect safety management systems.

Even if management complied with the specifics of every recommendation in an audit report, little would be gained, long term, if there was no change in the overall decision-making concerning hazards management. In the typical evaluation system, inadequate attention is given to assessing an organization’s safety culture.

ASSESSING SENIOR MANAGEMENT COMMITMENT TO SAFETY

Senior management’s commitment to safety is a part of and a reflection of the organization’s culture. And it may be that we don’t properly measure senior management commitment. Existence of a results-oriented accountability system that impacts on the financial and promotional well-being of the management staff is the principal measure of whether safety is a subject for which management is held accountable, and, thereby, the principal measure of senior management commitment to safety.

It is said that management measures what is important to it. That doesn’t go far enough. There are at least two classes of measures: measures of form and measures of substance.

Measures of form are just that. Measures may be produced and observed, such as safety audits, incident statistics, or incident costs, and have no bearing on the status of those responsible for operations.

Measures of substance have an impact on the well-being of those responsible for results as a part of an overall accountability system. Management is what management does. Unfortunately, what management does may differ from what management says. I would ask those who make management system safety audits whether, when commenting in their reports on management commitment, they often give credit for what management says, rather than evaluate what management does. Management commitment, or noncommitment, is described by what management does or does not do.
ON DESIGN AND ENGINEERING IMPLICATIONS

Evidence of an organization’s culture concerning safety and its management commitment to safety is first demonstrated through its design and engineering practices — through its upstream design decisions. Yet, a requirement for a review of design and engineering practices is seldom included in safety audit guides, whether in “packaged audit” guides or in those tailored to suit organizational needs.

System safety professionals have been trying for years to convince safety generalists that a superior level of safety performance cannot be achieved unless the upstream decision making properly addressed hazards and risks. And they are right. In auditing a safety, health, and environmental process, evaluating the upstream addressing of hazards and risks should be next in importance, following senior management commitment.

Joe Stephenson, in System Safety 2000, made strong comments on the importance of upstream design and engineering decision making. These two quotes are from his book:

The safety of an operation is determined long before the people, procedures, and plant and hardware come together at the work site to perform a given task.

Safety professionals, managers, or supervisors who think they can have a significant impact on safety in the workplace by putting on a hard hat and safety shoes and meandering out with a clip-board to make the world safe are really fooling themselves if the upstream processes have not been properly done. Good safety practices must begin as far upstream as possible [p. 10].

If a safety audit does not result in influencing the upstream design and engineering practices, it can be expected that there will be a continuation of the sort of decisions that resulted in the hazards observed during the audit being brought into the workplace. While individual hazards may be eliminated or controlled as a result of an audit, similar hazards will more than likely be designed into operations if the concepts to be applied in the design process are not changed.

Several chapters in this book speak of the significance of design and engineering within the practice of safety, and they can serve as references for safety professionals who want to be more proficient in assessing design and engineering practices when making audits.

As an additional reference pertaining to design and engineering practices, I suggest a section of An Environment, Safety, and Health Assurance Program Standard, which was prepared by Sandia Laboratories for the

A synopsis of what appears under Line Organization ES&H Functions follows. Note that the functions are assigned to line management. Basically, these functions should be considered as elements of all safety, health, and environmental endeavors, and the auditing practices that are to assess their effectiveness.

**Planning**: The line organization shall include ES&H considerations in the planning of all operations, and demonstrate through documentation that this has been done.

**Facility/Project Status Information**: Requires listing all facilities, projects, and activities which present significant hazards and classification by type of hazard.

**Identification of Hazards and Their Risks**: Significant hazards associated with each activity, project, or facility shall be identified and documented. The risk attendant upon each hazard shall be assessed and documented.

**Requirements**: ES&H requirements shall be correlated with identified hazards.

**Risk Factors**: Those factors which determine the risk shall be identified and controls established to adequately limit the risk. Control actions shall be documented and reported to management. The controls shall include those specified in the ES&H requirements and shall consist, as a minimum, of those applicable from the following:

- Funding — Budget proposals shall assure that ES&H needs are taken into account.
- Schedules — [are to see that] adequate time is allowed for safe operation.
- Facilities, Materials, and Equipment — The designs and specifications shall be reviewed to determine that ES&H considerations have been addressed, that hazards have been adequately controlled or eliminated, and that adequate facility environmental controls have been included [p. 19].

Remaining categories in this section include the qualifications and training of people, written operating procedures, review of changes to determine ES&H effects, maintenance of records, corrective action, and compliance
assurance. One feature of the latter pertains to *audits comparing performance to specifications*.

These provisions presume that the culture and the management commitment include upstream design and engineering considerations and knowledge of hazard identification and analysis and risk assessment methodologies.

**PURCHASING STANDARDS AND SPECIFICATIONS**

Sound design and engineering practices that address hazards and risks throughout the design process serve to avoid bringing hazards into the workplace. They must be supported by effective purchasing standards and specifications that serve the same purpose. This subject does not typically get the attention it deserves in management system safety audits. Too often safety practitioners tell of their experiences in which purchasing decisions were governed extensively by cost, the result being that the equipment purchased did not meet good safety requirements.

**PRIORITIZING RECOMMENDATIONS, GIVING ALTERNATE SOLUTIONS**

There would be no need to prioritize the recommendations for risk reduction included in an audit report if resources were unlimited and all risk reduction proposals could be scheduled for corrective action immediately. But that is never the case. A safety auditor has an obligation to assign a priority indicator to each hazard/risk situation for which a recommendation is submitted in an audit report.

All hazards do not have equal potential for harm or damage. All hazards-related incidents do not have equal probability of occurrence. Nor will the adverse effects from those incidents be equal. Higher priorities would be given to those hazard/risk situations that present the greatest potential for harm.

Guidance for the development of such indicators is displayed in a Hazard Analysis and Risk Assessment Decision Matrix in Chapter 14, “Hazard Analysis and Risk Assessment.”

Management has a right to ask the safety auditor these questions concerning an audit report:

- What are the most significant risks?
- In what order should I approach what you propose?
- Are there alternative risk reduction solutions?
• Will you help me develop costs for each of the alternatives?
• Will you work with me to determine that what we do attains sufficient risk reduction?

And the safety auditor should be able to give helpful responses to those questions. Too often safety auditors submit an audit report containing a laundry list of recommended actions without priority indications or an offer of assistance. Audit systems fail if they do not show an appreciation of management needs, if they are not looked upon as assisting management in attaining their goals.

AUDIT EFFECTIVENESS

If the audit is made to fulfill the purposes of the definition of an audit given earlier in this chapter, it would provide an evaluation of safety management effectiveness, a diagnosis of safety and health problems, a description of where and when to expect troubles, and guidelines concerning what should be done about the problems. If all that is done through the audit process, the auditor should be able to say to management with a high degree of confidence that the quality of hazards management has been assessed and that the principal management actions to reduce risk are being proposed.

But the confidence level cannot be absolute. Unfortunately, some hazard/risk situations remain obscure, and perfection in identifying them cannot be attained. It should be made clear to management that applied safety auditing is based on a sampling technique and that it is patently impossible for safety auditors to identify 100% of hazard/risk situations.

An often-heard criticism of safety audits is that incidents resulting in significant injury or damage occurred after the audit was completed and that the contents of the audit report had little or no relation to the causal factors for those incidents. One reason that occurs is that the audit process does not examine the procedures in place to identify those obscure hazards that are the causes of low probability–high consequence incidents.

To minimize the potential for occurrence of low probability–high consequence incidents, the safety management system must include a distinctly identified activity designed for that purpose. Perhaps in making audits, we spend too much time on the less significant and not enough time on the management systems that are intended to identify the potential for those seldom-occurring incidents that can result in severe harm or damage.
OTHER VIEWS ON SAFETY AUDITS

To provide the views of others with impressive reputations who have been successful in making safety audits, two colleagues were asked to write to me on the subject. Mr. Thomas W. Lawrence, Jr., CSP, PE, formerly at Monsanto, is now a Principal at Risk, Reliability & Safety Engineering in League City, Texas. That firm does many safety audits to assist clients in assuring compliance with OSHA’s Final Rule for Process Safety Management of Highly Hazardous Chemicals. This is what Mr. Lawrence wrote:

There are two approaches for conducting safety audits:

A baseline or gap analysis audit expects to find management systems early in implementation or inconsistent in application or insufficiently comprehensive. The compliance requirements or other objectives that the management system should be achieving are used to conduct a baseline audit. However, the assessment is typically at a fundamental level focusing on management system descriptive documents and discussions on actions related to the management system. That audit level is normally sufficient to identify the significant gaps and point direction for improvement.

A full management systems compliance audit expects to find management systems that are higher on a maturity scale. The focus first is on understanding the management system and whether its procedural documents will, if followed, accomplish the required or desired objective consistently. Following this understanding, the focus then shifts to determining if the outcomes of the management system are consistently meeting requirements or other objectives. Written records, interviews and observations are the mechanisms for conducting this essential portion of the audit.

The two main efforts in conducting an audit are: (1) Review and understanding of the policy and procedure documents for the management system(s) and (2) Assessment of expected system outcomes through reviews of records, through interviews, and by observations. The baseline audit assesses both Numbers 1 and 2 but typically directs most of its attention to Number 1. In contrast, the full management systems audit also assesses both Numbers 1 and 2 but typically directs most of its time and effort to Number 2.

Mr. Lawrence introduces the subject of baseline or gap analysis audits. They may be just what a client needs, in a given circumstance.

Mr. George Swartz writes of his experiences with safety audits while Director of Safety at Midas International Corporation:

I have used safety audits in my 31-year safety career and I consider the audit to be one of the finest tools to guide management’s safety and health
program. At Midas, the audit was initiated in 1978 to develop a fixed structure that would serve the safety efforts in all of the facilities in North America. The audit was designed and structured to provide a match for the types of businesses in which we were engaged.

Management endorsed the use of audits to ensure that each facility was following the Midas S & H program. Our intent was to utilize best safety practices and follow the requirements of the OSHA regulations. The safety and health audit verified what each facility was accomplishing.

When the first audits were conducted at our facilities, the base-line audits were a disappointment. With a potential of 100 available points, most facilities scored in the 20’s: the highest score for a manufacturing plant was 34. In other words, at Midas locations the safety program had little direction and content. It took months to complete the base-line audits. After the scores were revealed to senior management, the CEO made it his goal to have all locations improve.

Rather than have each location manager draft a safety program, one was provided them containing the basics with the understanding that they were to flesh it out to suit their particular operation and needs. Rather soon, facilities improved their safety program efforts to the extent that audit scores continued to climb while workplace injuries continued to decline. The higher audit scores provided a friendly competition among facilities to excel.

Facilities were placed in specific categories pertaining to their operations and size—manufacturing, warehousing—so that they were competing against near equals. The Presidents Safety Award was established and the competition for it was keen. It was the only award at Midas given by the President.

Audit scores continued to climb, reflecting continued improvement in safety management. Results became so good that it was decided to have some locations qualify for OSHA’s Voluntary Protection Program (VPP). For that program, superior results must be demonstrated and the location must meet the requirements of a thorough safety management audit.

All of the successes of the Midas safety program can be credited to three important factors:

1. Senior management responded to the audit findings, believed in the program adopted as a result of those findings, and endorsed its contents.

2. Supervisors and facility managers were held accountable for their safety programs. They were the safety directors. The number of injuries at each site had to be reduced and the audit score had to be at least 97% for them to receive a bonus or an increase as a result of their annual performance reviews.
3. There is no question that the safety and audit system molded, shaped and guided Midas to achieve VPP status and be identified as a corporation with a world-class safety program.

In this instance, the activity started with baseline audits, safety program development, management taking ownership of the safety program, continued audits, higher standards of performance, and people being held accountable for results in a way that effected their financial well being. Interesting.

CONCLUSION

In Chapter 24, “Measurement of Safety Performance,” it is said that precise and certain measures of safety, health, and environmental performance are difficult to obtain. Nevertheless, audits can be highly effective measures of the quality of hazards management in place if they are well conceived and well done. I suggest keeping in mind the observation made by Kase and Wiese concerning the purpose of a safety audit:

Success of a safety auditing program can only be measured in terms of the change it effects on the overall culture of the operation, and the enterprise it audits [p. 36].

REFERENCES


INTRODUCTION

It is typical for the various fields within the practice of safety to be in transition with respect to knowledge needs and the counsel given. And not surprisingly, that element within the practice called behavior-based safety is in the process of evolution.

In the August 2001 issue of the magazine *Industrial Safety and Hygiene News*, an editorial appeared on behavioral safety, written by Dave Johnson, the Editor and Publisher. Its title is “Beyond behavior — New Labels for Old Medicine.” Excerpts from that editorial follow.

Bottom line pressures, management turnover and good old human nature just about guarantee a steady stream of safety issues to deal with. So the hunt never ends for the next, new thing to cure, or at least arrest, those chronic challenges. Behavior-based safety has been the medicine of choice in recent years. But interest shows signs of waning, and the field’s experts now prescribe a cocktail mix of behavioral, systems and motivational remedies.

Two days in February 1998 might have been the field’s high-water mark. That’s when the American Society of Safety Engineer’s behavioral safety symposium in Orlando smashed all expectations in attracting more than 900 safety pros. The field’s luminaries — go-getter personalities with engaging
speaking styles and books and videos to their names — shared the stage for
the first time, and the star power was palpable.

But at several behavior-based safety sessions held this past June during
ASSE’S annual conference, a head count of attendees revealed a different
story. Topics and speakers that packed rooms five years ago were met with
plenty of empty seats.

Some of the well-known speakers shifted or expanded their focus at the
ASSE meeting. Dr. Scott Geller, for example, discussed qualities for effec-
tive safety leadership. Other talks connected behavior to culture change
and motivation. “Behavior” with its negative connotations, often gets no
mention at all — “performance” is now the bottom line. A recent ad for
the pioneering safety consulting firm Behavioral Science Technology talks
about “performance improvement,” “organizational citizenship culture” and
“safety systems,” but nowhere in the copy do you find the word “behavior.”

In the May 27, 2002 issue of ISHN’s E-News, Mr. Johnson asks,
“What’s next?” and says the question “came up lately because signs point
to the decline of behavior-based safety, which has been hailed as the latest,
greatest elixir for easing safety headaches.”

In exploring the transitions that are taking place in behavioral safety,
the behavior-based symposium held by ASSE in February 1998 will be
used as a starting point. This chapter will review the following:

- In Part 1 we review the two schools of thought in applied behav-
ioral safety.
- In Part 2 we review the substance of the concerns that some have
expressed about behavior-based safety.
- In Part 3 we review recent developments that may have an impact of
the future of behavior-based safety.

SELECTED REFERENCES

In my book Innovations in Safety Management: Addressing Career Knowl-
dge Needs, a chapter is titled “Current Developments In Behavioral
Safety.” Supportive excerpts are taken from that chapter and from my
article “Perspectives on ASSE’S Behavioral Safety Symposium,” which

Many of the prominent consultants in the field of behavior-based safety
were presenters at the 1998 ASSE conference on Behavioral Safety. Their
speeches, representing a wide diversity of views, are contained in the Pro-
That publication is recommended reading: It sets forth very well the
variations in concepts on which the practices of the behavioral safety consultants are based. And those variations are substantive.

PART 1: THE TWO SCHOOLS OF THOUGHT IN APPLIED BEHAVIORAL SAFETY

In “Perspectives on ASSE’S Behavioral Safety Symposium” (p. 32), I explored, among other things, the two major differences in the behavioral safety concepts offered by the presenters. One of the key points made in that paper is that the attendees could have logically come away from the symposium confused about what behavioral safety actually is.

Why the Confusion?

According to Dr. E. Scott Geller, who is often a writer and speaker on behavioral safety, a problem of consequence has arisen because some of those who offer themselves as behavioral consultants don’t, in his view, really practice behavior-based safety. Geller, who is a practitioner in worker-focused behavior-based safety, wrote an article titled “Confusion, Controversy, and Clarification,” which appeared in the January 1999 issue of Occupational Health & Safety. These excerpts from that article pertain to the ASSE conference on behavioral safety held in February 1998.

This ASSE conference was designed in part to clarify the principles and methods of BBS . . . . This mission was not accomplished. In fact, many presentations at this conference caused more confusion . . . . Part of the discord and confusion about BBS . . . occurred because several presenters do not practice BBS in their consulting, and thus, did not teach lessons consistent with BBS principles [p. 40].

Note that Geller said “several presenters do not practice BBS in their consulting.” Who practices behavior-based safety and who doesn’t?

Aubrey C. Daniels, a well-known and long-term practitioner in the field of performance management, has also expressed concerns about what is being offered as behavioral safety. His paper “The Imperative for an Integrated Approach to Behavior-Based Safety Initiatives” appears in the Proceedings, ASSE 1999 Professional Development Conference. These are excerpts from it:

I have some rather serious concerns that many of the products and services being marketed under the name of behavior-based safety are not truly behavior-based, as in behavior analysis. My concern is that a lot of what
I see going on in the name of behavior-based safety is not true behavior analysis, but what I call a watered-down variety of it [p. 287].

It is not the intent here to explore the many, many versions of behavior-based safety being offered by the multitude of consultants now in the field. But, it is important for safety practitioners to understand that most all of the consultancies being offered fall within one of two diverse schools of thought.

One school advances a culture change model; the other advocates a worker-focused behavior-based model. Practitioners in both schools make great claims concerning their successes. They do not speak of their failures. One behavioral safety practitioner, Jerry Pounds, does. He writes the following in “High-Risk Safety: The Six Biggest Mistakes in Implementing a Behavior-based Process,” an article that appeared in the Performance Management Magazine, a publication of Aubrey Daniels & Associates:

Warning: In all probability your organization’s behavior-based safety process will soon collapse. Statistics show that 70 percent of such initiatives fail, resulting in billions of dollars in lost time and revenues.

A CULTURE CHANGE MODEL

In the following section, the page numbers in ASSE’s 1998 Proceedings: A Behavioral Safety Symposium are given for the references cited.

Steven Simon, Ph.D., Michael D. Topf, M.A. and Terry E. McSween, Ph.D., made the case at the Conference in support of the culture change model. Simon indicated that there are two approaches in the behavior-based safety field. One takes a macro approach — the view that operation improvement is accomplished through a culture change. The other takes a micro approach — and assumes that such improvement can occur by changing the behavior of hourly workers.

Simon expressed the view that the culture drives the behavior and that a culture change is required for success in behavior-based safety. A culture assessment (such as the Simon Open System Culture Change Model) measures the culture process and impacts on the whole of operations — the technology, trust, leadership, symbols of the culture, et cetera. He also advised that before a behavior-based initiative is undertaken, management leadership must have been established. That’s implicit. This factor cannot be overlooked. These are excerpts from Simon’s paper titled “The Culture Change Model of Behavioral Safety”:

In sum, Behavioral Safety offers two different models to choose from: behavior modification or culture change. As a humanistic psychologist,
I have always respected the imperatives of the organizational/culture dynamic. Accordingly, my methodology of choice for changing behavior must engage the organization in defining and remaking its culture.

Culture change is a distinct model for the continuous improvement of safety performance. Whereas behavior modification is an individual-based training method in behavioral observation, analysis and feedback, culture change is a system-wide change effort, and the “organizational culture” is the client system. A behavior modification project could increase the number of safe behaviors while stopping short of changing the organization’s core values. Culture change requires analysis of systems that hold norms, assumptions and beliefs in place. It is strategy development carried out by leadership [p. 53].

Culture change offers a methodology to gain employee involvement and improve safety performance without dictating specific programs. There are six phases of change in the culture change model: Defining and Communicating the Need for Change; Envisioning a Desired Future; Assessing Organizational Systems and Culture; Strategic Planning; Implementation; and Evaluation and Measurement [p. 55].

In the paper titled “Improving Safety by Changing Culture,” this is how Topf addressed values and the culture:

When we want to improve safety, the transformation of corporate culture is an important strategy to consider. The essential element in corporate culture and its transformation is the issue of values. Values—the principles, standards, or qualities considered inherently worthwhile by individuals or organizations—are far more than empty platitudes that make a company or its people “feel good” about what goes on. Rather, values cautiously evolved and meaningfully pursued provide a working blueprint that dictates much about how a company will perform. Occupational safety and health and environmental stewardship, like all segments of a business, are directly affected by the values espoused and embraced by the organization. Taken together, these values and their embodiment in action make up an organization’s culture. By understanding a specific corporate culture and contrasting it against a created vision of an ideal, it is possible to develop lasting change in the attitudes and behaviors of employees and company leaders by implementing an effective safety and environmental culture change process [p. 64].

One of McSween’s papers in the Proceedings is titled “Culture: A Behavioral Prospective.” These excerpts are from that paper:

We need to understand the reasons people work safely or take risks at work and we need to create a work environment that supports people in working safely [p. 44].
We are striving to produce a culture where safety is a core value. If safety is a core value, then the members of the culture will work safely all of the time, whether anyone is there to observe them or not. This is truly a “safety culture” [p. 45].

Many companies have adopted an observation-based behavioral safety process to improve compliance with safety procedures. Alas, simply implementing the basic elements of a behavioral safety process does not always work [p. 48].

Addressing the safety culture of an organization requires utilization of a state-of-the-art process to address safety and an alignment of existing systems to support the mission and values of the organization [p. 49].

I recommend that Simon, Topf, and McSween be taken seriously, since I have believed for some time that an organization’s culture determines the level of safety to be achieved.

ON THE WORKER-FOCUSED BEHAVIOR-BASED MODEL

Dan Petersen’s definition of worker-focused behavior-based safety as shown in the Proceedings of the ASSE 1998 Seminar will be used here.

Perhaps the definitions we hear most about today are those that define behavior-based safety as a process of involving workers in defining the ways they are most likely to get hurt, thus getting their involvement and thus some buy-in, asking the workers to observe other workers to determine progress in the reduction of unsafe behaviors etc. [p. 2].

In the January 1997 issue of the magazine Occupational Safety and Health, an article by E. Scott Geller is titled “What Is Behavior-Based Safety, Anyway?” He outlined differing perspectives regarding BBS and then gave his seven key principles of BBS. Geller said that these seven basic principles should serve as guidelines when developing a BBS process. They are:

1. Focus intervention on behavior.
2. Look for external factors to understand and improve behavior.
3. Direct behavior with activators or events antecedent to behavior, and motivate behavior with consequences or events that follow behavior.
4. Focus on positive consequences to motivate behavior.
5. Apply the scientific method to improve behavioral interventions.
6. Use theory to integrate information, not to limit possibilities.
7. Design interventions with consideration of internal feelings and attitudes [p. 36].

Obviously, worker-focused behavior-based safety puts the spotlight on the worker and worker behavior. References in the relevant literature to the work of B. F. Skinner, “the father of applied behavior analysis,” on how to go about improving worker behavior are frequent.

This brief but helpful synopsis of Skinner’s theory appears in “Back to the Future: The Importance of Learning the ABCs of Behavioral Safety.” The author is Stephen H. Reynolds; and the article appeared in the February 1998 issue of Professional Safety.

B. F. Skinner theorized that all behaviors are a function of “antecedents” and, perhaps to a larger extent, the “consequences” of those behaviors. Antecedents (also called “activators”) serve as triggers to specific observable behaviors. Consequences either reinforce or discourage repetition of those behaviors. Most of today’s behavioral safety movements are founded on this “ABC” theory [p. 23].

IMPLEMENTING WORKER-FOCUSED BEHAVIOR-BASED SAFETY

How does one implement a worker-focused behavior-based safety initiative? A condensation cannot be given here of the methodologies presented in the many books available on applying worker-focused behavior-based safety methods that seek to achieve improvements through focusing on antecedents, behaviors, and consequences. As an example of those methods, the following is taken from The Behavior-Based Safety Process, 2nd edition by Thomas R., Krause. Chapter 6 is titled “Introducing the Behavior-Based Safety Process to a Site.”

Facilities that achieve continuous improvement as a safety goal do so by following certain steps and by treating each step as an opportunity to involve wage-roll employees.

These steps are displayed in an “implementation sequence” which shows the order of the approach to be taken.

- Implementation Planning Meeting
- Assessment Visit and Report
- Behavioral Inventory Tools Development
- Management Training
This is quite a process. All of it is directed toward identifying and minimizing at-risk behaviors. Data would be gathered on at-risk behaviors through interviews with employees, through safety surveys, and through analyses of accident reports. At-risk behavioral inventories would be produced. Worker groups would be trained to give each other positive reinforcement for safe behavior, the intent being that peer involvement would reduce at-risk behavior. Behaviorists write that immediate, frequent, and positive rewarding of proper behaviors will promote repetition of those desired behaviors.

PART 2: SUBSTANCE OF THE CONCERNS

An Interesting Meeting

Jim Howe, CSP, is the Assistant Director in the Health and Safety Department at the headquarters of the United Auto Workers Union. He and Thomas R. Krause, CEO of Behavioral Science Technology, were to be speakers at the Professional Development Conference to be held in June 2000. I was to be the moderator. Tom Krause asked for a meeting with Jim Howe and me for a discussion of the program. Scott Stricoff, President of Behavioral Science Technology (BST), also attended.

Although this was a private meeting, making the minutes of it public is being done with the approval of all in attendance. After the introductory pleasantries, Tom Krause asked Jim and me to tell him what we believed to be wrong with behavioral safety.

Minutes of the meeting were prepared by Jim Howe and edited and extended by Scott Stricoff. As you review the minutes, you will observe that Krause and Stricoff agreed with much of what Jim and I said.

In Stricoff’s extension, there are four columns captioned Statement, BST, Narrow Applied Behavior Analysis Advocates, and Condition/Acts
Standard Checklist. The first two columns pertain to the statements Jim Howe and I made expressing our concerns with respect to behavior-based safety, and the response to those concerns by BST.

Tom Krause asked that I explain that Scott and he were making the point in the last two columns “that much of what is done by others as ‘behavioral safety’ differs markedly from what we at BST do and consider good practice.” But, since the data in the last two columns are not relevant to this discussion, only the first two columns as in the extended minutes prepared by Scott Stricoff are repeated here.

<table>
<thead>
<tr>
<th>Statement</th>
<th>BST Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is untrue that 80–95% of the incidents are the result of unsafe behavior.</td>
<td>Agree; most are the result of the interaction of people with conditions and systems.</td>
</tr>
<tr>
<td>2. Every injury and illness is the result of exposure to hazards: there are no exceptions. (Definition: A hazard is the potential for harm, including the characteristics of things and the actions or inactions of persons.)</td>
<td>Agree</td>
</tr>
<tr>
<td>3. All hazards are not created equal — the level of risk varies.</td>
<td>Agree</td>
</tr>
<tr>
<td>4. The principal focus of safety improvement shouldn’t be on the psychology of correcting worker behavior; rather the focus should be on the design of the workplace, work methods, and management systems.</td>
<td>Agree. The principal focus for corrective action is on the systems, not the individuals.</td>
</tr>
<tr>
<td>5. Root cause analysis is necessary to item number 4.</td>
<td>Agree</td>
</tr>
<tr>
<td>6. Improvement in safety requires the ability to recognize and correct hazards.</td>
<td>Agree</td>
</tr>
<tr>
<td>Statement</td>
<td>BST Response</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7. If a safety director has the systems in place to identify, evaluate, and improve hazards and risks, then he does not need behavior-based safety.</td>
<td>Agree, provided that by “in place” we mean working effectively and that by “improve” we mean able to address equipment, systems, culture, and human error-based causes, and that behavior-based safety means observation and feedback to address behavior alone.</td>
</tr>
<tr>
<td>8. Safety incentives are not useful.</td>
<td>Agree</td>
</tr>
<tr>
<td>9. It is not true that the workers have the greatest knowledge of hazards in the job.</td>
<td>Agree</td>
</tr>
<tr>
<td>10. Workers do have the greatest knowledge of what actually goes on in the job.</td>
<td>Agree</td>
</tr>
<tr>
<td>11. Task analysis including observation is useful and important.</td>
<td>Agree</td>
</tr>
<tr>
<td>12. Behaviorists who say that their approach can solve all the problems do a great disservice to the profession.</td>
<td>Agree</td>
</tr>
<tr>
<td>13. It takes health and safety professionals to do root root cause analysis.</td>
<td>Agree if the wording were it takes trained professionals; we do not believe that only health and safety professionals can have this skill — for example, there are engineers who would not consider themselves H&amp;S professionals but who by training and experience possess this knowledge and skill.</td>
</tr>
<tr>
<td>Statement</td>
<td>BST Response</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14. A legitimate criticism of behavior-based safety is that it can divert attention from significant workplace and work method design problems.</td>
<td>Agree that it can, but not that it necessarily has to.</td>
</tr>
<tr>
<td>15. Because behavior-based safety people are not trained to identify hazards and the level of risk, they cannot identify those hazards that are most likely to lead to severe injury and fatalities. (This is based on the need to identify high severity potential hazards.)</td>
<td>Agree that the people practicing behavior-based safety without safety knowledge have this limitation; however, recognize that there are people practicing behavior-based safety who are health and safety professionals.</td>
</tr>
<tr>
<td>16. The hierarchy of controls should be used to reduce hazards in the workplace.</td>
<td>Agree</td>
</tr>
<tr>
<td>17. The “pyramid” or “iceberg” Diagram showing behavior at the bottom and increasing severity moving toward the top is invalid.</td>
<td>Agree that it can be (and sometimes has been) misinterpreted and misused.</td>
</tr>
<tr>
<td>18. There is a small percentage of jobs that cannot be error proofed (and for this there is a role for behavior safety).</td>
<td>Agree that behavior based safety has a role in this area, although it has a broader role as well.</td>
</tr>
</tbody>
</table>

All of the comments made in the left-hand column above represent our concerns over what practitioners in behavior-based safety have said or written or over what they have not recognized as fundamental and significant. For example, some of those practitioners state in their speeches and papers that 85%, 90%, or 95% of accidents are caused principally by unsafe acts. No matter what definitions they give for the term *unsafe act*, they immediately moved from those figures to addressing means for resolving the at-risk behavior of employees through behavior modification methods, with minimum or no consideration of systems causal factors. That’s absurd.

To obtain entire or partial agreement on the following was significant: The principal focus of safety should be on the design of the workplace, work methods, and management systems; if a safety director has the systems in place to identify, evaluate, and improve hazards and risks, then
he does not need behavior-based safety; root cause analysis is necessary; and the hierarchy of controls should be used to reduce hazards in the workplace. Responses by BST, a leader in the behavioral safety field, indicate a possible change in the direction behavioral safety may take if others respond to that organization’s leadership.

Rarely will you find in the behavioral safety literature that problems should be analyzed to determine their root causal factors before solutions are applied. A legitimate criticism of the practice of many behaviorists is that in the application of their systems, sizeable amounts of money are spent before the reality of the problems have been identified.

Root Causal Analysis Is Absent

Reynolds, in “Back to the Future: The Importance of Learning the ABCs of Behavioral Safety,” discusses the need “to first analyze the management controlled antecedents and consequences that actually drive those employee behaviors” (p. 24). Many of the concerns expressed by highly capable safety professionals over the worker-focused behavior-based safety approach center on the fact that causal factors deriving from the work environment and work practices are ignored. Most behavior-safety practitioners do not recognize the need to examine the reasons — the antecedents, if you like — for the existence of hazards and risks.

Worker-focused behavior-based safety directs efforts to correct worker at-risk behavior. Hardly ever in the relevant literature is there recognition that the antecedents for at-risk behavior should be analyzed to determine their sources. Seldom is there recognition that the antecedents may derive from the work environment created by management — for example, from the design of the work place or the work methods.

Identifying root causal factors is an important safety process. When applying the process to the at-risk behaviors identified, logic requires that a strong emphasis be given to separating causal factors that are systemic from those that are truly behavioral. If the antecedents derive from the work systems, which are the responsibility of management, then the first course of action should be to direct management attention to them.

As was stated previously, it is common for advocates of the worker-focused behavioral-safety model to state that 80–95% of accidents are principally caused by unsafe acts of workers, and, therefore, the proper action is to develop worker-focused solutions. That creates the impression in the minds of managements and many safety practitioners that the workers are the problem, that all risk situations can be resolved by worker observation techniques and positive reinforcement, and that the antecedents that derive from the design of the work methods and the workplace can be ignored.
In *Safety Management*, 2nd edition, Dan Petersen offers a premise from which one must conclude that the antecedents for some at-risk behaviors must be resolved by management.

In most cases, unsafe behavior is normal human behavior; it is the result of normal people reacting to their environment. Management’s job is to change the environment that leads to the unsafe behavior [p. 15].

Management is responsible for the work environment created, for the design of the workplace, and for the design of the work methods. If the antecedents for at-risk behavior derive—for example, from material handling ergonomics problems that overstress a large percentage of the employee population—the focus for reducing at-risk behavior logically has to be on revising the material handling methods.

**Mr. Thomas A. Smith**

Smith’s article titled “What’s Wrong With Behavior-Based Safety?” was published in *Professional Safety* in September 1999. It caused quite a stir and has been cited often. Smith questions the premises on which behavior-based safety depends and the research supporting it. He writes:

Many articles point to the large body of research substantiating BBS, yet neglect to mention the large amount of scientific research that refutes it. A major problem with BBS is the fact that, when held up to the scrutiny of the scientific method, behaviorism failed [p. 37].

The cornerstone of BBS is the principle that most accidents are caused by unsafe acts of workers. Traditional safety management theory (as developed by Heinrich, yet based on no scientific proof) is that management should focus on unsafe actions since they account for 85 to 95 percent of accidents. If one accepts this premise, it is only a small step to assume that, to improve safety, one must change employee behavior [p. 38].

Consequently, BBS misses the mark (much like quality programs did in the 1970s). A quality management system requires that management act on the system, not the workers, in order to solve quality problems. Quality management theory recognizes that output problems are built into the system. The same is true of safety. Most quality and safety problems are not created by individual employees [p. 39].

When management realizes that the system itself causes accidents, BBS is no longer useful [p. 40].

Smith places a strong emphasis, as have others including myself, on the premise that root causal factors for accidents—that is, the
hazards—derive principally from the design of the work system and the work methods. Effective quality management is based on the same premise. Such causal factors are the responsibility of management and can only be resolved by some sort of management action. They cannot be corrected by worker observation and positive feedback.

**Mr. James F. Whiting, MSc**

Mr. Whiting is the Managing Director & Principal Risk Engineer at risk@workplaces pty ltd, in Brisbane, Australia. He was a presenter at the Professional Development Conference held by the American Society of Safety Engineers in Nashville in June 2002. His paper is titled “The Missing Element of Behavior-Based Programs — Calculating and Evaluating Risk.” His theme is that for a behavioral safety initiative to be effective, the risks must first be assessed. That has a close relationship to saying that root causal factor analysis must be made to identify the hazards and the risks that derive from them.

Whiting says that “Nearly all behavior-based safety programs don’t recognize the need, and don’t provide any adequate process for adherence to (his) logic chain” for understanding, perceiving, assessing, and calculating risk. And his statement is true.

**Mr. Dan Petersen**

Reference was made previously in this chapter to Dan Petersen’s writings. He is prominent in the occupational safety field, a noted speaker, and a prolific author. His article “The Barriers to Safety Excellence” was published in the December 2000 issue of *Occupational Hazards*. Behavior-based safety is one of the barriers to safety excellence Petersen cited.

How can behavior-based safety (BBS) be a barrier to achieving excellence in safety?

This sounds ridiculous: yet, in many companies, it is happening. BBS is being implemented in some form in 31 percent of companies where *Occupational Hazards* readers are employed. It is popular; it is discussed in every safety conference today. Most BBS programs are primarily programs of peer observation and intervention. Hourly workers are trained and become trainers. Trainers train hourly workers to be observers.

Usually, there is little management involvement. In some cases, management cannot even see what the observers are finding. In short, it often is an employee-only program.
This, then, provides the perfect opportunity, because safety is taken care of, for management to abdicate their responsibility, as they already have more to do every day than they can possibly get to.

BBS has the great potential to be a huge barrier to safety excellence. I believe you cannot achieve safety excellence without management. In some cases, BBS has widened the gap between management and the work force [p. 37].

In conversation, Petersen cited examples of managements having abandoned responsibility for safety because of the introduction of a behavior-based safety initiative, with adverse results. Unfortunately, some behavioral safety practitioners have created the impression that behavioral safety is the panacea, the cure for all problems. This is an absolute: Superior safety (or quality) cannot be achieved without management direction, involvement, and accountability.

**Mr. John Kamp**

Mr. Kamp’s paper “It’s Time to Drag Behavioral Safety into the Cognitive Era” was the ASSE 2001 first place Professional Paper Award winner. It was published in the October 2001 issue of *Professional Safety*. Kamp poses this question: “What is it about behavioral safety that motivates employees to make extra effort to work safely when they are not being observed?” He then writes:

This “why” question is at the heart of behavioral safety. The shocking part is that the psychological model commonly used to explain the conceptual foundation of behavioral safety — variously called “behaviorism,” “behavior analysis,” or “reinforcement theory” — cannot explain why employees choose to work safety when not being formally observed. Yet few seem to recognize this “emperor has no clothes” situation.

In the 1960’s Bandura showed how behaviorism’s simple, “empty-headed” model is unable to explain much human behavior. He pointed out that humans often adjust their behavior based on seeing what others do and what consequences they experience, a phenomenon he termed “observational learning.” More broadly, Bandura showed that it is not actual consequences (those experienced in the past), but rather anticipated consequences (what people think will happen) that control human behavior. Because of human thinking capabilities (termed “cognitive processes” by psychologists), people often change behavior without having to experience consequences that behaviorists see as having sole control of behavior [p. 30].
Kamp’s article puts into question the validity of the familiar A–B–C model often used to explain behavioral safety (antecedents, behavior, consequences). He also recognized the value of the previously cited paper by Thomas A. Smith, as follows:

The fact that strict behaviorism is no longer popular in psychology does not make it wrong; however, most psychologists today believe it has limited “real-world” application. In a controversial critique of behavioral safety, Thomas Smith, a safety professional, repudiated the behaviorist paradigm in psychology, stating, “when held up to the scrutiny of the scientific method, behaviorism failed.” Although this overall conclusion is broader than most psychologists would endorse, Smith’s critique provides a healthy corrective to an unquestioning acceptance of Skinnerian psychology by the safety profession [p. 31].

Kamp invites the behaviorists and safety professionals into the field of cognitive psychology “for knowledge that will enhance behavioral safety theory and methods” [p. 32].

Mr. Jim Howe

Jim Howe is the Assistant Director in the Health and Safety Department at the headquarters of the United Auto Workers Union. Jim is often a speaker on behavioral safety, and he takes a strong position that “behavior-based safety can be hazardous to your health and safety program.” His views are set forth in A Union Critique of Behavior Based Safety, a paper issued by the UAW Health and Safety Department.

I believe that the following are the key points in the union Critique and in Jim Howe’s position, and that thoughtful safety practitioners should give them due consideration.

- Behavior-based safety is based on one of the oldest and most outdated approaches to safety — the Heinrich premise that 88% of all industrial accidents are caused primarily by unsafe acts of persons [p. 1].
- Behavior-based safety does not focus on what really causes accidents. Injuries and illnesses are caused by exposures to hazards. What do I mean by hazards? Hazards include any aspect of technology or activity that produces risk. If the work methods designed and prescribed put employees at risk, those methods are hazardous [p. 5].
- Behavior-based safety does not recognize the most effective method of controlling hazards, which is through the application of the hierarchy of controls [p. 7]. (See “The Safety Decision Hierarchy” in Innovations in Safety Management: Addressing Career Knowledge Needs.)
• Behavior-based safety places responsibilities on workers for which they may not be qualified. Although worker involvement is important, it has limitations and is not a substitute for technically competent health and safety experts reviewing both existing and future operations to insure that hazards are identified and controlled. Few workers have been trained in hazard identification, risk evaluation or methods of control (hierarchy) [p. 17].

For as long as the behavior-based safety literature ignores injury causal factors that derive from (as cited above) “work methods designed and prescribed (that) put employees at risk,” it can be expected that Mr. Howe and other union representatives will continue to make the case that behavior-based safety is not what some of the practitioners make it out to be. One of Mr. Howe’s concerns is the presentations by speakers, of which there have been many, who would have the audience believe that behavior-based safety is all that needs to be done.

PART 3: RECENT DEVELOPMENTS

In the Introduction to this chapter, reference was made to an editorial by Dave Johnson, Editor and Publisher of Industrial Safety and Hygiene News. He wrote that at an ASSE 2001 meeting, “some of the well-known speakers shifted or expanded their focus.” Obviously, significant changes in the rhetoric have occurred.

Behavior-based safety is in a state of transition. Several key players are repositioning their products. That’s understandable. As Johnson wrote, terms such as performance improvement and organizational culture change appear more often in the literature. But, take care. These terms imply a significant impact on the management systems and an entity’s culture. That is attainable if the culture change school of thought is applied: It’s doubtful that applying the worker-focused behavior-based model can reach up to impact on the management systems, without significant change in the methods typically applied.

Developments of consequence have occurred in the presentations of two of the key players in the behavioral safety field, and they will be discussed here. If others follow the lead of these two organizations, behavioral safety will have undergone a notable change.

Mr. Thomas A. Krause, CEO, Behavioral Science Technology

In June 2000, at the ASSE Professional Development Conference, Tom Krause gave a speech titled “Moving to the 2nd Generation In Behavior-Based Safety.” In May 2001, an article having the same title appeared
in the ASSE magazine Professional Safety [p. 27]. Krause speaks of his current model that “combines ABA (applied behavioral analysis) with techniques of quality management and organizational development to create a comprehensive safety improvement methodology.” That’s great.

He writes: “Use of observation data is a significant element of an integrated BBS program. By using behavioral data to develop action plans for improvement, the focus shifts from the worker to systems, design, maintenance, and other, more-subtle mechanisms such as purchasing and decision making” (p. 30).

In a later article by Krause titled “Improving the Working Interface” that appeared in the September 2001 issue of Occupational Hazards (p. 71), this is the opening sentence:

Managers and union spokespersons who have not used behavior-based safety are often surprised to hear that one of its primary functions is to find and fix systems barriers to safe work.

And I also would have been surprised. There is no such indication in the second edition of Krause’s book The Behavior-Based Process that the process is to find and fix systems barriers to safe work. Nevertheless, the statement may predict change.

Krause presented an updated exhibit titled “Proportion of Barriers for 13,264 At-Risk Behaviors.” A study was made at BST of 13,264 observed behaviors and it was found that: “There were many system barriers in place that made the critical behaviors difficult to do or impossible. When we looked further, we found that the different barriers in the proportions shown (in his exhibit) caused the observed at-risk behavior” (p. 72). This is the substance of the exhibit.

**Proportion of Barriers for 13,264 At-Risk Behaviors**

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities and Equipment</td>
<td>33%</td>
</tr>
<tr>
<td>Hazard Recognition and Response</td>
<td>22%</td>
</tr>
<tr>
<td>Personal Choice</td>
<td>17%</td>
</tr>
<tr>
<td>Disagreement on Safe Practices</td>
<td>9%</td>
</tr>
<tr>
<td>Culture</td>
<td>7%</td>
</tr>
<tr>
<td>Personal Factors</td>
<td>5%</td>
</tr>
<tr>
<td>Business Systems</td>
<td>4%</td>
</tr>
<tr>
<td>Rewards/Recognition</td>
<td>3%</td>
</tr>
</tbody>
</table>

Under the caption “Understanding the Working Interface, Krause said: Broadly speaking, in the workplace there are three factors influencing exposure to injury: management systems (methods and procedures), conditions
(facilities and equipment) and the critical things that people do. To achieve lasting improvement in safety performance, all three of these factors need ongoing calibration with each other.

The fact that barriers to safe behavior are primarily related to hardware and management systems rather than to individual choice changes the focus of safety improvement efforts from the worker to the systems than enable safe behavior.

We call the interaction of these three factors—conditions, management systems, and what people do—the **working interface**. The working interface is essentially *how the work is done*, the place where conditions, procedures and behavior interact with each other.

Krause’s speech titled “Moving to the Second Generation in Behavior-Based Safety” is included in the Proceedings for the 2000 ASSE Professional Development Conference. To say that the focus of improvement is not on the worker, but on the systems that enable safe behavior is a major conceptual change in behavioral safety. Can it be doubted that Krause presents a substantial shifting in behavioral safety concepts?

If other behaviorists follow the Krause organization and the concentration is on the management systems, the work practices, and conditions, a sea change will have resulted. This author believes that centering safety management efforts on what Krause calls the working interface is not only the proper thing to do, but also a necessity. Other authors have written about the importance of understanding the interrelationships to which Krause alludes.

In *MORT Safety Assurance Systems*, a 1980 publication, William G. Johnson refers to work done by R. J. Nertney, who developed “a provocative method of examining the successive phases in hardware-procedure development and also examining the all important interfaces between those three elements.” Elements in the Nertney system are

- Hardware and personnel interface
- Procedural–hardware interface
- Personnel–procedural interface (p. 285)

Frank E. Bird, Jr., and George L. Germain emphasized the importance of understanding the working interface for effective safety management in *Practical Loss Control Leadership*, first published in 1985. A second edition, from which the following text and exhibit are taken, was issued in 1996.
In order to better understand the circumstances which lead to the causes of uncontrolled incidents, it would be helpful to consider the four major elements or subsystems in the total business operation that provide their sources. These four elements include: (a) people, (b) equipment, (c) materials, and (d) environment. All four of these elements must relate or interact properly as a system or problems may be created which could lead to loss [p. 16].


Those professionals involved in establishing effective loss control programs must understand the interrelationships in the worker–equipment–environment system. A system approach to hazard control recognizes the interaction between the worker, equipment, materials, and the environment in the performance of work [p. 104].

With permission, the matrix shown in Figure 23.1, developed by Human Factors Engineering and Ergonomics personnel at Boeing, is included here as an example of how the thinking about designing with respect to workplace interrelationships has progressed. This display encompasses all of the “factors” that I could conceive with respect to achieving the desired human effectiveness. Note that there is a question—Will they be effective?—beneath Human Actions at the

![Figure 23.1](image)

*Figure 23.1.* Designing for human effectiveness requires the consideration of a wide range of factors.
right of the display. This question presents an overriding theme when considering each of the “factors” when designing and managing to achieve human effectiveness.

This “sea change” in concept resulting from the Krause studies may have considerable impact on what practitioners in behavioral safety propose. As Krause has said: “The fact that barriers to safe behavior are primarily related to hardware and management systems rather than to individual choice changes the focus of safety improvement efforts from the worker to the systems than enable safe behavior.” Directing safety management efforts on improving the work system has been strongly advocated by many authors, including this writer, for some time.

But, there may also be a down side for behaviorists if the Krause premise is broadly accepted. Some safety professionals may rationalize that if the concentration should properly be on improving the interrelationship between people, equipment, materials, and the work environment, why are behaviorists needed at all? They may conclude that operational efficiency requires that such interrelationships be approached directly through the means available in good safety management, rather than through a costly employee observation system. Obtaining the knowledge of the workers to help identify hazards and risks would continue to be an important part of those endeavors.

Mr. Jerry Pounds, Vice President, Marsh, Inc.

A combination of performance improvement concepts and a particular approach to behavioral safety illustrates an additional change in how behavioral safety is offered and practiced. Aubrey Daniels & Associates has been a notable and successful practitioner in performance improvement for many years. In 2001, the safety aspects of the Aubrey Daniels organization was spun off and became a part of Marsh, Inc. under the leadership of William H. Grimes, Managing Director. Jerry Pounds, a practitioner in behavioral safety and formerly with Aubrey Daniels, has submitted a paper to ASSE for publication consideration, the title of which is “Behavior-Based Safety: Where Does It Go from Here?”

As Pounds says, several of the behavioral tools he describes are not a part of the typical BBS process. Also, Pounds says that the concept that he puts forth can be extended to resolve a multitude of business initiatives. A list of the major captions in his program follows. It’s different; it’s performance-oriented. No other BBS outline that has come to this author’s attention is comparable, nor do others include such elements as root cause analysis, environmental impact analysis (reengineers performance systems), behavioral consequence impact analysis (evaluates job
design, workflow, etc.), critical behavior identification, and performance-potential gap analysis.

1. Operational definitions: Clarifying performance language
2. Behavioral measurement
3. Behavioral root cause analysis (BRCA)
4. Environmental impact analysis
5. Behavioral consequence impact analysis
6. Critical behavior identification
7. Initiative enhancement capability
8. Performance coaching enhancement
9. Performance-potential gap analysis

Obviously, this approach to behavioral safety does not focus on the worker and the observations of worker behavior that are the core of many other behavioral safety approaches. And, it emphasizes performance, overall. Those who have an interest in an imaginative approach to behavioral safety will want to read Pounds’ article, which describes in depth the elements outlined above.

CONCLUSION

For some of the practitioners in behavioral safety, a transition is in process that recognizes the importance of

- Fitting behavioral safety within an organization’s culture and its operating methods;
- Those fundamentals of accident causation that address the interrelationships of people, the equipment they use, task demands, and the work environment, and how systems are designed and redesigned; and
- The need to incorporate behavioral concepts within the elements of good safety management.

If the problem is behavioral, then behavioral solutions are appropriate. But if the problem is systemic, the proper thing to do is to apply tried and tested concepts of problem solving, within which the hierarchy of controls is interwoven.

Some practitioners in behavioral safety rhetorically asked this question at conferences: Will behavioral safety be another passing fad? Although interest has diminished, behavioral safety is not going to go away for
some time, particularly as offered by those consultancies that interweave their concepts with good safety design and operational practices.

REFERENCES


INTRODUCTION

In the second edition of this book, I wrote that a renewed interest had developed in having measurement systems that effectively assess occupational safety performance, measurements that are universally applicable. Preferably, those measures would not only be historical but also predictive and serve as a base from which to prioritize future safety efforts. A significant goal was to have those measures communicate well in terms that managements understand. This renewed interest in performance measures arose out of the increased desire of some environmental, safety, and health professionals to move the profession forward by being able to establish more definitively the value of their work in relation to organizational goals.

Measures of safety performance are now an often-explored subject for which there have been some interesting developments. In this chapter, comments will be made on

- The emergence of a new performance measure, called leading indicators
- A significant study in progress
- The importance of measurement as a component within the professional practice of safety
The requirements of a sound measurement system

Some guiding thoughts

The reality of what is conceptually valid, usable, predictive, and attainable

LEADING INDICATORS

As was to be expected, a new form of measure has arisen and it’s getting some publicity. Its name is leading indicators, a term commonly used by economists. Although presented as a measurement technique, applying leading indicators is really a programmatic endeavor. In a given situation, those safety system elements considered to be effective in preventing accidents are chosen as leading indicators and given emphasis in an organization’s safety initiative. The measurements are to determine whether the necessary actions were taken with respect to the chosen indicators: Were safety meetings held, was housekeeping maintained at a top level, was the required training given?

At the Professional Development Conference held by the American Society of Safety Engineers in June 2002, there were at least three sessions pertaining to leading indicators. Speakers and writers say that this new form of measurement is offered as a response to the dissatisfaction some safety practitioners have expressed concerning the use of what they say are trailing indicators — OSHA statistics, costs — as the sole measure of safety performance.

A uniform definition of leading indicators has not yet emerged, although the definitions being touted have the same base. They separate activities to prevent accidents, and the measurement of them, from the measures of outcomes. Consider these definitions.

Having defined the problems, through analyses of hazards and risk assessments, leading indicators are those actions that point you to where you want to be in relation to the problems identified.

Leading indicators are quantifiable measures of the efforts being made to prevent accidents.

Leading indicators are measurements linked to actions taken to prevent accidents; trailing, or lagging indicators, are measurements linked to the outcomes of accidents.

Leading indicators are those safety activities that favorably impact on trailing indicators, and thereby validate the financial business case for the efforts being undertaken.
Leading indicators are the performance drivers that communicate how outcome measures are to be achieved.

In these five definitions, terms like measurements and measures appear only twice. As the concept evolves, I hope that a precise and generally accepted definition of leading indicators emerges, along with an understanding that the leading indicators should relate to the reality of an organization’s risks. That implies doing hazards analyses and risk assessments and giving the proper attention to severe injury potential, which, often, is inadequately done.

Properly administered, choosing leading indicators, promoting their application, and measuring the quality of those endeavors is a good idea.

But, having listened to presentations on leading indicators and having had discussions with safety directors, I am concerned that the leading indicators chosen may not address the real needs, particularly with respect to severe injury potential. Consider these two situations:

A speaker described how Leading Indicators were selected and applied on a construction project. The Leading Indicators were housekeeping, morning safety meetings, barricade protection, and safety walk-throughs by supervisors and by upper management. A chart was shown displaying a continuously descending OSHA recordable incident rate. After stating that the OSHA rate eventually achieved was 1.0, which is a great accomplishment for the type of construction project being discussed, the speaker then said—but three people were killed. The Leading Indicators did not match the severe injury potential.

In a well-known company, it was agreed that a location would experiment with a Leading Indicators initiative for 2001, and its incident record for that year was very good. But boasting about the activities undertaken and the accomplishments was stilled when, for the first quarter of 2002, the incident experience trended poorly. Quoting the corporate safety director—the lost workday case rate trended so adversely that it spiked off the chart. Activities pertaining to the Leading Indicators made some people feel good, but they did not relate to the causal factors for the types of accidents that had the potential to occur.

That organization is now extending the risk assessment component of its safety system to identify where the most significant gains can be made. The corporate safety director has not given up on Leading Indicators, but he wants them to address real needs so that the Trailing Indicators are positively effected.

I offer the following guidelines for those who undertake leading indicator initiatives. They reflect my views and the comments of others made at the recently held ASSE conference.
1. Define leading indicators and achieve an understanding of the meaning of the term as it is to be applied. Leading indicators are to be indicative and relate to real needs, and their application should achieve a beneficial conclusion. If resources (always limited) are to be allocated to the leading indicators, the benefits to be achieved should be defined?

2. Measure what is important. Do a needs assessment.

3. Apply basic problem solving techniques so that the principal hazards are identified and the risks are assessed. The leading indicators chosen should relate primarily to the situations in which risk reduction is needed.

4. In selecting leading indicators, methods to identify severe injury potentials must be addressed, particularly the potential for low probability–high consequence events.

5. If there are design and engineering risk problems, management systems to eliminate or control them must be considered in choosing leading indicators.

6. Consider the organization’s culture, and how things get done, in choosing and applying leading indicators.

7. A measure of success for the application of leading indicators will be that they correlate favorably with trailing indicators, meaning reported OSHA incidents and costs.

8. Outcomes of leading indicator initiatives must support the business case for the initiative.

Emphasizing those safety activities that prevent accidents, and measuring what has taken place concerning those activities, is just fine. But I am concerned that activity will be equated with results, particularly in the short term. Having served as the managing director for a large safety and fire protection consultancy, I learned that while promoting and measuring activity was a necessity, the only true measure of success was whether the outcome of the activity achieved established goals. Equating activity with results is deceptive management, and it can be embarrassing in the long term.

Professionals who undertake leading indicator initiatives are obligated to declare what is to be accomplished by the initiatives. And the only realistic measures of success are in what those promoting the leading indicators call trailing indicators.
AN INTERESTING AND VALUABLE STUDY

I also wrote in the second edition that in more than one place, money was being spent to develop predictive measures of safety performance, as well as to determine how to make better use of existing measures. One entity that has undertaken such a study is Organization Resources Counselors, often referred to as ORC. Its literature says that ORC is “an international management and human resources consulting firm dedicated to advancing the art, knowledge, and practice of organizational and human relationships.” A goodly number of Fortune 500 companies participate in ORC activities.

At ORC, a study group with representation from 55 companies has been working on a publication pertaining to measurement systems. This is important work. Not since 1980 has a major, broad-ranged publication been issued pertaining to the measurement of safety performance. And the 1980 publication is out of print. Its title is The Measurement Of Safety Performance. William F. Tarrants was the editor. In 1995, for its member companies only, the Chemical Manufacturers Association issued “Program Performance Measures,” about which more will be said later.

Mr. Stephen A. Newell is on the staff at ORC as a consultant. At a conference held by the American Society of Safety Engineers in October 2001, he gave a speech titled “A New Paradigm for Safety and Health Metrics: Framework, Tools, Applications and Opportunities.” When commenting on an ORC Alternative Metrics Task Force, he said that:

- Fifty-five companies are promoting a balanced approach for S&H metrics.
- A reference document is being created that will be provided to ORC membership and shared with industry.
- The initial domestic S&H focus will be expanded to international and environmental issues.

With Stephen Newell’s permission, I quote from relevant parts in his speech outline. When giving this permission, Mr. Newell asked that I also recognize the contributions of Ms. Dee Woodhull at ORC since the work on developing a text on metrics is a team effort. Note that a balanced approach is to be taken concerning leading, trailing, and financial measures.

Task Force Objectives

- Address current use of OSHA data as primary S&H metric.
- Create a useful set of measurement reference materials that:
• Support a balanced approach to measurement with leading, trailing, and financial measures;
• Includes candidate measures and examples of model metrics processes; and
• Are capable of eventually being “owned” by operators, and easily understood by company leadership.
• Develop benchmarking alternatives

The Reference Manual to Be Issued Must Support a Wide Array of Users

• Menu driven — one size can’t fit all.
• Metrics will be hierarchical.
• Linkages are important.
• Metrics expressed in terms used by other parts of the business.
• Different metrics are appropriate for different levels of the enterprise — corporate, business unit, facility.

Insights into an Alternative Approach

• Measure S&H consistent with other parts of the business (e.g., quality).
• Use S&H metrics to:
  • Drive continuous improvement
  • Measure process variables and outcomes
  • Incentivize the right behavior
  • Make the “Business Case.”

Some authors have said that trailing indicators — incident statistics, costs — are valueless as performance indicators. Newell does not support that view. In his speech outline, he says, “Trailing measures not only gage performance, but are critical for S&H management system improvement efforts.”

To repeat, it looks like the ORC Alternative Metrics Task Force is taking a balanced approach in its study of leading, trailing, and financial measures. The work of this task group could have a significant impact on the practice of safety.
Let’s hope that, as Newell says, the reference document to be published is made available to the general public.

A LITERATURE REVIEW

Computer searches made of the records of the American Society of Safety Engineers and the National Safety Council for publications relative to performance measurement prior to the writing of the second edition of this book indicated that not a great deal had been written on the subject. For example, I then wrote that since 1980, no articles had been published in the magazine *Professional Safety* that had “performance measures” or “performance measurement” in their titles or abstracts. A further search was made using “effective” and “effectiveness” as the key phrases. Two articles were found: The June 1981 issue of the magazine contained “How Do You Know Your Hazard Control Program Is Effective,” written by Fred A. Manuele; the February 1989 issue included “Using Perception Surveys to Assess Safety System Effectiveness” by Charles W. Bailey and Dan Petersen.

But, performance measurement now receives more attention at conferences and in magazines. The following are examples of what is being written.

- The entirety of Stephen A. Newell’s previously referenced speech on “A New Paradigm for Safety and Health Metrics: Framework, Tools, Applications, and Opportunities” is available at [www orc dc com].
- From the magazine *Professional Safety*, these articles were selected as pertinent to this chapter.
  - “Measuring Safety Performance to Achieve Long-Term Improvement” by James C. Manzella, September 1999.
  - “Safety Management 2000, Our Strengths & Weaknesses” by Dan Petersen, January 2000. (Petersen writes “Perhaps the greatest problem in safety has been — and continues to be — measurement.”)

Only one other book, besides the Tarrants’ text, was located that treats safety performance measurement in any depth. There is a chapter titled “Measurement Tools for Management” in *Loss Control Management* by Bird and Loftus. Several texts were found that give the measurement of safety performance cursory treatment.

In 1995, *for its members only*, the Chemical Manufacturers Association issued an important publication on *Program Performance Measures*. Its introduction states “A group of member company industrial hygienists and safety professionals recently acknowledged a need for additional guidance on voluntary internal company performance measures.” The purpose of the group was “to identify additional objective and voluntary performance measures to assess the effectiveness of occupational safety and health programs.” It is significant that users of “Program Performance Measures” are encouraged to develop their own performance measures, tailored to suit specific company needs. That theme will be developed further in this chapter.

Some background is provided here concerning publication of Tarrants’ book *The Measurement of Safety Performance* since it refers to activities that safety professionals should promote again. Tarrants comments on symposia that addressed safety performance measurement held in 1966 and 1970 under the sponsorship of the National Safety Council. The first symposium was held, as the Tarrants text says, “for the purpose of studying the current methods and needs for the measurement of safety performance by employers and establishing measurement methods that lead to total accident prevention.” The second symposium concentrated on aspects of measurement as a concept, along with safety performance evaluation as viewed by persons primarily outside the occupational safety field. Tarrants’ book is a composite of the papers presented at those symposia, along with the chapters he wrote.

If major endeavors through symposia or any other type of forum to disseminate knowledge about the measurement of safety performance have been held since 1970, their proceedings remain secluded.

Renewed interest in having valid performance measures indicates that safety professionals would benefit from additional symposia on the subject.
SIGNIFICANCE OF PERFORMANCE MEASURES IN THE PRACTICE OF SAFETY

If we safety professionals state that our practice is based on sound science, engineering, and management principles, it logically follows that we should be able to provide measures of performance that reflect with some degree of accuracy the outcomes of the hazards management initiatives we propose. Understanding the validity and shortcomings of our performance measures is an indication of the maturity of the practice of safety as a profession.

Safety professionals must accept that the quality of the hazards management decisions made in an organization is impacted directly by the validity of the information they provide through their performance measurement systems. Their ability to provide accurate information to be used in the decision-making process is a measure of their effectiveness.

In the following paragraph, I paraphrase Tarrants, whose observations on measurement and measurement systems are sound.

Measurement is a prerequisite for control and prediction. The main function of a measure of safety performance is to reveal the level of safety effectiveness. A second purpose is to provide continuous information concerning the safety state. Measures of safety performance must help prevent, not just record, incidents. They must indicate where hazards-related incidents will likely occur and provide guidelines concerning the appropriate preventive initiatives.

REQUIREMENTS FOR AN IDEAL SAFETY PERFORMANCE MEASUREMENT

Assume that a safety professional undertook the development of an ideal instrument for measuring safety performance. Numerous books and articles are available as references on the subject of performance measurement, generally. Two safety-related texts that also could serve as references are those by Tarrants and by Bird and Loftus, to which I referred previously.

In this exercise, the safety professional would probably look for a standard against which the validity of the measurement system developed could be assessed. Such a standard follows. I borrowed from several sources in its development. It is generic.

Regardless of what is to be measured, the following traits would be considered in developing, or assessing the value of, a performance measuring system.
Administrative Practicality. One must be able to develop and use the system, within typical, practical, management limits.

Measurement Criteria Should Be Quantifiable. Criteria selected must be quantifiable with a good degree of accuracy.

Sensitivity. Measures should be sufficiently sensitive to detect changes in process and performance levels.

Reliability. The technique should be capable of producing the same results from successive application to the same situation.

Stability. If a process does not change, the measure of its performance level should remain unchanged.

Validity. Of prime importance is the need for a measure to be valid. This means that it produces information that is representative of what is measured.

Objectivity and Accuracy. Measures used would, desirably, yield precisely objective and error-free results (a state for which science has not yet produced such an instrument).

Efficiency and Understandability. A good measurement technique should be both efficient and understandable. Efficiency requires that the cost of obtaining and using the instrument is consistent with the benefit to be gained. To be understandable, the criterion must be understood by those charged with the responsibility for approving and using it.

No single safety performance measurement system has been designed that meets all of the preceding requirements. It may not be possible to do so, and that should be understood by those who fashion safety performance measurement systems. Nevertheless, the measurement systems used should be tested against these characteristics to determine their reliability.

SOME GUIDING THOUGHTS

An understanding of the nature of hazards and the risks that derive from them is necessary in determining what performance measurement systems can give reasonably accurate assessments of the quality of safety management, and the extent to which those systems can be predictive. To help in developing that understanding, this outline of thoughts is offered.

1. The entirety of purpose of those accountable for safety, in fulfilling their societal responsibilities, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are
at an acceptable level. *How well those endeavors are managed is what is to be measured.*

2. Safety results are determined by an organization’s culture: its values, beliefs, legends, goals, emphases, performance measures, and its sense of responsibility to its employees, to its customers, and to its community.

3. A system of expected behavior derives from an organization’s culture, which is demonstrated by
   - Its policies, standards, and procedures
   - How well those policies, standards, and procedures are implemented, and its accountability systems

4. To the extent that policies, standards, and procedures, or their implementation, are less than adequate, hazards that derive from design and engineering, operations management, and task performance practices will have been integrated into systems and processes, over time.

5. Unless radical events take place, an organization’s culture changes slowly. It is commonly said that achieving a major culture change could take as long as 4 or 8 years.

6. Significant accomplishments in avoiding, eliminating, or controlling hazards that derive from aspects of the culture and that are inherent in an operation can be achieved only over considerable time.

7. A hazard is defined as the potential for harm. Hazards include the characteristics of things and the actions or inactions of persons.

8. All occupational risks of injury or illness derive from hazards. There are no exceptions.

9. Risk is defined as a combination of the probability of a hazards-related incident occurring and the severity of harm or damage that could result.

10. Realizations of the potentials of hazards have various occurrence probabilities, and severities of consequences. Definitions of probability and severity can be tailored to suit particular needs.

11. As the sample base (the number of hours worked) increases in size, the historical incident record (assuming consistency and accuracy in record keeping) has an increasing degree of confidence as
   - A measure of the quality of safety in place
   - A general, but not hazard-specific, predictor of the experience that will develop in the future
12. Statistical, historical performance measurement systems cannot accurately encompass the potential for low probability–severe consequence events occurring since such events seldom appear in the statistical history.

13. Even for the large organization with significant annual hours worked, in addition to historical data, hazard-specific and qualitative performance measures are also necessary, particularly to identify low probability–severe consequence risks.

**STATISTICAL, HISTORICAL PERFORMANCE MEASURES**

While statistical, historical data are an “after-the-fact” indicator and while the data do not give hazard-specific direction concerning the actions that should be taken for risk reduction, it does provide broad, macro, and meaningful measures of safety performance and serve as a predictor of the future. No matter what criticisms are offered by safety professionals about the shortcomings of historical performance measures, it would be folly for them to ignore the reality that managements usually set goals for improvement that are based on previous results. Historical measures to be discussed here are workers compensation experience rating, workers compensation costs, and OSHA rates.

**WORKERS COMPENSATION EXPERIENCE RATING**

The workers compensation experience modification rating system is based on actuarial science. In an undated publication titled *The ABC’S of Experience Rating* issued by the National Council on Compensation Insurance, these statements appear.

Simply stated, experience rating is a procedure utilizing past insurance experience of the individual policyholder to forecast or predict future losses. In workers compensation experience rating, the actual characteristics of the individual employer are determined over a period of time, usually three years. This experience is then compared with the average as reflected by the manual rate or rates which apply to the employer’s business. If the employer has lower than average costs, then a comparable rate credit is awarded, while for a higher than average experience, a debit rate is applied.

What does all this mean? Actuaries have established that workers compensation claims costs, payrolls, and rates for an insured’s occupational classes, over time, form a statistical base from which to compute expected claims experience.
Experience rating is mandatory for all employers who buy workers compensation insurance from insurance companies. For those employers, experience rating is one of the historical performance measures that can be used, cautiously, as an indicator of the quality of safety in place. Self-insured companies would not have workers compensation experience modifications.

I do not suggest that experience rating is an absolutely accurate indicator of the future. There are many checks and balances in the system, but its preciseness and its sensitivity to change are questioned. And the system is influenced by one-time events that effect the computations for several years. An example would be the shutdown of an operation that resulted in a rash of claims. Nevertheless, with caution, an experience rating modification can be used as one indicator of the quality of safety in place and as a predictor of the future — along with other measures.

For at least one industry, the experience modification system is particularly significant. In the construction business, it is common practice for a bidder’s experience modification to be one of the qualification and acceptance criteria used by a general contractor.

WORKERS COMPENSATION COSTS

If it was possible to obtain accurate and current workers compensation claims costs, a trending of that data would be the best performance indicator for most companies, since the data would be expressed in financial terms. That is a language that managements understand. Unfortunately, the actual cost of individual claims is not immediately known. For claims reported in a given year, the actual costs may not be finalized for as long as six or more years.

Still, workers compensation costs present opportunities for computation as performance measures. With the help of insurance personnel, fairly good estimates of the expected claims costs for an ensuing year can be made, provided that there are no catastrophic occurrences. With that data, interesting and useful performance indicators can be computed. Some examples follow.

1. If the workers compensation costs are stated as a fixed number, not subject to later revision because of changes in dollar reserves for particular claims, doubt concerning their reliability will be less frequently expressed. To get to a fixed cost number, consider this exercise. Assume that a company’s culture has been pretty well set, that things have been somewhat stable, that the quality of safety management has not significantly
changed, and that the company’s hours worked represent a fairly sound statistical base.

Then, the workers compensation cost figure to be used in this exercise is the total of claims paid in one year, regardless of when the injury or illness was reported. That figure, once established, would not change. For successive years, those figures will indicate trends, favorably or unfavorably. Allowances are necessary for increases in workers compensation benefits and for inflation when comparing cost data for successive years.

2. In a real-world situation, a safety director obtained numbers that management agreed were reasonable estimates of how annual workers compensation costs were trending. She then determined that her company’s OSHA incident recordable and lost workday case rates were about one-fifth that of its industry average. Doing a simple extrapolation, she computed that the company’s annual workers compensation costs would be $40,000,000 higher if its OSHA rates were at the industry average. Very impressive.

3. Where it might get attention, I suggest experimenting with a computation that establishes annual workers compensation costs per hour worked, using as a base the total dollars for claims paid in a year, regardless of when the claim was reported. In one company where the costs were computed to be $0.45 cents an hour, the CEO jested that he would kill for a 20% reduction. Why such a response? A savings of $0.09 an hour, for 2000 hours worked, translates to $180 per employee, per year. For 30,000 employees, that becomes $5,400,000. With 40,000,000 shares of stock outstanding, a 20% reduction in workers compensation costs improves earnings by $0.135 per share. Very impressive.

But, using workers compensation costs per hour won’t get much attention in a company in which the culture has required and achieved exceptionally good safety performance. For a company that has operations the public would consider high hazard, the annual workers compensation cost per employee has recently ranged a bit plus or minus of $100. That computes at $0.05 per hour. A 20% reduction nets the employer $0.01 per hour, or $20 per employee per year. Not very impressive.

4. Over time and when the exposure base is sufficiently large, comparisons of workers compensation costs and OSHA statistics, with other companies in the same industry or those considered to have comparable risks, should have a positive and linear relationship. In a benchmarking process, an individual shared data with a company that had an OSHA incident recordable rate of 0.9, which was about one-seventh of his own company’s record. He expressed doubt about the validity of the 0.9 OSHA rate, but became a believer when workers compensation cost trendings
were compared. There was a match between the OSHA records and the workers compensation costs of the two companies. That should not be an isolated case. Such relationships should commonly exist.

5. Another measurement system that could be of value is the rate, recorded over time, of workers compensation claims reported per 200,000 hours worked.

Data for such a graph would readily be available. While the rate of workers compensation claims reported will not match precisely a similar graph showing the OSHA recordable rate or the lost workday case rate, great differences should be a subject of concern. Such a graph would be a trend indicator and could provide an alert concerning situations that need attention.

For example: In a very large company, where an edict had been issued that a dramatic reduction was to be achieved in the OSHA incident recordable rate, the reduction is being accomplished; but, the number of workers compensation claims reported remained steady and did not match the OSHA incident recordable rate reduction.

OSHA RATES

Without question, there are inconsistencies, even within companies, in classifying and recording OSHA statistics. Still, if the inconsistencies in the reporting system remain constant, the data produced will serve as useful performance and trend indicators.

The actuarial premises on which the workers compensation experience rating system was developed give credibility to OSHA incident recordable and lost workday case rates as measures, and predictors, of safety performance, with these qualifications: The statistical base (the hours worked) on which the records are developed has to be large enough; and low probability–severe outcome risks may not be encompassed within the experience base.

In statistical circles, a commonly used term is “the myth of small numbers.” Assume that an employer had 100 employees who worked 200,000 hours in a year. For the employer’s industry, the average OSHA incident recordable rate is eight, and the employer’s experience was right on average. For some months in the year, no recordable incidents would have occurred. If the incident distribution is random, more than one incident could have occurred in more than one month. As the year progressed, or at the end of a year, presuming that this employer’s OSHA record accurately represented the quality of safety in place would be mythical. Statistically, the exposure sample is not large enough to be credible.
For an entity that small, a combination of statistical measures (the experience modification, a trend chart on which recordings are made of totals of 3 years of OSHA data, dropping a quarter of a year and adding a new quarter) and qualitative performance measures would be necessary.

Now, do some wild speculation with me, and consider whether what follows begins to have credibility.

An employer has 500 employees who work 1,000,000 hours a year. Before OSHA, ANSI Z16.1 — Method of Recording and Measuring Work Injury Experience — was the prevailing recording and measuring guide, and the base for computations was 1,000,000 hours. Computations based on that unit of exposure had some, but not exceptional, reliability.

Do the OSHA statistics — the recordable case rate and the lost workday case rate — for an exposure of 1,000,000 hours have a confidence level of, say, 68.27%, as measures of the quality of safety performance? An entity of this size would more than likely purchase workers compensation insurance and have an experience modification as an additional measure.

Now move the hours worked to 10,000,000. Will the confidence level of OSHA statistics as performance indicators be as high as 95.44%? At 20,000,000 hours, how about a confidence level of 99.73%? At 40,000,000 hours, would you go for 99.9937%? We could go on with this exercise, increasing the size of the exposure base and, thereby, the validity of the OSHA statistics. But, no matter how large the statistical base became, we could never conclude that OSHA rates, nor any other historical data, has a 100% confidence level as performance measures or predictive indicators.

Thus, even the largest employers should also be using hazard-specific and qualitative performance measures, for which discussion follows.

HAZARD-SPECIFIC IDENTIFICATION MEASURES

A criticism of historical, after-the-fact data (of outcome statistics) is that such measures are not hazard-specific; that is, they do not identify incident causal factors without additional analysis. That’s so. If safety professionals want to identify hazard-specific situations that may be predictive and give direction to the actions that should be taken to reduce risk, they will have to do some analysis.

Some of those analyses will be based on historical data, some will be made of specific tasks, and some will seek to identify hazards for which the potentials have not yet been realized.

All such initiatives — such as incident analysis, task analysis, and Incident Recall Surveys — produce outcomes that are predictive in one respect. They identify those aspects of technology (the characteristics of things) or
the actions or inactions of persons, which, if not eliminated or controlled, may be the causal factors for hazards-related incidents. They are qualitative measures in that they give an indication of the extent to which policies, standards, and procedures, or their implementation, have been adequate or less than adequate.

INCIDENT ANALYSIS

Patrick R. Tyson was right in his article “OSHA Proposes Changes to Recordkeeping Rules” when he wrote this.

After all, a company’s injury and illness experience should be a cornerstone of its safety and health program. More simply, it is hard to design a program to keep people from getting hurt if you don’t know what’s hurting them.

To “know what’s hurting them” requires effective incident analysis. Identifying “what’s hurting them” provides predictive information on what may hurt employees in the future. To “know what’s hurting them,” a safety professional must understand incident causation and craft an analysis system that effectively identifies causal factors. A balance must be built into such a system that gives the necessary emphasis to hazards that derive from design and engineering, operations management, and task performance practices.

If incident investigations and analyses are done poorly, the conclusions drawn from an analysis will result in misdirected actions to reduce risk. Also, the conclusions will not be accurate predictors of the future. Incident analysis is a subject that should be taken seriously and considered as a predictive exercise, treated as though it is one of the cornerstones of a safety and health initiative.

Help in crafting an incident investigation and analysis system can be found in

- Chapter 9, “Observations on Causation Models for Hazards-Related Incidents”
- Chapter 10, “A Systemic Causation Model for Hazards-Related Incidents”
- Chapter 11, “Incident Investigation: Studies of Quality”
- Chapter 12, “Designer Incident Investigation”

TASK ANALYSIS

While incident analysis is done after-the-fact, task analyses can be made after-the-fact or before-the-fact. Task analysis may be called job hazard
analysis, job safety analysis, or total job analysis. Whatever the name given to the process, the results of task analyses are qualitative and can be predictive. The following is said in the *Handbook of Occupational Safety and Health*, for which Lawrence Slote was the editor:

Job Safety Analysis (JSA) or Job Hazard Analysis (JHA), a systematic study of work procedures, is utilized by those firms who desire to identify and control hazards before such hazards result in injury [p. 120].

In *Management Guide to Loss Control*, by Frank E. Bird, Jr., a chapter on “Proper Job Analysis and Procedures” extends the purposes of a task analysis to include aspects other than safety. Bird said:

The proper job analysis and standard job procedure chapter is based on the concept that all elements of a worker’s job, such as quality, production, safety and health, are inseparable. Any one or all can effect the others, and to consider them as separate elements when teaching a worker to do his job is to invite the confusion and misunderstanding that leads to downgrading incidents [p. 60].

For information on task analysis that incorporates all aspects of work, see “Task Analysis: For Productivity, Cost Efficiency, Safety and Quality,” a chapter in my book *Innovations in Safety Management: Addressing Career Knowledge Needs*.

I suggest that safety professionals give task analysis a greater emphasis as a qualitative predictor of the probability of hazards-related incidents occurring. Task analyses are to define hazardous or inefficient work procedures.

If a safety professional really wants to know what hazards may create problems tomorrow, task analysis is a highly effective way to identify them. Of course, the process would culminate in proposals for the appropriate preventive actions. The ancillary benefits are considerable, since many people can be trained through the task analysis process to identify hazards and how to seek their elimination or control.

**SURVEYS TO IDENTIFY POTENTIAL CAUSAL FACTORS**

The survey system to be discussed here had its origins in what has been known as the *Critical Incident Technique*. Although the technique has not been broadly used, it has real possibilities in identifying hazards before their potentials are realized. Also, application of such a system would build a body of predictive, hazard-specific knowledge.
In *The Measurement of Safety Performance*, William E. Tarrants devoted a chapter to “The Critical Incident Technique as a Method of Identifying Potential Accident Causes.” His comments on the origin of the technique and its purposes follow:

The critical incident technique is regarded as an outgrowth of studies in the Aviation Psychology Program of the U.S. Army and Air Forces in World War II. It is an accident study method in which an interviewer questions a number of persons who have performed particular jobs and asks them to recall within a specified time period unsafe acts and/or conditions they have committed or observed [p. 303].

The persons are selected on a stratified random sampling basis, with stratifications designated according to the type of exposure, quantity of exposure, degree of hazard present, and other criteria considered important to the representativeness of the sample. The objective is to discover causal factors that are critical, that is, that have contributed to an accident or potential accident situation. The unsafe acts and unsafe conditions identified by this method then serve as the basis for the identification of accident potential problem areas and the ultimate development of countermeasures designed to control accidents at the no-loss stage [p. 304].

Willie Hammer wrote this in his *Handbook of System and Product Safety*.

The Critical Incident Technique is one means by which previously experienced difficulties can be determined by interviewing persons involved. It is based on collecting information on hazards, near misses, and unsafe conditions and practices from operationally experienced personnel.

The technique consists of interviewing personnel regarding involvement in accidents or near accidents; difficulties, errors, and mistakes in operations; and conditions that could cause mishaps [p. 188].

A modification of The Critical Incident Technique was published by the Division of Safety, Standards, and Compliance of the United States Energy Research and Development Administration in 1976. Because the method was also to be applied in the nuclear industry, where the terms “Critical” and “Incident” have their own connotations, a new name was used: *Reported Significant Observation (RSO) Studies*. In a paper with that title, it is said that “RSO was formally recognized as a significant hazard reduction tool.”

In *MORT Safety Assurance Systems*, William G. Johnson refers to a similar process known as incident recall. This is what he says about it:
Incident recall is an information gathering technique whereby employees (participants) describe situations they have personally witnessed involving good and bad practices and safe and unsafe conditions. Such studies, whether by interview or questionnaire, have a proven capacity to generate a greater quantity of relevant, useful reports than other monitoring techniques, so much as to suggest that their presence is an indispensable criterion of an excellent safety program [p. 386].

Why make so much of the idea on which the Critical Incident Technique is based? A system that seeks to identify causal factors before their potentials are realized would serve well in attempting to avoid low probability–severe consequence events. Chapter 9, “Addressing Severe Injury Potential,” is devoted to that subject. In that chapter, in support of the premises I put forth, I quoted from Dan Petersen who said the following in his book Safety Management, 2nd edition:

If we study any mass data, we can readily see that the types of accidents that result in temporary total disabilities are different from the types of accidents resulting in permanent partial disabilities or in permanent total disabilities or fatalities. The causes are different. There are different sets of circumstances surrounding severity. Thus if we want to control serious injuries, we should try to predict where they will happen. Today we can often do just that.

Studies in recent years suggest that severe injuries are fairly predictable in certain situations. Some of those situations involve:

- Unusual, non-routine work;
- Non-production activities;
- Sources of high energy; and
- Certain construction situations.

These are just a beginning point. A long list could be made which would more extensively specify the areas where severity is predictable [p. 11].

Therefore, safety professionals must have within their endeavors a separate and distinct activity to seek those hazards that present the most severe injury or damage potential so that they can be given the priority consideration they require. Making Hazardous Incident Recall Surveys would serve that purpose.

In Profitable Risk Control, William W. Allison makes a good case when he suggested that we learn how to identify and concentrate limited time and money on controlling the significant few, high-potential risks
before they become costly risks. This is how Allison defined a high-potential risk:

A high potential risk is any situation, practice, procedure, policy, process, error, occurrence or accident which may or may not have resulted in loss or harm but can result in significant harm to people, product, services, equipment, facilities, or property [p. 19].

A system designed to make Hazardous Incident Recall Surveys, which is a qualitative measurement system, would produce data that could be predictive of the future.

**GRADING (SCORING) INDIVIDUAL SAFETY PROCESSES**

Some have suggested that predictive measures could result from the grading of — giving numerical scores on — the accomplishments of individual safety activities, such as housekeeping, training, inspections, compliance with standards, or health exposure assessment surveys.

If an activity truly related to an entity’s risks, a scoring system could be developed that had predictive values, but my experience requires that I be skeptical of the validity of such numerical scoring systems. Scoring systems that produce numerical indicators such as the number of training sessions conducted and the number of persons trained, or the number of inspections made, or the number of health exposure surveys completed would be of little value if those processes did not relate to the hazards in place. As an example, I cite this personal experience about training.

For many years, I led training programs on how to lift safely. I now know that in most of those situations, training did not address the root problem. Back injuries occurred because the design of the work was overly stressful for a large percentage of the working population, and ergonomics solutions were needed. If a performance measure gave a favorable score based on the number of training sessions I conducted or the number of people trained, it would give a false indication of effectiveness.

There are a variety of numerical scoring systems for the elements reviewed when safety audits are made. The scorings are subjective assessments that are eventually translated into a finite score. My experience has been that the final score often did not relate to the accident experience that eventually evolved. Nevertheless, safety audits, properly conducted, provide highly effective, qualitative performance measures.
SAFETY AUDITS AND PERCEPTION SURVEYS

It is my belief that the paramount purpose of a safety audit is to provide an assessment of the quality of safety in place, which is a reflection of the organization’s culture. Thus, the audit report must contain assessments of the effectiveness of the policies, standards, procedures, and systems which should be in place. Hazards noted — physical or operational — are to be viewed as being representative of possible deficiencies in management systems.

A management that wants to achieve a culture change is best served if the deficiencies noted and the proposals for improvement made in audit reports principally effect safety management systems. Successes of safety audits are determined by how they affect the organization’s culture. (See Chapter 22, “On Safety, Health, and Environmental Audits.”)

Perception surveys have also been used to provide measurements of the quality of safety management in place. Through an interview system or the completion of surveys, they provide management with a picture of what employees at various levels of responsibility think about the management of safety in the organization. Perception surveys are outcome surveys in that the perceptions people have of how safety is managed derive from their observations of what got done or didn’t get done with respect to the safety system elements covered in the interview of questionnaire process. What got done or didn’t get done defines the pattern of expected behavior within the organization, and that is a derivation of the organization’s culture. Thus, a perception survey defines the reality of the organization’s culture with respect to safety.

Dr. Stephen Simon has attained notable credentials in safety culture improvement. He developed the Simon Open System (S.O.S) Culture Change Model, which is discussed in a chapter titled “Achieving The Necessary Change” in the book Safety Through Design [p. 37]. It is noteworthy that, in the title of his survey instrument, he includes both the terms “perception” and “culture.” It is known as the S.O.S Culture Perception Survey.

Dan Petersen is a consultant who has stressed, among other things, the significance of accountability for safety being well established—at all levels. He is the principal presenter in a video and disc-based program titled Safety Accountability. Its message to senior management is this:

To gain control over your safety processes and outcomes, an organization must manage safety in the same way it manages production and quality—by making each individual accountable.

Literature on the program instructs senior management that the overall culture of the organization should be measured. This is Petersen’s view of perception surveys.
After many years of development and testing, we found that a perception survey of employees and managers in an organization gave us a better prediction of the future of the safety record than any other indicator we tested. We have been using perception surveys for a number of years and found their use to be invaluable in diagnosing what needs to be done to improve safety systems in organizations.

As a part Peterson’s program, a manual is provided, the purpose of which is to “describe how to use CoreMedia’s Dan Petersen Safety Perception (SPS) software program package.” Its purpose is to identify shortcomings in safety management systems and to provide information to management on incorporating improvements into the accountability system.

A perception survey provides management with a performance measure of itself. Major proposals deriving from such a survey — leading indicators if you like — should affect the pattern of expected behavior of senior executives, and thereby the culture.

**CONCLUSION: BEING REALISTIC**

Because of the impossibility of knowing about every risk on an anticipatory basis, it is folly to expect that a perfect performance measurement system can be developed. Also, because of human limitations, it is not possible for an employer to attain a risk-free environment and assure zero occurrences of hazards-related incidents.

Several years ago, Motorola established a quality performance level known as Six Sigma. In its literature on the program, this appears.

As we have seen, even the most well-controlled processes experience shifts of the process mean due to changes in equipment, operators, environmental conditions, and incoming materials. Such shifts can be as much as 1.5 standard deviations.

Because process shifts do normally happen, a Six Sigma quality level in Motorola’s manufacturing operations has been defined as 99.99 966 percent. In other words, 99.99 966 percent of all parts produced are defect-free. This is the same as saying that only 0.00034 percent of parts produced — 3.4 parts of every million — are defective.

This is just about as close to perfection as human beings can get.

Since we are not capable of knowing, avoiding, or controlling all risks on an anticipatory basis, should we realistically accept the idea, as the
Motorola statement implies, that developing perfect, predictive measurement systems and achieving zero hazards-related incidents is unattainable?

Nevertheless, it should be understood that, in their safety achievements, a few companies have done better than Six Sigma. Assume that an OSHA recordable incident is the defect to be measured. How does 3.4 defective parts per million relate to an OSHA recordable incident rate? OSHA rates are computed from a base of 200,000 hours worked. To be at an OSHA incident recordable rate of 3.4 incidents per million hours, the computed rate using a 200,000 hour base would be 0.68. That rate has been bettered by a few of the best performing companies, but only a few. Thus, on occasion, humans are capable of doing better than Six Sigma.

But, even in the best of the best large companies, the OSHA recordable incident rate over time has never been zero. In operations considered moderate or high hazard, attaining a 0.68 OSHA incident recordable rate over the long term is virtually impossible. (For the year 2000, the composite OSHA incident recordable incident rate for Private Industry was 6.1.)

I find the following comments about the practical limitations on knowing all there is to know about risks, before or after the fact, to be illuminating. They are taken from “The Crash Detectives” by Jonathan Harr, an article on airplane crashes and the work of investigators to identify their causal factors. It appeared in the August 5, 1996 issue of *The New Yorker*:

Modern jet airplanes are designed with highly redundant systems, which make accidents highly improbable. When they do occur, they are usually the result of a concatenation of discrete events — of mechanical or human failures — any one of which by itself would not likely cause a catastrophe. It is this unforeseen sequence of events, resulting from what accident theorists call the “tight coupling” of complex interacting systems, that causes accidents.

The F.A.A. announced a goal of zero accidents early last year. This, of course, sounds like a laudable goal. Perhaps it is just meant to reassure a worried public, for almost no one — least of all the investigators at the Major Investigations Division of the (National Transportation) Safety Board — believes that such a goal is attainable.

Those familiar with the concepts of risk understand that attaining zero risk is impossible and that a predictive measurement system that can identify every possible risk on an anticipatory basis has not yet been developed. Furthermore, I believe we have to admit that we are not good yet at having developed measurement systems to determine whether cause-and-effect relationships exist for the safety interventions we propose.

For those who would like an intellectual challenge, I suggest a study of the *Guide to Evaluating the Effectiveness of Strategies for Preventing*
Work Injuries: How to Show Whether a Safety Intervention Really Works. This is a NIOSH publication. It’s free. Its message to me is that safety professionals can bring the measurement systems they use up to generally accepted standards to determine the effectiveness of the safety interventions they propose, and that this text will show them how. Since I have been a proponent of defining the problem before solutions are applied, I was pleased that the first in a list of seven types of intervention evaluations discussed is a “Needs Assessment.” The “Purpose” of a “Needs Assessment,” the text says, “Defines what type of intervention is needed.”

This is an impressive, thought provoking, valuably informative discussion of measurement systems. Excerpts from it appear in the addendum to this chapter.

REFERENCES


ADDENDUM


Preface

Our aim in this book is to provide students, researchers and practitioners with the tools and concepts required to conduct systematic evaluations of injury prevention initiatives and safety programs. Successful evaluations will advance the discipline of occupational safety by building a body of
knowledge, based on scientific evidence, that can be applied confidentially in the workplace. This knowledge will provide a solid foundation for good safety practice, as well as inform the development of standards and regulations. Building such a knowledge base will help practitioners avoid the temptation of adopting safety procedures simply because they appear "intuitively obvious" when no scientific evidence actually exists for these practices.

Users of the guide are encouraged to demonstrate the strongest level of evidence available for an intervention by measuring the effect on safety outcomes in an experimental design. Even when this level of evidence is not obtained, much useful information can still be gained by following the recommendations in the book. In doing so, the safety field will become current with other disciplines, such as clinical medicine, where evaluation information is increasingly available and allows for evidence-based decision-making.

We hope that this guide will assist safety specialists to meet the challenge of effectiveness evaluations [p. xi].

A safety intervention is defined very simply as an attempt to change how things are done in order to improve safety [p. 1].

We are focusing here on effectiveness evaluation (also known as outcome evaluation, or summative evaluation), which determines whether a safety initiative has had the intended effect [p. 2].

Other types of evaluation, besides effectiveness evaluation, are useful in the process of improving safety in the workplace. They will only be described briefly here. A needs assessment can be carried out to determine exactly what type of intervention is required in a workplace [p. 2].

Table 1.1. Types of Intervention Evaluations [p. 4]

<table>
<thead>
<tr>
<th>Types of evaluations</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs assessment</td>
<td>Determines what type of intervention is needed</td>
</tr>
<tr>
<td>Process evaluation</td>
<td>Assesses the quality of the intervention delivery and identifies areas for improvement</td>
</tr>
<tr>
<td>Effectiveness evaluation</td>
<td>Determines whether an intervention has had the effect intended on outcomes, and estimates the size of the effect</td>
</tr>
<tr>
<td>Cost–outcome analysis</td>
<td>Determines the net cost of an intervention relative to its health effect</td>
</tr>
<tr>
<td>Cost-effectiveness</td>
<td>Compares different analysis intervention alternatives using cost–effect ratios</td>
</tr>
<tr>
<td>Cost–benefit analysis</td>
<td>Compares different intervention alternatives using net benefits</td>
</tr>
</tbody>
</table>
### Table 3.1. Threats to Internal Validity [p. 20]

<table>
<thead>
<tr>
<th>Threat to internal validity</th>
<th>Description of threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>Some other influential event(s) which could affect the outcome, occurs during the intervention</td>
</tr>
<tr>
<td>Instrumentation/Reporting</td>
<td>Validity of measurement method changes over course of the intervention</td>
</tr>
<tr>
<td>Regression-to-the-mean</td>
<td>Change in outcome measure might be explained by a group with a one-time extreme value naturally changing towards a normal value</td>
</tr>
<tr>
<td>Testing</td>
<td>Taking measurement (e.g. test) could have an effect on the outcome</td>
</tr>
<tr>
<td>Placebo</td>
<td>Intervention could have a non-specific effect on the outcome, independent of the key intervention component</td>
</tr>
<tr>
<td>Hawthorne</td>
<td>Involvement of outsiders could have an effect on the outcome, independent of the key intervention component</td>
</tr>
<tr>
<td>Maturation</td>
<td>Intervention group develops in ways independent of the intervention (e.g. aging, increase experience, etc.), possibly affecting the outcome</td>
</tr>
<tr>
<td>Dropout</td>
<td>The overall characteristics of the intervention group change due to some participants dropping out, possibly affecting the outcome</td>
</tr>
</tbody>
</table>

*Editorial note: Only selected examples of the types of threats to outcome validity are recorded here.*

### A History Threat

A “history threat” occurs when one or more events, which are not part of the intervention but could affect the outcome, take place between “before” and “after” measurements. Common history threats include changes in the following: management personnel; work processes, structure or pace; legislation; and management–labor relations. Clearly, the longer the time between the “before” and “after” measurements, the more opportunity there is for an extraneous, interfering event to happen [p. 20].

**Example of a History Threat.** You are trying to evaluate a new ergonomic intervention for nurses in a hospital. An educational program
about back health and lifting techniques was provided, a program of voluntary stretches introduced and lifting equipment purchased. It was found that the injury rate for the two years before the intervention was 4.4 lost-time back injuries per 100,000 paid hours and for the two years following it was 3.0. Thus, you conclude that the ergonomic intervention has been effective.

But what if one month after the education program, a government ministry launched a year-long public awareness campaign aimed at reducing back injury? And, what if the president of the hospital was replaced two months after the in-house ergonomic program and her replacement introduced human resource initiatives to improve communication among staff? This would make you less confident about concluding that it was the intervention alone that made the difference in back injuries [p. 20].

Testing Threat

A testing threat to internal validity is a concern when the act of taking the before measurement might itself affect the safety outcome used to evaluate the intervention.

Example of a Testing Threat. You want to evaluate a training intervention designed to increase worker participation in plant safety. You use a questionnaire to assess pre-intervention worker attitudes, beliefs and practices concerning participation. You administer a second, post-intervention questionnaire after a three month program of worker and supervisor training. Comparison of the questionnaire results shows a significant change in scores, indicating that participation has increased.

Upon reflection you are not really sure what accounts for the improvement in the score. You reason that it could be any of the following: a) an effect of the training program alone; b) an effect of having awareness raised by completing the first questionnaire; or c) a combined effect of completing the questionnaire and then experiencing training. Either of the latter two possibilities involves a testing threat to the internal validity of the evaluation [p. 24].

Placebo Threat

The “placebo effect” is a concept from clinical studies of medical treatments. It has been observed that a percentage of the study subjects treated with a placebo (i.e., an inactive substance), instead of a medical treatment, will show an improvement of symptoms beyond that expected of the normal course of their medical condition. It seems that the placebo operates
through a psychological mechanism which results in an alleviation of symptoms. The patients believe that the treatment will be successful and this has an effect in itself on the outcome.

**Example of a Placebo Effect.** Due to an increasing prevalence of “repetitive strain injury” in a telecommunications firm, the management agreed to purchase new keyboards for one division. A survey of employee upper extremity symptoms was conducted the week before the keyboards were introduced and then three weeks afterwards. Everyone was pleased to find a significant decrease in reported symptoms between the “before” and “after” measurements. Management was on the verge of purchasing the same keyboards for a second division, but there was concern about a “placebo effect” of the new keyboard [p. 25].

**The Hawthorne Effect**

The Hawthorne effect usually refers to an effect of the involvement of researchers or other outsiders upon the measured outcome. This term arose from a famous study of factory workers at Western Electric’s Hawthorne Works in the 1920s. A subset of workers was moved to a different section of the factory, their working conditions manipulated and the effect of this on their productivity observed. It turned out that workers were more productive under any of the work conditions tried—even an uncomfortable one like low lighting conditions. It is believed that the effect of the new psychosocial working conditions (i.e., increased involvement of workers) in the experimental situation actually overshadowed any effect of the changes in the physical environment.

**Example of a Hawthorne Threat.** A work-site decides to implement and evaluate a new training program focused on changing safety practices by providing feedback to employees. A consultant examines injury records and, with the help of workers and supervisors, develops a checklist of safety practices. The list will be used by the consultant to observe the work force and provide feedback to the employees about their practices. The consultant realizes that his presence (and the taking of observations) could make workers change their normal behavior. To avoid this potential Hawthorne effect, he makes baseline observations on a daily basis until his presence seems to no longer create a reaction and the observations become constant [p. 25].

Dealing with Hawthorne or placebo effects requires somehow “separating” them from the effect of changing an injury risk factor as part of the intervention. In the example above, the effect of the consultant (and
that of taking observations) was separated from the effect of providing
feedback by having the consultant take baseline measurements prior to
starting the feedback.

All of the foregoing in this addendum has been taken verbatim from
the NIOSH text. The following is in my verbiage.

Chapter 6 is titled “Measuring Outcomes.” It commences with addi-
tional discussion of the reliability and validity of measurements. Subjects
covered are injury statistics, other statistics, behavioral and work-site
observations, employee surveys, analytical equipment measures, work-
place audits, unintended outcomes, and practical considerations.

Chapter 7 is titled “Qualitative Methods for Effectiveness Evaluation:
When Numbers Are Not Enough.” Subjects covered are interviews and
focus groups, questionnaires and open-ended questions, and observations
and document analysis. Again, stress is given to verification of the
measures.

Chapter 8 is titled “Statistical Issues: Are the Results Significant?” It’s
interesting and challenging. I quote from it.

Having emphasized the vital importance of statistical analysis, we warn you
about indiscriminately using statistical packages. Inexperienced researchers
are sometimes tempted to feed their data into a standard software package
and ask for everything to be compared with everything else.

For safety professionals who want to move the state of the art forward,
this is a valuable and challenging document.
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