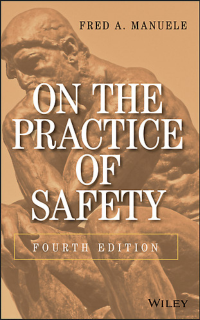

FRED A. MANUELE

ON THE PRACTICE OF SAFETY

FOURTH EDITION

WILEY

2

DEFINING THE PRACTICE OF SAFETY

INTRODUCTION

After participating with safety professionals in what he considered a baffling discussion of concepts, a highly regarded professor in industrial engineering observed that what we who call ourselves safety professionals do will never be accepted as a profession by those outside of our field until we agree on a clear definition of our practice. This author agrees with that premise. In this chapter, the currently applicable scope and function of the professional safety position will be reviewed and the practice of safety will be defined in terms of providing a societal benefit.

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 language used by safety professionals should convey an immediate perception of the intent of their practice. In his book *General Insurance*, David L. Bickelhaupt (1983) made a significant statement about the need for clear communications that speaks to the purpose of this treatise.

On the Practice of Safety, Fourth Edition. Fred A. Manuele.

> 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. (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

Safety professionals must agree on the meaning of the word *safety*, as in "the practice of safety," so that their communications including the word *safety* convey a singular and understandable message. Dictionary definitions of safety are commonly given in the safety literature, and the use of them indicates a lack of understanding of safety, as well as of 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." Being absolutely "free from danger" is not possible.

In the book *Introduction to Safety Engineering*, Gloss and Wardle (1984) 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. (3)

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

> Safety is relative—nothing is 100% safe under all conditions. (3)

In *Occupational Safety Management and Engineering*, Willie Hammer (1985) wrote this:

> Safety is 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. (142)

William W. Lowrance (1976) 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. (8)

None of the authors cited defined safety in the absolute sense of dictionary definitions indicating 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.

This author chaired the committee that wrote ANSI/ASSE Z590.3—2011, which was approved September 1, 2011—thus, a recent endeavor. This American National Standard is titled *Prevention through Design: Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes.* Agreement was reached by the 80+ professionals who participated in developing the standard to adopt the definition of safety as in the 1999 version of ISO/IEC Guide 51, the title of which is *Safety Aspects—Guidelines for their inclusion in standards*.

The definition of safety in Guide 51 is "Freedom from unacceptable risk" (3.1). That definition is in concert with all previously cited definitions, other than for the dictionary definitions. It also implies an understanding of hazards and risks.

Guide 51 lists definitions of terms that have been agreed to by the guideline writing committee. It is issued by the International Organization for Standardization (ISO) jointly with the International Electrotechnical Commission (IEC). Both of those organizations are recognized international standards organizations. (Issued in 1999, some of the definitions in the Guide need revision. A committee to update the Guide is active. It is doubtful that its definition of safety or risk will be changed.)

Further, safety professionals must be aware that even if all that they recommend to reduce risk is implemented and the risk is reduced significantly, there always be a residual risk—unless a facility or operation will no longer exist. It is unrealistic to presume that an environment could be created in which the probability of an injurious or damaging event occurring is zero.

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 acceptable (driving an auto, skiing, boating, etc.).

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 (1976) stated that risk assessments made as a result of studies for the public good 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 (9).

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

DEFINING ACCEPTABLE RISK

In the previously mentioned standard on prevention through design (ANSI/ASSE, 2011), these definitions of acceptable risk and ALARP are given.

Acceptable Risk That risk for which the probability of an incident or exposure occurring and the severity of harm or damage that may result are as low as reasonably practicable (ALARP) in the setting being considered.

As Low as Reasonably Practicable (ALARP) That level of risk that can be further lowered only by an increase in resource expenditure that is disproportionate in relation to the resulting decrease in risk.

Although the prevention through design standard applies to occupational hazards and risks, the previously given definitions of acceptable risk and ALARP apply to all hazards-related exposures (fire protection, transportation safety, environmental safety, etc.).

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 the 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. It is not realistically conceivable that safety professionals would present themselves as consultants in uncertainty reduction.

Also, the definitions of risk given in the risk management and insurance literature seldom mention the severity of an event's consequences—even by implication. Giving advice to reduce the severity of the 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 (1976) wrote that:

> Risk is a measure of the probability and severity of adverse effects. (94)

Rowe (1977), 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. (464)

Expanding on Lowrance and Rowe, the following definition of risk relates more precisely to the work of the many safety professionals who have responsibilities for environmental matters in addition to occupational safety and health. It appears in the previously mention prevention through design (ANSI/ASSE, 2011) standard.

> Risk is defined as an estimate of the probability of a hazards-related incident or exposure occurring and the severity of harm or damage that could result. (8)

That definition is close to two almost identical definitions appearing in recently issued documents. In the American National Standard ANSI B11.0 approved in November 2010 and titled *Safety of Machinery—*

General Requirements and Risk Assessment, this definition of risk is given.

> Risk: The combination of the probability of harm and the severity of that harm. (3.68)

That definition duplicates the definition of risk given in ISO/IEC Guide 51 (3.2). 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 or exposure 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
- Reducing the *severity* of harm or damage that may result, if an incident or exposure occurs

DEFINING HAZARDS

Having defined risk, these questions should then be asked. What is the source of risk? What presents the probability of incidents or exposures 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 previously cited documents—ANSI B11.0-2000 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. (3.24 in ANSI B11.0 and 3.5 in Guide 51)

Note the significance of what is occurring, internationally. It is accepted that a hazard is defined as the potential for harm. For the work of safety professionals whose responsibilities include giving counsel on occupational safety and health and environmental controls, the following definition is offered.

> Hazards are defined as the potential for harm or damage to people, property, or the environment: Hazards include the characteristics of things (e.g., equipment, technology, processes, dusts, fibers, materials, and chemicals) and the actions or inactions of people.

It should be understood that 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 as expressed in an Internet entry on the Board of Certified Safety Professionals (BCSP) website (www.bcsp.org/safetyprofessional) (quoted with permission).

> **The Safety Professional Today: The Challenges of the New Millennium**
>
> In the 21st century, safety professionals confront new challenges not faced a generation or even a decade ago. Today's safety professionals are well-educated, highly-motivated and aim to recognize, evaluate, and control risks to people, property and the environment. They must be able to apply technology and work with top management to minimize risk and ensure that safety, health and environmental performance are fundamental measures of business success.
>
> Professional safety practice today involves aspects of engineering, business, health, education, laws and regulations, human behavior, education and training and computer and internet technologies. 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.
>
> Besides 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, and other like industries).

> Safety professionals who can demonstrate their competency are in demand and receive compensation well above their colleagues. To be able to compete for positions with responsibility requires safety professionals take charge of their own professional development. Those moving to leadership positions are arming themselves with advanced degrees. In addition, safety professionals are obtaining nationally accredited and highly recognized certifications to demonstrate competency to qualify for positions, to compete for government and private contracts and to gain new clients.
>
> Whether the career goals include seeking a new position, moving up in the current organization or moving to private practice, one can accelerate opportunities by achieving a BCSP certification. Having one of our certifications enhances the chance of being selected for leadership and senior positions, as well as increased salary.

Members of the board of directors for BCSP represent several and differing organizations and hold a variety of technical and management positions. And, people who obtain certification as safety professionals through the BCSP examinations represent many occupational variations and, thus, a broad range of safety practice. Nevertheless, they have agreed on and published their statement on "The Safety Professional Today." It has validity.

A paper issued by the American Society of Safety Engineers titled "Scope and Functions of the Professional Safety Position" is exceptionally well done. Because of its thoroughness and accuracy, it is recommended as a knowledge source and as reference. With the permission of ASSE, the entirety of the Scope and Functions document appears as Addendum A to this chapter. This author believes that the definition of the practice of safety given later in this chapter is in concert with the "Scope and Functions of the Professional Safety Position."

OUR BAFFLING AND NONDESCRIPTIVE TITLES

Unfortunately, safety practitioners 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. Some of the job titles in common usage do not communicate a favorable image of what they do.

An informal and unscientific study was conducted by this author to determine the perceptions management personnel have of the titles used by safety practitioners. Corporate Risk and Insurance Managers were approached who had personnel on their staffs 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 so that discussions could be held with their bosses or their bosses' bosses so that a determination could be made at that level of their understanding of 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. What personnel did 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 personnel 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 professionals, the terms are understood. But, those terms do not convey clear messages of purpose and function to people outside that group.

If this author had a magic wand with which the titles Loss Control, Loss Prevention, and Industrial Hygienist could be eliminated, he would do so. And he would believe that he had performed a highly beneficial service. If the names safety professionals give themselves are baffling, can what safety professionals do ever be considered a profession?

DEFINING THE PRACTICE OF SAFETY

With the dissertation from the Board of Certified Safety Professionals titled "The Safety Professional Today" 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. Roger L. Brauer's (1990) definition of safety engineering, in his book *Safety and Health for Engineers* is a valuable reference.

> Safety engineering is the application of engineering principles to the recognition and control of hazards. (12)

A compatible definition appears in *Introduction to Safety Engineering* by Gloss and Wardle (1984):

> Safety engineering is the discipline that attempts to reduce the risks by eliminating or controlling the hazards. (3)

At a meeting of the Board of Certified Safety Professionals in which this author participated, a definition of the practice of safety was written during discussions of a project to validate that the examinations given by BCSP properly measure what safety professionals actually do:

> The practice of safety 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.

Reflecting on all of the foregoing, this author proposes the following definition of the practice of safety.

The Practice of Safety

- Is hazard and risk focused.
- Serves the societal need to prevent or mitigate harm or damage to people, property, and the environment.
- Is based on knowledge and skill in the following categories:
  - Applied engineering
  - Applied sciences
  - Sound management principles
  - Information and communications
  - Legal and regulatory affairs
- Is accomplished through:

  - Anticipating, identifying, and evaluating hazards and assessing the risks that derive from them
  - Taking action to avoid, eliminate, or control those hazards
- Has as its ultimate purpose attaining safety—defined as freedom from unacceptable risk.

This definition applies to all occupational fields of endeavor for which the generic base is hazards, that is, 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 the like.

While safety professionals may undertake many tasks, the underlying purpose of each task is to have the attendant risks be at acceptable levels. 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 four major stages in the applied practice of safety. All are hazards focused.

1. Preoperational Stage In the initial planning, design, specification, prototyping, and construction processes, where the opportunities are greatest and the costs are lowest for hazard and risk avoidance, elimination, reduction or control.
2. Operational Stage Where hazards and risks are identified and evaluated and mitigation actions are taken through redesign initiatives or changes in work methods before incidents or exposures occur.
3. Postincident Stage where investigations are made of incidents and exposures to determine the causal factors that will lead to appropriate interventions and acceptable risk levels.
4. Postoperational Stage when demolition, decommissioning, or reusing/rebuilding operations are undertaken.

For all four 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 be at an acceptable level.

KNOWLEDGE AND SKILL REQUIREMENTS

Knowledge and skill requirements to enter the practice of safety and to fulfill the requirements of professional safety practice are discussed in Chapter 4, "Academic and Skill Requirements for the Practice of Safety." Of necessity, knowledge and skill requirements cited are notably 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, regardless of their titles, 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 to have their practice be thought of as representing a profession are invited to move this discussion forward.

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Addendum A*

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 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 workforce, 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:

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.

Comments follow on the details applicable to each of the four major elements.

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.

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, sub-system, or component failures.
   b. Human error.
   c. Incomplete or faulty decision-making, judgments or administrative actions.
   d. Weaknesses in proposed 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. Ensure completeness, accuracy and validity of required information
   c. Evaluate the effectiveness of classification schemes and data collection methods.
   d. 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 which integrate safety performance into the goals, operation 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 engaged in
    a. Planning, design, development and installation or implementation of systems or programs involving hazard controls.
    b. 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 which communicate valid and comprehensive recommendations for hazard controls which 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 hazard control policies, procedures 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 which are within the duties of the individual's professional safety position.

D. Measure, audit and evaluate the effectiveness of hazard controls and hazard control programs. This function involves:
1. Establishing and implementing techniques, which 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 which assess safety performance of entire systems, organizations, processes and operations or their components and involve both deterrents and incentives.

3

PRINCIPLES FOR THE PRACTICE OF SAFETY: A BASIS FOR DISCUSSION

INTRODUCTION

For the practice of safety to be recognized as a profession, it must have a sound theoretical and practical base that, if applied, will be *effective* in hazard avoidance, elimination, or control and achieving acceptable risk levels. This author believes that there is a generic base for the work of safety professionals that must be understood and applied if they are to be effective. But, safety professionals have not yet agreed on those fundamentals or on the definitions of related terms. As Grimaldi and Simonds (1989) 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. (10)

Safety professionals 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, a listing is presented of general principles, statements, and definitions that are believed to be rational. The list is a beginning: It is not complete.

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It is intended that this list will encourage dialog by those who have an interest in moving the state of the art forward.

A. ON HAZARDS

1. Hazards are the generic base of, the justification for the existence of, the entirety of the practice of safety. If there were no hazards, safety professionals need not exist.
2. The entirety of purpose of those responsible for safety, regardless of their titles, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are acceptable.
3. A hazard is defined as the potential source of harm.
4. Hazards include the characteristics of things (e.g., equipment, technology, processes, dusts, fibers, gases, materials, and chemicals) and the actions or inactions of persons that have the potential to harm or damage people, property, or the environment.
5. 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 (Fischhoff, 1989, 217).
6. Two considerations are necessary in determining whether a hazard exists. Do the characteristics of the things 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?
7. Every activity undertaken as a part of an Operational Risk Management System should serve to avoid, eliminate, or control hazards so that the risks deriving from those hazards are acceptable.
8. Hazard analysis is the most important safety process in that, if that fails, all other processes are likely to be ineffective (Johnson, 1980, 245).
9. To complete a hazard analysis after a hazard has been identified and its potential for harm has been evaluated, the exposure must be assessed. An exposure assessment would determine the number of people, the extent of the property, and the aspects of the environment in a particular setting that could be affected by the realization of the hazard and the extent of harm or damage that could result.

10. If hazard identification and analysis do not relate to actual causal factors, corrective actions will be misdirected and ineffective.
11. If a hazard is not avoided, eliminated, or controlled, its potential may be realized and a hazards-related incident or exposure may occur that will likely result in harm or damage, depending on exposures.
12. Hazards and risks are most effectively and economically avoided, eliminated, or controlled in the design and redesign processes.
13. 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.
14. Hazards-related incidents or exposures, even the ordinary and frequent, are complex and may have multiple and interacting causal factors.

B. DEFINING RISK, ACCEPTABLE RISK, AND SAFETY

1. Risk is defined as an estimate of the probability of a hazard-related incident or exposure occurring and the severity of harm or damage that could result.
2. Probability is defined as an estimate of the likelihood of an incident or exposure occurring that could result in harm or damage for the selected unit of time, events, population, items, or activity being considered.
3. Severity is defined as an estimate of the magnitude of harm or damage that could reasonably result from a hazard-related incident or exposure. (Severity considerations include injury and illness to people, damage to property and the environment, business down time, loss of business, etc.)
4. Acceptable risk is that risk for which the probability of an incident or exposure occurring and the severity of harm or damage that may result are as low as reasonably practicable (ALARP) in the setting being considered.
5. As low as reasonably practicable (ALARP) is that level of risk that can be further lowered only by an expenditure that is disproportionate in relation to the resulting decrease in risk.
6. Safety is defined as freedom from unacceptable risk.

7. All risks to which the practice of safety applies derive from hazards: There are no exceptions.
8. 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.
9. Setting a goal to achieve a zero-risk environment may seem laudable, but doing so requires chasing a myth.
10. Residual risk is the risk remaining after risk reduction measures have been taken.
11. The professional practice of safety requires consideration of the two distinct aspects of risk:
    a. Avoiding, eliminating, or reducing the probability of a hazard-related incident or exposure occurring
    b. Reducing the severity of harm or damage if an incident or exposure occurs
12. For an operation to proceed, its risks must be judged to be acceptable.

C. RISK ASSESSMENT

1. Risk assessment is a process that commences with hazard identification and analysis that produces an estimate of the severity of harm or damage that may result if an incident or exposure occurs, followed by an estimate of the probability of an incident or exposure occurring and concluding with a risk category (e.g., Low, Moderate, Serious, High).
2. In producing the measure that becomes a statement of risk, it's necessary that determinations be made for the:
    - Existence of a hazard or hazards
    - Exposure to the hazard
    - Frequency of endangerment of that which is exposed to the hazard
    - Severity of the consequences should the hazard be realized (the extent of harm or damage to people, property, or the environment)
    - Probability of the hazard being realized
3. A successful communication with management 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.

4. 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.
5. It will not be unusual when risk decisions are made 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.
6. Risk assessment should be the cornerstone of an operational risk management system.
7. The risk assessment process applies to all aspects of operational risk management—occupational safety, occupational health, environmental matters, product safety, all aspects of transportation safety, safety of the public, health physics, system safety, fire protection engineering, property damage and business interruption avoidance, and the like.
8. If the risk assessment process is not done well or not at all, the appropriate preventive measures are unlikely to be identified or put in place.

D. DEFINING THE PRACTICE OF SAFETY

For the practice of safety 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.

The Practice of Safety

1. With respect to hazards, the potential for harm, serves the societal need to prevent or mitigate harm or damage to people, property, and the environment.
2. Is based on knowledge and skill as each of the following pertain to occupational safety and health, and environmental concerns:
    a. Applied engineering
    b. Applied sciences
    c. Management principles
    d. Information and communications
    e. Legal and regulatory affairs

3. Is accomplished through
   a. Anticipating, identifying, and evaluating hazards and assessing the risks that derive from them
   b. Taking actions to avoid, eliminate, or control those hazards
4. Has as its ultimate purpose attaining a state for which the risks are judged to be acceptable.
5. Whatever the particular field of a hazard-related endeavor or the name given to it, the previously given definition is applicable. That includes 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 the like.
6. While safety professionals may undertake many tasks in their work, the underlying purpose of each task is to have the attendant risks be acceptable.
7. There are four major stages in operational risk management to which this definition of the practice of safety applies.
   a. Preoperational Stage In the initial planning, design, specification, prototyping, and construction processes, where the opportunities are greatest and the costs are lowest for hazard and risk avoidance, elimination, reduction, or control.
   b. Operational Stage Where hazards and risks are identified and evaluated and mitigation actions are taken through redesign initiatives or changes in work methods before incidents or exposures occur.
   c. Postincident Stage Where investigations are made of incidents and exposures to determine the causal factors that will lead to appropriate interventions and acceptable risk levels.
   d. Postoperational Stage When demolition, decommissioning, or reusing/rebuilding operations are undertaken.

E. HIERARCHY OF CONTROLS

1. A hierarchy of controls provides a systematic way of thinking, considering steps in a ranked and sequential order, to choose the most effective means of avoiding, eliminating, or reducing hazards and their associated risks.
2. Acknowledging that premise—that risk reduction measures should be considered and taken in a prescribed order—represents an important step in the evolution of the practice of safety.

3. In all of the four stages in Operational Risk Management, a hierarchy of controls (Figure 3.1), is to be applied to achieve acceptable risk levels.

Most Preferred	Risk Avoidance: Prevent entry of hazards into a workplace by selecting and incorporating appropriate technology and work methods criteria during the design processes.
	Eliminate: Eliminate workplace and work methods risks that have been discovered.
	Substitution: Reduce risks by substituting less hazardous methods or materials.
	Engineering Controls: Incorporate engineering controls/safety devices.
	Warning: Provide warning systems.
	Administrative Controls: Apply administrative controls (the organization of work, training, scheduling, supervision, etc.).
Least Preferred	Personal Protective Equipment: Provide personal protective equipment (PPE).

Figure 3.1 Risk reduction hierarchy of control: Z590.3.

4. With respect to the seven levels of control shown in the hierarchy of controls, it should be understood that the first through the fourth are most effective because they:
   a. Are preventive actions that eliminate or reduce risk by design, elimination, substitution, and engineering measures.
   b. Rely the least on human behavior—the performance of personnel.
   c. Are less defeatable by managers, supervisors, or workers.
5. Actions in the fifth, sixth, and seventh levels are contingent actions that rely greatly on the performance of personnel for their effectiveness—thereby, they are less reliable.

F. 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 (1994), 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. (79)

4. When safety is seamlessly integrated into the way an organization functions on a daily basis, a separately identified safety management system is not needed, theoretically, since all actions required to achieve safety would be blended into operations.
5. Thus, the theoretical ideal for a safety management system is nothing.

G. ON ORGANIZATIONAL CULTURE

1. Management creates the culture for safety—positive or negative.
2. 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.
3. 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.
4. Management obtains, as a derivation of its culture—as an extension of its system of expected performance—the hazards-related incident experience that it establishes as acceptable. For personnel in the organization, "acceptable" is their interpretation of what management does.
5. An organization's culture, translated into a system of expected performance, determines management's:
   a. Commitment or noncommitment to safety and its level of involvement

   b. Accountability system
   c. Provision or nonprovision of the necessary resources
   d. Safety policy
   e. Safety organization
   f. Standards for workplace and work methods design
   g. Requirements for continuous improvement
   h. The climate that is to prevail concerning management and personnel factors (leadership, training, communication, adherence to safe work practices, etc.)
6. Management commitment is questionable if:
   a. The accountability system does not include safety performance measures that impact on the well-being of those responsible for results.
   b. Adequate resources to maintain acceptable risk levels throughout the organization are not provided.
7. What management does, rather than what management says, defines the actuality of commitment or noncommitment to safety.
8. Principal evidence of an organization's culture with respect to safety 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.
9. If the design of a system (the facilities, equipment, work methods, etc.) does not achieve acceptable risk levels, it is unlikely that superior results with respect to safety can be attained.
10. Where the culture and the operating system demand superior safety performance—design and engineering, management and operations, and task performance aspects of safety are well balanced.
11. Major improvements in safety will be achieved only if a culture change takes place—only if major changes occur in the reality of the performance system.

H. CONCERNING LEADERSHIP, TRAINING, AND BEHAVIOR MODIFICATION

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

2. But, training and behavior modification, et al, 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 (1990) 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. (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 (1986):

   > 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. (242)

5. In *Out of the Crisis*, by W. Edwards Deming (1986), 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. (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 Deming (1986), 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. (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.
12. If the design of the system presents excessive operational risks for which the cost of retrofitting is prohibitive—administrative controls, which perhaps may be the only actions that can be taken, will achieve less than superior results.

I. PREVENTION THROUGH DESIGN

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, great strides forward with respect to all hazard-related endeavors that fit under the caption "Operations Risk Management" can be made in the design and redesign processes.
3. For the practice of safety, the terms "design and redesign processes" apply to:
   a. Facilities, hardware, equipment, tooling, selection of materials, and operations layout and configuration.

b. Work methods and procedures, personnel selection standards, training content, management of change procedures, maintenance requirements, and personal protective equipment needs.

4. The goal to be achieved in the design and redesign processes is acceptable risk levels.
5. 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.
6. 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.
7. A fundamental design goal is to have processes that are error proof. Juran and Gryna (1983), 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. (347)

8. Requirements to achieve an acceptable risk level in the design and redesign processes can usually be met without great cost if the decision making takes place early enough 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.

J. ON SYSTEM SAFETY

1. The *Scope and Functions of the Professional Safety Position* issued by the American Society of Safety Engineers (1998) 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 processes. 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 processes and using hazard analysis and risk assessment techniques to achieve acceptable risk levels 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 (1980) 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 (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 the task performance aspects of safety, application of hazard analysis and risk assessment methods are vital to achieving acceptable risk levels.
7. In *System Safety for the 21st Century*, Richard Stephans (2004) makes this sensible statement: "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" (13). This statement is valid.

K. SETTING PRIORITIES AND UTILIZING RESOURCES EFFECTIVELY

1. These principles are postulated.
   a. All hazards do not present equal potential for harm or damage.
   b. All incidents that may result in injury, illness, or damage do not have equal probability of occurrence, nor will their adverse outcomes be equal.
   c. Some risks are more significant than others.
   d. Resources are always limited. Staffing and money are never adequate to attend to all risks.
   e. 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. The professional practice of safety 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 and of rating risks.
5. Causal factors for low-probability incidents resulting in severe harm or damage may be different from the causal factors for incidents that occur more frequently. Such low-probability 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.

L. 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, management and operations, and personnel task performance.
2. In *MORT Safety Assurance Systems*, Johnson (1980) 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. (74)

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

   b. A person or thing in the system, or both, are stressed beyond the limits of tolerance or recoverability.
   c. The incident process begins with an initiating event in a series of events.
   d. Multiple interacting events occur, sequentially or in parallel, over time and influencing each other, to a conclusion that is likely to result in injury or damage.
4. *Severity potential* should determine whether hazards-related incidents are 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. 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.
6. Heinrich's 88–10–2 ratios indicate that among the direct and proximate accident causes, 88 percent are unsafe acts, 10 percent are unsafe mechanical or physical conditions, and 2 percent are unpreventable (174).
   a. The methodology used in arriving at those ratios cannot be supported.
   b. Current causation knowledge indicates the premise to be invalid.
   c. Heinrich's 88–10–2 premise conflicts with the work of others, such as Deming, whose research finds root causes to derive from shortcomings in the management systems.
   d. Among all the Heinrichean 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 improving the operating system.
   e. Those who continue to promote the idea that 88 percent of all industrial accidents are caused primarily by the unsafe acts of persons do the world a disservice.
7. The Foundation of a Major Injury, the 300–29–1 ratios (Heinrich's triangle) is the least tenable of his premises (27).
   a. 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.

b. 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 statistical evidence and is questioned by several authors.

d. 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 (Heinrich, 1959, 33).

8. Investigation of numerous accidents resulting in fatality or serious injury by modern-day safety professionals leads to the conclusion that the causal factors are different and that they may not be linked to the causal factors for accidents that occur frequently and result in minor injury.
9. No documentation exists to support Heinrich's 4-to-1 ratio of indirect injury costs to direct costs. Further, arriving at a ratio that is applicable universally is implausible (40).
10. 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 systemic causal factors. It is this author's 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" (4).
11. 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 (15).
12. Incident investigation, initially, should address the work system, applying a concept that:

a. Commences with inquiries to determine whether causal factors derive from workplace design decisions.

b. 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.

M. PERFORMANCE MEASURES

1. If the practice of safety professionals is based on sound science, engineering, and management principles, it follows that safety professionals should be able to provide measures of performance that reflect the outcomes of the risk management initiatives they propose with some degree of accuracy.
2. Understanding the validity and shortcomings of the performance measures used 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 the risks that derive from them are impacted directly by the validity of the information they provide. 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. A measure of the quality of safety in place
   b. A general, but not hazard specific, predictor of the experience that will develop in the future
6. However, 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 the data base is large enough and 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.
11. Much interest has developed in what are being called leading and lagging indicators for the measurement of safety performance. Statistics traditionally gathered are lagging indicators. Example of leading indicators would be training programs conducted, inspections made, hazard communication sessions held, and the like. 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 costs.

N. 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 (1990) concluded properly 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. (36)

3. Since evidence of an organization's culture and its management commitment to safety is first demonstrated through its upstream design and engineering decisions, 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.
5. Safety audits must also determine whether adequate resources are provided to achieve and maintain acceptable risk levels.

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 dialog. To some extent, that has occurred and continues.

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10

REVIEWING HEINRICH: DISLODGING TWO MYTHS FROM THE PRACTICE OF SAFETY

INTRODUCTION

In *The Standardization of Error*, Vilhjamur Stefansson makes the case that people are willing to accept as fact what is written or spoken without adequate supporting evidence. When studies show that a supposed fact is not true, dislodging it is difficult because that belief has become deeply embedded in the minds of people and, thereby, standardized. Stefansson pleads for a mindset that accepts as knowledge only that which can be proven and which cannot be logically contradicted. He states that his theme applies to all fields of endeavor except for mathematics.

Safety is a professional specialty in which myths have become standardized and deeply embedded. This chapter examines two myths that should be dislodged from the practice of safety:

1. Unsafe acts of workers are the principle causes of occupational accidents.
2. Reducing accident frequency will achieve an equivalent reduction in injury severity.

On the Practice of Safety, Fourth Edition. Fred A. Manuele.

These myths arise from the work of H. W. Heinrich. They can be found in the four editions of *Industrial Accident Prevention: A Scientific Approach.* Although some safety practitioners may not recognize Heinrich's name, his misleading premises are perpetuated as they are frequently cited in speeches and papers. Analytical evidence indicates that these premises are not soundly based, supportable, or valid and, therefore, must be dislodged.

This chapter was written as a result of encouragement from several colleagues who encountered situations in which these premises were cited as fact, with the resulting recommended preventive actions being inappropriate and ineffective. Safety professionals must do more to inform about and refute these myths so that they may be dislodged.

RECOGNITION: HEINRICH'S ACHIEVEMENTS

Heinrich was a pioneer in the field of accident prevention and must be given his due. Publication of the four editions of his book spanned nearly 30 years. From the 1930s to today, Heinrich likely has had more influence than any other individual on the work of occupational safety practitioners. In retrospect, the good done by him in promoting greater attention to occupational safety and health should be balanced with an awareness of the misdirection that has resulted from applying some of his premises.

HEINRICH'S SOURCES UNAVAILABLE

Attempts were made to locate Heinrich's research, without success. Dan Petersen, who with Nestor Roos (1980) authored a fifth edition of *Industrial Accident Prevention*, was asked whether he had located Heinrich's research. Petersen said that they had to rely entirely on the previous editions of Heinrich's books as resources.

Thus, the only data that can be reviewed are contained in Heinrich's books. His information-gathering methods, survey documents that may have been used, the quality of the information gathered, and the analytical systems used cannot be examined.

Two items of note for this chapter:

1. Citations from Heinrich's texts are numbered H-1, H-2, and so forth and correspond to the chart in the References for this

chapter. Page numbers and editions in which each citation appears are recorded. For all other citations, page numbers are shown at the end of the quote (e.g., 14).

2. In today's social climate, some of Heinrich's terminology would be considered sexist. He uses phrases such as *man failure, the foreman*, and *he is responsible.* Consider the time in which he wrote. The first edition was published in 1931. The fourth edition was published in 1959.

PSYCHOLOGY AND SAFETY

Applied psychology dominates Heinrich's work with respect to selecting causal factors and as being of great importance in safety-related problem resolution. Consider the following:

1. Heinrich expresses the belief that: "Psychology in accident prevention is a fundamental of great importance" (H-1).
2. His premise is that: "Psychology lies at the root of sequence of accident causes" (H-2).
3. In the fourth edition, Heinrich states that he 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" (H-3).
4. The focus of applied psychology is on the employee, as in the following quotation: "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. (H-4)

Note that the focus of applied psychology is on the worker, as are other Heinrichean premises. Since application of practical psychology is confined to the worker, who reports to a supervisor, the psychology applier is the supervisor.

With due respect to managers, supervisors, and safety practitioners, it is doubtful that many could knowledgeably apply psychology "as a fundamental of great importance" in their accident prevention efforts.

HEINRICH'S CAUSATION THEORY: THE 88–10–2 RATIOS

Heinrich professes that among the direct and proximate causes of industrial accidents:

- 88 percent are unsafe acts of persons.
- 10 percent are unsafe mechanical or physical conditions.
- 2 percent are unpreventable (H-5).

According to Heinrich, man failure is the problem and psychology is an important element in correcting it. In his discussion of the "Relation of Psychology to Accident Prevention," Heinrich advocates identifying the first proximate and most easily prevented cause in the selection of remedies. He says:

> Selection of remedies is 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. (H-6)

Note that the first proximate and most easily prevented cause is to be selected (88 percent of the time a human error). 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. For example, the report prepared by the Columbia Accident Investigation Board (CAIB, 2003) states the need to consider the complexity of incident causation:

> Many accident investigations do not go far enough. They identify the technical cause of the accident, and then connect it to a variant of "operator error." But this is seldom the entire issue. When the determinations of the causal chain are limited to the technical flaw and individual failure, typically the actions taken to prevent a similar event in the future are also limited: fix the technical problem and replace or retrain the individual responsible.
>
> Putting these corrections in place leads to another mistake: The belief that the problem is solved. Too often, accident investigations blame a failure only on the last step in a complex process, when a more comprehensive understanding of that process could reveal that earlier steps might be equally or even more culpable. (97)

A recent example of the complexity of accident causation appears in this excerpt from the September 8, 2010 report prepared by BP personnel following the April 20, 2010 *Deepwater Horizon* explosion in the Gulf of Mexico.

> The team did not identify any single action or inaction that caused this incident. Rather, a complex and interlinked series of mechanical failures, human judgments, engineering design, operational implementation and team interfaces came together to allow the initiation and escalation of the accident. (5)

Consider another real-world situation in which a fatality resulted from multiple causal factors:

> An operation produces an odorless, colorless highly toxic gas in an enclosed area. The two-level gas detection and alarm system has deteriorated over many years of use, and the system often leaks gas. An internal auditor recommends it be replaced with a three-level system, the currently accepted practice in the industry for that type of gas. The auditor also recommends that maintenance give the existing system high priority.
>
> Management puts high profits above safety and tolerates excessive risk taking. That defines culture problems. Management decides not to replace the system, and begins a cost-cutting initiative that reduces the maintenance staff by one-third. The gas detection and alarm system continue to deteriorate, and maintenance staff cannot keep up with the frequent calls for repair and adjustment.
>
> A procedure is installed that requires employees to test for gas before entering the enclosed area. But, supervisors condone employees entering the area without making the required test. Both detection and alarm systems fail. Gas accumulates. An employee enters the area without testing for gas. The result is a toxic gas fatality.
>
> Causal factor determination would commence with the deficiencies in the organization's culture whereby: Resources were not provided to replace a defective detection and alarm system in a critical area; Staffing decisions resulted in inadequate maintenance; and Excessive risk taking was condoned. The employee's violation of the established procedure was a contributing factor, but not principle among several factors.

Heinrich's theory that an unsafe act is the sole cause of an accident is not supported in the cited examples. Also, note that Heinrich's focus on man failure is singular in the following citation:

> 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 (H-7).
>
> *Note:* Heinrich does not define man failure. In making the case to support directing efforts toward controlling man failure, he cites personal factors such as unsafe acts, using unsafe tools and willful disregard of instruction.

A directly opposite view is expressed by W. Edwards Deming (1986) in *Out of the Crisis*. Deming is known throughout the world for his work on the principles to be applied to achieve superior quality. This author finds those principles to be comparable to the concepts required to achieve superior results in safety.

> The supposition is prevalent throughout the world that there would be no problems in production or service if only our production workers would do their jobs in the way that we taught. Pleasant dreams. The workers are handicapped by the system, and the system belongs to the management. (134)

Of all Heinrich's concepts, his thoughts on accident causation, expressed as the 88–10–2 ratios, have had the greatest impact on the practice of safety and have resulted in the most misdirection. Why is this so? Because when basing safety efforts on the premise that man failure causes the most accidents, the preventive efforts are directed at modifying worker behavior rather than on improving the operating system in which the work is performed.

Many safety practitioners operate on the belief that the 88–10–2 ratios are soundly based and, as a result, focus their efforts on reducing so-called man failure rather than attempting to improve the system. This belief also perpetuates because it is the path of least resistance for an organization. It is easier for supervisors and managers to be satisfied with taking superficial preventive action, such as retraining a worker, reposting the standard operating procedure, or reinstructing the work group than it is to try to correct system problems.

Certainly, operator errors may be causal factors for accidents. But, consider Ted Ferry's (1981) comments on this subject as 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. (56)

If, during an accident investigation, a professional search is made for causal factors beyond an unsafe act, such as through the Five Why Method, it will likely be found that the causal factors built into work systems may be of greater importance than an employee unsafe act. Fortunately, a body of literature has emerged that recognizes the significance of causal factors that originate from decisions made above the worker level. Several are cited here.

HUMAN ERRORS ABOVE THE WORKER LEVEL

Particular attention is given to the *Guidelines for Preventing Human Error in Process Safety*, a 1994 publication. Although "process safety" appears in the book's title, the first two chapters provide an easily read primer on human error reduction. The content of those chapters was influenced largely by personnel with safety management experience at a plant or corporate level.

Safety professionals should view the following highlights as generic and broadly applicable. They advise on where human errors occur, who commits them and at what level, the effect of organizational culture, and where attention is needed to reduce the occurrence of human errors. These highlights, taken from the Guidelines, apply to organizations of all types and sizes.

- It is readily acknowledged that human errors at the operational level are a primary contributor to the failure of systems. It is often not recognized, however, that these errors frequently arise from failures at the management, design or technical expert levels of the company (xiii).
- A systems perspective is taken that views error as a natural consequence of a mismatch between human capabilities and demands, and an inappropriate organizational culture. From this perspective, the factors that directly influence error are ultimately controllable by management (3).
- Almost all major accident investigations in recent years have shown that human error was a significant causal factor at the level of design, operations, maintenance or the management process (5).
- One central principle presented in this book is the need to consider the organizational factors that create the preconditions for errors, as well as the immediate causes (5).

- Attitudes toward blame will determine whether an organization develops a blame culture, which attributes error to causes such as lack of motivation or deliberate unsafe behavior (5).
- Factors such as the degree of participation that is encouraged in an organization, and the quality of the communication between different levels of management and the workforce, will have a major effect on the safety culture (5).

Since "failures at the management, design or technical expert levels of the company" affect the design of the workplace and the work methods—that is, the operating system—it is logical to suggest that safety professionals should focus on system improvement to attain acceptable risk levels rather than principally on affecting worker behavior.

James Reason's book, *Managing the Risks of Organizational Accidents*, is a must-read for safety professionals who want an education in human error reduction. It has had five additional printings since its original publication in 1997. Reason writes about how the effects of decisions accumulate over time and become the causal factors for incidents resulting in serious injuries or major damage when all the circumstances necessary for the occurrence of a major event fit together. This book stresses the need to focus on decision making above the worker level to prevent major accidents. Reason states:

> Latent conditions, such as poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls in training, less than adequate tools and equipment, may be present for many years before they combine with local circumstances and active failures to penetrate the system's layers of defenses.
>
> They arise from strategic and other top level decisions made by governments, regulators, manufacturers, designers and organizational managers. The impact of these decisions spreads throughout the organization, shaping a distinctive corporate culture and creating error-producing factors within the individual workplaces. (10)
>
> The traditional occupational safety approach alone, directed largely at the unsafe acts of persons, has limited value with respect to the "insidious accumulation of latent conditions [that he notes are] typically present when organizational accidents occur." (224, 239)

If the decisions made by management and others have a negative effect on an organization's culture and create error-producing factors in the workplace, focusing on reducing human errors at the worker level—the unsafe acts—will not address the problems.

The principle embodied in what is referred to as W. Edwards Deming's 85–15 rule also applies to safety. The rule supports the premise that prevention efforts should be focused on the system rather than on the worker. This author draws a comparable conclusion as a result of reviewing more than 1700 incident investigation reports. This is the rule as cited in Mary Walton's (1986) book *The Deming Management Method*:

> The rule holds that 85% of the problems in any operation are within the system and are the responsibly of management, while only 15% lie with the worker. (242)

In 2010, the American Society of Safety Engineers sponsored a symposium titled "Rethink Safety: A New View of Human Error and Workplace Safety." Several speakers proposed that the first course of action to prevent human errors is to examine the design of the work system and work methods. Those statements support Deming's 85–15 rule. Consider this statement by a human error specialist [from this author's notes]:

> When errors occur, they expose weaknesses in the defenses designed into systems, processes, procedures and the culture. It is management's responsibility to anticipate errors and to have systems and work methods designed so as to reduce error potential and to minimize severity of injury potential when errors occur.

Since the majority of the problems in an operation are systemic, safety efforts should be directed toward improving the system. Unfortunately, the use of the terms *unsafe acts* and *unsafe conditions* focuses attention on a worker or a condition and diverts attention from the root-causal factors built into an operation.

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 book *The Measurement of Safety Performance*. Chapanis' message is that if the design of the work is error provocative, it is a near certainty that errors will occur.

It is illogical to conclude in an incident investigation that the principal causal factor is the worker's unsafe act if the design of the workplace or the work methods is error inviting. In such cases, the error-producing aspects of the work (e.g., design, layout, equipment, operations, . . . the system) should be considered primary.

Each of the previously cited publications refutes Heinrich's premise that unsafe acts are the primary causes of occupational accidents.

HEINRICH'S ANALYTICAL METHOD

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 the 88–10–2 ratios. For example, the National Safety Council's *Accident Prevention Manual for Industrial Operations: Administration and Programs*, 8th ed., cites two historical studies establishing 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. (241)

Although aware that others studying accident causation had recognized the multifactorial nature of causes, Heinrich continued to justify selecting a single causal factor in his analytical process. Heinrich's data-gathering methods force the accident cause determination into a singular and narrow categorization. The following quote is found in the second through 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. (H-8)

Heinrich's study resulting in the 88–10–2 ratios was made in the late 1920s. Both the relationship of a study made then to the work world as it now exists and the methods used to produce it are unknown and questionable. As to the study methods, consider the following quote, which appears in the first edition; 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. (H-9)

The source of the data was insurance claims files and records of plant owners, which cannot provide reliable accident causal data because they rarely include causal factors. Nor are accident investigation reports completed by supervisors adequate resources for causal data. When this author provided counsel to clients in the early stages of developing computer-based incident analysis systems, insurance claims reports and supervisors investigation reports were examined as possible sources for causal data. It was a rarity for insurance claims reports to include information from which causal factors could be selected.

This author has examined more than 1700 incident investigation reports completed by supervisors and investigation teams, mostly for incidents that occurred in larger companies and that resulted in serious injury or fatality. In approximately 80 percent of those reports, causal factor information was inadequate. These reports are not a sound base from which to analyze and conclude with respect to the reality of causal factors.

SUMMATION ON THE 88–10–2 RATIOS

The data collection and analytical methods used by Heinrich to develop the 88–10–2 ratios are unsupportable. Heinrich's premise that unsafe acts are the primary causes of occupational accidents cannot be sustained. The myth represented by those ratios must be dislodged from the practice of safety and actively refuted by safety professionals.

An interesting message of support with respect to avoiding use of the 88–10–2 ratios comes from Thomas Krause, the author of *Leading with Safety*, which was published in 2005. Krause has been a major player in worker-focused behavior-based safety. He writes:

> Many in the safety community believe a high percentage of incidents, perhaps 80% to 90%, result from behavioral causes, while the remainder relate to equipment and facilities. We made this statement in our first book in 1990. However, we now recognize that this dichotomy of causes,

> while ingrained in our culture generally and in large parts of the safety community, is not useful, and in fact can be harmful. (10)

FOUNDATION OF A MAJOR INJURY: THE 300–29–1 RATIOS

Heinrich's conclusion with respect to the ratios of incidents that result in no injuries, minor injuries, and major injuries was the base on which educators taught (and still teach), and many safety practitioners came to believe that reducing accident frequency will achieve equivalent reduction in injury severity. The following statement appears in all four editions of Heinrich's text:

> The natural conclusion follows, moreover, that in the largest injury group—the minor injuries—lies the most valuable clues to accident causes. (H-10)

The following discussion and statistics establish that the ratios upon which the foregoing citation is based are questionable and that reducing incident frequency does not necessarily achieve an equivalent reduction in injury severity. Heinrich's 300–29–1 ratios have been depicted as a triangle or a pyramid (Figure 10.1).

In his first edition, Heinrich wrote:

> Analysis proves that for every mishap resulting in an injury there are many other accidents in industry which 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 result in no injuries, 29 in minor injuries, and 1 in a major or lost-time case. (H-11)

Figure 10.1 Foundation of a major injury.

In the second edition, "similar" was added to the citation above so that it reads: "Analysis proves that for every mishap, there are many other similar accidents in industry . . ." (H-12). Heinrich's study resulting in the 88–10–2 ratios was made in the late 1920s. Both the relationship of a study made then to the work world as it now exists and the methods used in producing it are questionable and unknown.

Within a chart displaying the 300–29–1 ratios in the first edition, Heinrich writes: "The total of 330 accidents all have the same cause." Note that cause is singular (H-13). This statement, that all 330 incidents have the same cause, challenges credulity. Also, note that the sentence in quotations in this paragraph appears only in the first edition. It does not appear in later editions (H-14).

For background data, Heinrich says in the first, second, and third editions:

> The determination of this no-injury accident frequency followed a *most interesting and absorbing study* [emphasis added]. The difficulties can be readily imagined. There were few existing data on minor injuries—to say nothing of no-injury accidents. (H-15)

In the fourth edition, published 28 years after the first edition, the source of the data is more specifically stated:

> The determination of this no-injury accident frequency followed a *study of over 5,000 cases* [emphasis added]. The difficulties can be readily imagined. There were few existing data on minor injuries—to say nothing of no-injury accidents. (H-16)

The credibility of such a revision after 28 years must be questioned. In Heinrich's second and third editions, major changes were made in his presentation on the ratios, without explanation.

1. The statement in the first edition that the 330 accidents all have the same cause was eliminated.
2. In the second edition, changes were made indicating that the unit group of 330 accidents are "similar" and "of the same kind" (H-17).
3. In the third edition, another significant addition is made. The 330 accidents now are "of the same kind and involving the same person" (H-18).

The following appears 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* [emphasis added], 300 result in no injuries, 29 in minor injuries and 1 in a major or lost-time injury. (H-19)

Heinrich's changes are not explained. If the original data were valid—how does one explain the substantial revisions in the second, third, and fourth editions—Heinrich gives no indication of other data collection activities or of other analyses. Changes made in the 300–29–1 ratios in the second and third editions, and carried over into the fourth edition, present other 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 incident types, such as falling from a height to a lower level or struck by objects.

For example, a construction worker rides the hoist to the 10th floor and within minutes backs into an unguarded floor opening, falling to his death. Heinrich's ratios would give this person favorable odds of 300 to 330 (10 out of 11) of suffering no injury at all. That is not credible.

Consider the feasibility of finding data in the 5000-plus cases studied to support the ratios, keeping in mind that incidents are to be of the same type and occurring to the same person.

1. If the number of major cases is 1, the number of minor injury case files would be 29 and the number of no-injury case files would be 300.
2. If the number of major cases is 5, the number of minor injury case files would be 145 and the number of no-injury case files would be 1500.
3. If the number of major cases is 10, the number of minor injury case files would be 290 and the number of no-injury case files would be 3000.

Because of the limitations Heinrich imposes on himself, that all incidents are to be of the same type and occurring to the same person, it is implausible that his database could contain the information necessary for analysis and the conclusions he drew on his ratios. Particularly disconcerting is the need for the database to contain information on more than 4500 no-injury cases (300 ÷ 330 × 5000). Unless a special study was initiated, creating files on no-injury incidents would be a rarity. Given all this, one must ask, did a database exist upon which Heinrich established his ratios? This author thinks not.

STATISTICAL INDICATORS: SERIOUS INJURY TRENDING

Data on the trending of serious injuries and workers' compensation claims contradict the premise that focusing on incident frequency reduction will achieve equivalent severity reduction. The following data have been extracted from publications of the National Council on Compensation Insurance (NCCI). A July 2009 NCCI bulletin is titled *Workers' Compensation Claim Frequency Continues Its Decline in 2008*. The reduction was 4.0 percent. A May 2010 NCCI report says that the cumulative reduction in claims frequency from 1991 through 2008 is 54.7 percent.

A 2005 NCCI report, *Workers' Compensation Claim Frequency Down Again*, states: "There has been a larger decline in the frequency of smaller lost-time claims than in the frequency of larger lost-time claims." Also, consider the following trend numbers. They are taken from a 2005 National Council paper titled "State of the Line." They show reductions in selected categories of claim values for the years 1999–2003, expressed in 2003 hard dollars (Table 10.1).

Table 10.1 Categories of Injury Reductions

Value of the Claim	Declines in Frequency (%)
<$2,000	34
$2,000–$10,000	21
$10,000–$50,000	11
>$50,000	7

While the frequency of workers compensation cases is down, the greatest reductions are for less serious injuries. The reduction in cases valued from $10,000 to $50,000 is about one-third of that for cases valued at less than $2000. For cases valued at over $50,000, the reduction is about one-fifth of that for less costly and less serious injuries. The data show, unequivocally, that a comparable reduction in injury severity does not necessarily follow a reduction in injury severity.

In the August 2011 NCCI Research Brief titled *Workers Compensation Claims Frequency*, NCCI says that from 2005 through 2009, "after accounting for wage and medical cost inflation, claims below $50,000 exhibited a greater rate of decline than those above $50,000" as shown in Table 10.2.

Table 10.2 Current Severity Trending

Claim Value	Percent Reduction (%)
<2,000	–25
2,000–10,000	–22
10,000–50,000	–20
50,000–250,000	–14
250,000 and over	–9

The data listed in Table 10.2 is in concert, generally, with the trending previously shown for the years 1999–2003. Reductions in less serious injuries are down substantially more than that for more serious injuries.

One additional resource is of particular note. It states that managing operations to reduce frequency will not equivalently reduce severity. A bulletin was issued by DNV Consulting in 2004 titled *Leading Indicators for Major Accident Hazards: An Invitation to Industry Partners*. DNV is a worldwide consulting firm. Its purpose in sending an "invitation to industry partners" was to obtain contributions for research on serious injury and property damage prevention. (Not successful.)

> **What about the pyramid?**
>
> Much has been said over the years about the classical loss control pyramid, which indicates the ratio between no loss incidents, minor incidents and major incidents, and it has often been argued that if you look after the small potential incidents, the major loss incidents will improve also.
>
> The major accident reality however is somewhat different. What we find is that if you manage the small incidents effectively, the small incident rate improves, but the major accident rate stays the same, or even slightly increases.

CONTRADICTIONS: UNSAFE ACTS AND INJURIES

Heinrich's texts contain contradictions about when a major injury would occur and the relationship between unsafe acts and a major injury. 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 from the first and third editions.

> Keep in mind that a careless act occurs approximately 300 times *before* [emphasis added] a serious injury results and that there is, therefore, an excellent opportunity to detect and correct unsafe practices before injury occurs (H-20).

> Keep in mind that an unsafe act occurs several hundred times *before* [emphasis added] a serious injury results (H-21).

Before is a key word here. While an unsafe act may be performed several times before a particular accident occurs, that is not the case in a large majority of incidents that result in serious injury or fatality. In his fourth edition, Heinrich gave this view of the relationship of unsafe acts or exposures to mechanical hazards.

> 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. (H-22)

There is a real problem here. All of those unsafe acts or exposures to mechanical hazards take place before even one accident occurs. That is illogical.

SUMMATION ON THE 300–29–1 RATIOS

Use of the 300–29–1 ratios is troubling. Since the ratios are not soundly based, one must ask whether the ratios have any substance. (Repeating for emphasis: This author thinks not.) Does their use as a base for a safety management system result in a concentration of resources on the frequent and lesser significant while ignoring opportunities to reduce the more serious injuries?

One of Heinrich's premises is that: "The natural conclusion follows, moreover, that in the largest injury group. The minor injuries lie the most valuable clues to accident causes." (P31–3rd edition, P33–4th edition). Heinrich's premise is wrong. This is a myth that must be dislodged from the practice of safety.

Applying this premise leads to misdirection in resource allocation and ineffectiveness, particularly with respect to preventing serious injuries. In this author's experience, many incidents resulting in serious injury are singular and unique events, with multifaceted and complex causal factors. Furthermore, all hazards do not have equal potential for harm. Some risks are more significant than others. That requires priority setting.

MISINTERPRETATION OF TERMS

Not only have many safety practitioners cited the 300–29–1 ratios in their public presentations and writings, but many also have misconstrued what Heinrich intended with the terms *major injury, minor injury*, and *no-injury accidents*.

Some practitioners who cite these ratios in their presentations assume that a "major injury" is a serious injury or a fatality. 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 (e.g., slip, fall, flying object, inhalation) having the probability of causing personal injury or property damage. The great majority of reported or major injuries are not fatalities or fractures or dismemberments; they are not all lost-time cases, and even those that are do not necessarily involve payment of compensation. (H-20)

Heinrich's definitions compel the conclusion that any injury requiring more than first-aid treatment is a major injury. When these definitions were developed in the late 1920s, few companies were self-insured for workers' compensation. On-site medical facilities were rare. Insurance companies typically paid for medical-only claims and for minor and major injuries.

According to Heinrich's definitions, almost all such claims would be considered major injuries. Then, is it not so that every OSHA-recordable injury is a major injury in this context?

Heinrich's 300–29–1 ratios have been misused and misrepresented many times as well. For example, a safety director recently said that in the previous year his company sustained one fatality and 30 OSHA days-away-from-work incidents, and, therefore, Heinrich's progression was validated. Not so. All of the injuries and the fatality would be in the major or lost-time injury category.

In another instance, a speaker referred to Heinrich's 300–29–1 ratios and said that the 300 were unsafe acts, the 29 were serious injuries, and the 1 was a fatality. These are but two examples of the many misuses of these ratios.

HEINRICH'S PREMISES VERSUS CURRENT SAFETY KNOWLEDGE

Heinrich emphasized improving the performance of the individual worker, rather than improving the work system established by management. That is not compatible with current knowledge. Unfortunately, some safety practitioners continue to base their counsel on Heinrich's premises, which narrows the scope of their activities as they attempt principally to improve worker performance. In doing so, they ignore the knowledge that has evolved in the professional practice of safety. A few examples follow:

- Hazards are the generic base of, and the justification for the existence of, the practice of safety.
- Risk is an estimate of the probability of a hazard-related incident or exposure occurring and the severity of harm or damage that could result.
- The entirety of purpose of those responsible for safety, regardless of their titles, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are acceptable.
- All risks to which the practice of safety applies derive from hazards. There are no exceptions.
- Hazards and risks are most effectively and economically avoided, eliminated, or controlled in the design and redesign processes.
- The professional practice of safety requires consideration of the two distinct aspects of risk:
  - Avoiding, eliminating, or reducing the probability of a hazard-related incident or exposure occurring
  - Reducing the severity of harm or damage if an incident or exposure occurs
- Management creates the safety culture, whether positive or negative.
- An organization's culture, translated into a system of expected behavior, determines management's commitment or lack of commitment to safety and the level of safety achieved.

- Principal evidence of an organization's culture with respect to occupational risk management is demonstrated through the design decisions that determine the facilities, hardware, equipment, tooling, materials, processes, configuration and layout, work environment and work methods.
- 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.
- While human errors may occur at the worker level, preconditions for the commission of such errors may derive from decisions made with respect to the workplace and work methods at the management, design, engineering, or technical expert levels of an organization.
- Greater progress can be obtained with respect to safety by focusing on system improvement to achieve acceptable risk levels, rather than through modifying worker behavior.
- A large proportion of problems in an operation are systemic, deriving from the workplace and work methods created by management, and can be resolved only by management. Responsibility for only a relatively small remainder lies with the worker.
- While employees should be trained and empowered up to their capabilities and encouraged to make contributions with respect to hazard identification and analysis, and risk elimination or control, they should not be expected to do what they cannot do.
- Accidents usually result from multiple and interacting causal factors that may have organizational, cultural, technical, or operational systems origins.
- If accident investigations do not relate to actual causal factors, corrective actions taken will be misdirected and ineffective.
- Causal factors for low-probability/high-consequence events are rarely represented in the analytical data on incidents that occur frequently, and the uniqueness of serious injury potential must be adequately addressed. However, accidents that occur frequently may be predictors of severity potential if a high-energy source was present (e.g., operation of powered mobile equipment, electrical contacts).

As this list demonstrates, Heinrich's premises are not compatible with current knowledge.

CONCLUSION

As knowledge has evolved about how accidents occur and their causal factors, the emphasis is now properly placed on improving the work system, rather than focusing on the worker. A colleague who gets disturbed when he learns of safety professionals referencing Heinrich's premises as fact writes in an email that "It is borderline unethical on their part."

The intent of this chapter is to present a review of the origin of certain premises that have been accepted as truisms by many educators and safety practitioners, how they evolved and changed over time, and to examine their validity. Beyond doubt the two premises discussed here are wrongly based and cannot be sustained by safety practitioners. The premises themselves and the methods used to establish them cannot withstand a logic test. They are myths that have become deeply imbedded in the practice of safety, and it is the responsibility of safety professionals to take action to have them dislodged.

RECOMMENDATIONS

Safety professionals should accept the responsibility to see that these two Heinrichean misconceptions are discarded by the profession. Each safety professional has the responsibility to:

- Cease using or promoting the mistaken premises that unsafe acts are the primary causes of accidents and that focusing on reducing accident frequency will equivalently reduce injury severity.
- Actively dispel these mistaken premises in presentations, writings, and discussions.
- Politely but firmly refute allegations by others who continue to promote the validity of these mistaken premises in presentations, writings, and discussions
- Apply current methods that look beyond Heinrich's myths to determine true causal factors of accidents.

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	Page Numbers by Edition			
Citation	First (1931)	Second (1941)	Third (1950)	Fourth (1959)
H-1	128	269	32	17
H-2	127	268	325	173
H-3				171
H-4	127	268	325	173
H-5	45	19	18	21
H-6	128	269	326	174
H-7		22	2	4
H-8		20	18	21
H-9	44	20	18	20
H-10	95	34	31	33
H-11	31			
H-12		26		
H-13	91			
H-14		27	24	27
H-15		27	24	27
H-16				31
H-17		26		
H-18			24	26
H-19			24	26
H-20	90	30	28	30
H-21	101			
H-22				28
H-23	22			28