CHAPTER 1

THE IMPORTANCE OF SAFETY AND HEALTH

1-1 INTRODUCTION

Modern Western society continues to place a high value on human life. That was not always the case. Even today, some societies place a limited value on human life.

In the United States today, life expectancy for males is 76 years and 81 years for females and increasing slowly. Some other developed countries have slightly higher life expectancies. Some underdeveloped countries have life expectancies around 50 years.

In the past few centuries, engineering and medicine have all but eliminated some diseases that previously were major threats. Examples are smallpox, typhoid, cholera, bubonic plague, diphtheria, tuberculosis, and polio. Medicine has contributed vaccinations, improved treatments, and the use of antibiotics. Engineering contributed sanitation systems to manage human and other waste and to prevent the spread of diseases and illnesses by treating water.

Today we are on the threshold of biological medicine that helps with diagnosis and treatment of disease. A few drops of blood can test for nearly 1,000 medical conditions. Mapping of the DNA molecule and DNA testing can now link many diseases to individual conditions. Biologically grown substances, tissue, and even organs are leading to revolutionary treatments.

The industrial revolution occurred between 1760 and 1840. Early in the industrial revolution, the life expectancy for the working class in Manchester, England, was 17 years. For the gentry living in the country on manors, life expectancy was 35 years. Child labor was common. The industrial revolution introduced new hazards to workers. Early on, the rate of injury and death at work was very high, often from machines. While the rates have come down a lot, there is still much to be done. New equipment and technology have added hazards, often extending from workers to the general population. For example, the automobile continues to cause significant injury and death to the general population. The number of chemicals and materials in daily use has exploded. The *CAS Registry*[1] contains more than 65 million entries with 15,000 additions daily. There are about 300,000 inventoried or regulated substances. We know little about the safety and health hazards of many of these substances.

The industrial revolution spawned a major safety movement. The result was government laws and regulations aimed at protecting workers. Early in 1900, many new organizations devoted to safety and health were founded. One surviving example is the National Safety Council. There were many others at national, state, regional, and industry levels. Many no longer exist. Another derivative of the industrial revolution is workers' compensation, the idea that workers receive compensation for work-related injuries.

What is the value of a human life today? In defending proposed regulations, federal agencies often estimate the value of human life. The Environmental Protection Agency has used $9.1 million. The Food and Drug Administration estimated human life at $7.9 million. The Transportation Department set human worth at $6 million. The average payout for victims of the 9/11 terrorist tragedy in New York in 2001 was $2.1 million. Some insurance companies use $50,000 per year in managing insurance decisions.

Governments, employers, and individuals spend significant money to avoid loss of human life and to prevent injuries and illnesses. Many buy insurance to cover the financial risks related to death, injury, illness, and property loss. For employers, there is also the resulting return on such investments.

Many professions, including engineers and others, play significant roles in these protective endeavors. Protection focuses on people, property and the environment. While all are important, this book will focus primarily on people. The book will concentrate on matters that cause injury, illness, and death. Injury, illness, and death can occur at work, at home, while traveling and during leisure and recreational activities. This book mainly addresses work situations. However, discussion of some topics extends to other activities as well.

Safety and Health for Engineers, Third Edition. Roger L Brauer.

1-2 WHY SAFETY?

Why is safety important? Why bother with it? There are three general reasons.

One reason is *humanitarianism*. Many societies place value on human life and welfare. Not all societies have the same degree of regard for people. Having value for human life is a moral basis for the field of safety and health.

Another reason is the *law*. Different societies use different standards for right and wrong. Societies set standards of conduct through laws and regulations. This reason for safety derives from the first. Laws define a society's moral code. The laws protect the safety, health, and welfare of individuals, property, and the environment.

Cost is a third reason. Some governments and businesses have established a value for human life. Some have established values for injuries and illnesses. The costs involved in injury, illness and death are part of the economic system of a society. So are costs for loss of property. Damage to the environment may also incur costs as part of business. Society often defines the costs through laws.

Humanitarianism

The Value of Human Life and Property Humanitarianism has many aspects derived from the value placed on human life, property and the environment in which we live. Humanitarianism represents the moral part of safety and health. Protecting people is the right thing to do, the moral action.

Humanitarianism varies with societies. Some place a high value on human life, property, and the environment. Others have little regard for these elements, especially when one group has different views from other groups. The differences may involve political or religious factors or other characteristics.

Professional Conduct and Ethics The moral aspect of safety and health often is linked to professional ethics. Many codes of professional conduct and ethics place high value on human life. For example, the National Society of Professional Engineers (NSPE) places protection of people at the top of its Code of Professional Conduct:[2]

I. Fundamental Canons
Engineers, in the fulfillment of their professional duties, shall:
1. Hold paramount the safety, health, and welfare of the public.

The Code continues later with the first Rule of Practice:

II. Rules of Practice
1. Engineers shall hold paramount the safety, health, and welfare of the public.
2. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

There are other codes of ethics and professional conduct for those involved in safety and health. The codes have similar provisions placing high importance on protecting people, property, and the environment.

Corporate Social Responsibility (CSR) Many companies have set a moral standard for their businesses that defines responsibilities to their stakeholders. These companies make a commitment to those they serve, including employees, customers, communities and others. Corporate Social Responsibility refers to operating a business in a manner that accounts for the social and environmental impact created by the business. Often CSR policies include commitments to the safety and health of workers, customers and communities, and action plans to implement them. The Internet shows many sources of help with CSR and examples of corporate CSR statements and action programs.

In 1984, chemical releases in Bhopal, India, killed between 2,300 and 16,000 people (depending on estimates) and harmed as many as 550,000 others. As a result, the American Chemical Society set up a program called "Responsible Care." This program reflects the moral basis for the field of safety and health. The program sets standards that guide producers and users of chemicals in protecting people, property, and the environment.

Sustainability Another moral concept involving protection of people, property, and the environment is sustainability. Sustainability is similar to CSR. One definition of sustainability is "improving the quality of human life while living within the carrying capacity of supporting eco-systems." Sustainability involves three elements: economy, society, and environment.

One study asked senior executives from around the world to rank their top ten challenges. Overall, sustainability came in ninth. The European Union (EU) has proposed setting sustainability reporting requirements as part of the Global Reporting Initiative (GRI). The goal is to improve transparency and accountability to the public.

Some studies have included safety and health as part of the sustainability concept. Safety and health are simply parts of the societal element of sustainability. The Center for Safety and Health Sustainability[3] addresses ways to assure that employee safety and health become part of sustainability globally.

Laws, Regulations, and Standards

The domain of laws, regulations and standards that require protection of people, property and the environment has many

parts. Individuals, companies, and organizations seek to comply with them. Part II of this book deals with laws, regulations, and standards in greater detail.

Government Laws, Regulations, and Standards In general, society codifies protection through laws enacted at international, national, state or province, and local government levels. Often, government agencies issue regulations and standards as interpretations of laws. Laws may conflict with each other, a problem for those trying to comply.

Voluntary or Consensus Standards In addition, groups of interested parties, such as companies, industry groups and associations or others, may create and publish voluntary or consensus standards applicable to their groups. A variety of associations and organizations engage in the creation of these standards.

Standards of Practice Finally, standards may refer to standards of practice. These are generally accepted practices by crafts, professions, managers or others without formally codifying them.

Costs

There are many kinds of costs associated with the protection of people, property, and the environment. One way to discuss costs involves dividing costs into direct and indirect costs.

Direct Costs For safety and health, there are direct costs focused on prevention of injury, illness, and death. Examples are training on how to perform jobs properly and safely. There are costs for equipment and clothing to prevent injuries, illness, and deaths. There are costs to complete work effectively.

There are safety costs for employers. Examples are creating a brand that includes safety concepts and creating loyalty of employees and customers in support of safety. Costs may include creating a positive image for a company or a product that includes safety. There are costs to incorporate safety into designs and the testing of products and processes.

There are costs to comply with laws, regulations, and standards. There are costs to establish and operate safety management systems, covered in Part V. Preventive costs should have significant returns on investments and contribute to business financial success.

Indirect Costs When there is a loss, there are many possible costs. Treating injuries and illnesses incur costs. Deaths create costs. The costs may involve cleanup, recovery, repair, and replacement of materials, equipment and facilities and hiring and training new personnel. Investigations have expenses. Lost production and productivity cost money. Insurance and processing of insurance claims incur costs. There may also be costs related to preventing or resolving legal challenges related to loss events.

1-3 THE RECORDS

Many statistics tell stories about the protection of people, property, and the environment. Over the years, many people have helped improve the performance statistics. However, much remains to be done. In addition, change brings new challenges to address.

The terminology has changed over the years. Some time ago records tracked injuries, illnesses and deaths from "accidents." Today, records use the term "unintentional" instead, such as unintentional injury deaths.

Worldwide Record

The International Labour Organizations (ILO) estimates[4] that around the world:

- Every 15 seconds, a worker dies from a work-related accident or disease.
- Every 15 seconds, 160 workers have a work-related accident.
- Every day, 6,300 people die as a result of occupational accidents or work-related diseases.
- Every year, 317 million accidents occur on the job.
- Every year, there are more than 2.3 million deaths per year.
- The annual economic burden is 4% of global Gross Domestic Product.

The World Health Organization statistics for 2008 show that there were nearly 4 million unintentional injury deaths worldwide. The average unintentional fatality rate among all age groups was 59 per 100,000 population. Road traffic accidents were the leading unintentional fatality cause for all age groups under 70.

The globalization of businesses and the interconnection among world economies cause change. Companies and entire industry groups have a growing responsibility to ensure safe practices among their global partners. There are many examples, see the Bangladesh story in Case1-1 that highlights such efforts among retailers.

Another example is the global pressure on the airline industry to improve the overall safety of air travel.[5] During 2012 and 2013, there was a significant drop in airline fatalities below the 10-year average of 750 fatalities. In 2013, there were 29 airline accidents and a record-low 265 fatalities for about 31 million passenger and cargo commercial flights worldwide. In 2012, there were 23 airline accidents and 475 fatalities. Qantas Airline is one of the

CASE 1-1

In April, 2014, a garment factory in the Rana Plaza of Dhaka, Bangladesh, collapsed, killing 1,129 people and injuring 2,515 others. An investigation report blamed the mayor for wrongly granting construction approvals and the owner for bribing local officials for construction permits. It appears that the project used substandard materials and had a blatant disregard for building codes.

The day before, cracks had appeared in the building, shaking the structure. An engineer who then inspected the building declared it unsafe, but factory bosses disregarded the concerns and ordered workers into the building the next morning.

The disaster sparked global responses. New safety standards for garment factories in third world countries and closer involvement in supply chains by major retail companies from the United States and other countries were instigated. Many saw the need for clothing retailers to conduct audits of supplier facilities and safety practices as part of their corporate social responsibilities.

Wal-Mart Stores does business with more than 200 factories in Bangladesh and began inspecting all of them after the April 2013 tragedy. The first 75 audits cost more than $4 million. Wal-Mart found that nearly half of the factories failed the initial safety inspections. One factory was torn down and others faced major changes. Wal-Mart stopped doing business with two of the 75 factories. It employed 10 engineers to regularly inspect factories in Bangladesh and posted the audit results on its website.

safest airlines in the world and has not had a fatal accident since 1951.

The European Aviation Safety Agency (EASA) reported that there were 17 commercial (non-cargo) air transport aircraft accidents in 2013, compared with an average of 27 annually during the last decade.[6] During the same periods, there were 224 fatalities compared to an average of 703. There were no fatal crashes among EASA member companies during 6 million flights in 2013, carrying 800 million passengers.

The US Record

There are at least three major sources of injury, disease, and death statistics in the United States. One is the Centers for Disease Control and Prevention (CDC). Another is the Bureau of Labor Statistics (BLS). These are federal government agencies. A private source is the National Safety Council. In addition, there are many other federal and state agency sources for injury data. Overall, the data show that accidental injuries are significant. After achieving major reductions, there is still an ongoing need to prevent injuries, illnesses, and deaths.

Centers for Disease Control and Prevention (CDC)

CDC has several data collection and analysis resources. An agency within CDC is the National Center for Injury Prevention and Control (NCIPC).[7] Its mission is to prevent violence and injury and reduce their impacts. The agency operates an online database of injury data and statistics called "Web-based Injury Statistics Query and Reporting System" (WISQARS). This is an interactive database system that provides customized reports of injury-related data.

NCIPC data for 2010 include the following:

- 120,859 unintentional injury deaths.
- 26,009 unintentional fall deaths.
- 33,687 vehicle traffic deaths.
- 33,041 unintentional poisoning deaths.
- More than 180,000 total injury deaths each year.
- Injuries are the leading cause of death for people ages 1 through 44.
- About 2.5 million people hospitalized with injuries each year.
- About 31.6 million people treated for injuries in emergency departments each year.
- Violence and injuries cost more than $406 billion annually.

The overall death rate from all causes in 2011 was 807 per 100,000 population. Table 1-1 lists the top ten causes of death in 2011 for the total population, based on death rates.

Bureau of Labor Statistics (BLS) BLS, an agency within the U.S. Department of Labor, compiles work-related injury, illness and death statistics for workers in the United States.[8] BLS refers to this activity as the Injuries, Illnesses and Fatalities (IIF) program. While the Occupational Safety and Health Administration (OSHA) sets rules for work-related injury and illness recordkeeping, BLS compiles information from data submitted by employers. Refer to BLS annual and other reports for detailed statistics on injuries, illnesses, and deaths broken down by age, industry, occupation, injury type, and other factors.

TABLE 1-1 Major Causes of Death in 2011

Cause	Death rate per 100,000
1. Diseases of the heart	191
2. Malignant neoplasms	185
3. Chronic lower respiratory diseases	46
4. Cerebrovascular diseases	41
5. Accidents (unintentional injuries)	39
6. Alzheimer's disease	27
7. Diabetes mellitus	24
8. Influenza and pneumonia	17
9. Nephritis, nephrotic syndrome and nephrosis	15
10. Intentional self-harm (suicide)	12

TABLE 1-2 U.S. Unintentional Injury Deaths for 2009

Class	Number of deaths	Percent of total
All classes	**128,200**	**100**
Motor vehicle	35,900	28.0
Public non-work	34,293	26.7
Work	1,407	1.1
Home	200	0.1
Work	3,582	2.8
Non-motor vehicle	2,175	1.7
Motor vehicle	1,407	1.1
Home	65,200	50.9
Non-motor vehicle	65,000	50.7
Motor vehicle	200	0.1
Public	25,100	19.6

Results for 2012 include 4,693 fatal work injuries, the third lowest since the Census of Fatal Occupational Injuries (CFOI) began in 1992. The overall fatal injury rate in 2012 was 3.5 per 100,000 full-time equivalent workers.

Here are a few facts from the 2012 report about work-related deaths:

- 1,789 were transportation related, with 1,044 occurring on roadways.
- 125 involved aircraft incidents.
- 463 were homicides and 225 suicides.
- 668 died from slips, trips, and falls, with 544 from falls.
- 509 resulted from objects or equipment striking people.
- 838 occurred in construction-related occupations.
- 1,150 occurred in transportation and material moving occupations.
- 224 occurred in protective service occupations.
- 245 occurred in farming, fishing, and forestry occupations.
- 429 occurred in management occupations, with 268 in agricultural business.

National Safety Council (NSC) For several decades, the National Safety Council (NSC) has compiled data on accidents, incidents, injuries, illnesses, and deaths. An annual publication provided detailed analysis of the data. For many years the publication title was *Accident Facts*. More recently, the title is *Injury Facts*. This publication breaks down data and analysis into three groups: occupational, motor vehicle, and home and community. Also the publication now reports information on intentional injuries, such as assaults and self-harm. Data come from a variety of sources.

The U.S. population today is four times larger than in 1903. During the same period, the annual number of unintentional deaths has increased from about 70,000 to more than 120,000. The death rate per 100,000 has decreased from about 90 to about 40. This shows some progress, but much preventive work remains.

Table1-2 shows the NSC-reported unintentional injury deaths information for 2009. The data provide a picture of current performance.

NSC also lists the odds of dying (1 in x odds) from various kinds of causes. Table 1-3 provides a sample of data from 2007 for individuals born in that year.

For 2012, NSC reported information about work-related injuries and illnesses. For example, the top three events leading to injuries, the rate per 100,000 workers and median days away from work include:

- Overexertion and bodily reaction (39.8, 12)
- Slips, trips or falls (27.8, 11)
- Contact with object or equipment (25.5, 5).

Also for 2012, NSC reported the five deadliest industry sectors and death rates per 100,000:

- Agriculture (21.2)
- Mining, quarrying, and oil and gas extraction (15.6)
- Transportation and warehousing (13.3)
- Construction (9.5)
- Wholesale trade (5).

TABLE 1-3 Odds of Dying from Various Causes, 2007

Cause of death	Deaths	One-year odds	Lifetime odds
All external causes	185,067	1,628	2
Heart disease			6
Cancer		7	
Stroke			28
Unintentional injury	123,706	2,436	3
Transport accidents	23,706	6,432	83
Motor vehicle accidents	43,945	5,856	88
Non-transport accidents	76,862	3,920	50
Accidental poisoning			30

Similarly, the five deadliest occupations in 2012 were (along with death rates per 100,000):

- Logging workers (127.8)
- Fishers and related fishing workers (117)
- Aircraft pilots and flight engineers (53.4)
- Roofers (40.5)
- Structural iron and steel workers (37).

The above are samples of injury and death statistics. The aim is to illustrate how well or badly modern society is preventing injuries and deaths. While work-related injury and death rates continue to go down, the need remains to ensure that workers and others return home safely each day.

1-4 IMPACT OF CHANGES

Change is constant. The rate of change appears to be increasing, almost accelerating. There are changes in materials, technology, business practices, societal expectations, and governments and elsewhere. Each of these affects people and the risks they face at work and home as well as in travel and recreation. Not everyone will recognize or understand the changes. Not everyone will learn how to deal with the changes. Not everyone will recognize the risks and foresee how to reduce potential harm.

This section will provide a few examples of challenges for safety and health practice.

Materials Changes

Nanomaterials Nanomaterials have emerged recently as a new class of materials. The hazards associated with them are not well known, but studies are starting to track potential hazards. Nanotechnology in general covers engineered structures, devices, and systems that have a length scale between 1 and 100 nanometers. At this size, materials begin to exhibit unique properties that affect physical, chemical, and biological behavior.

Some nanoparticles may be toxic. Early studies show toxicity varying with various chemical and physical properties. Some nanoparticles can penetrate through the skin or move from the respiratory system to other organs. Research is beginning to understand properties leading to specific health effects. Those involved in protecting workers and other from potential harm from nanomaterials must monitor research results. NIOSH continues to publish guidelines[9] for nanomaterials.

Technology Changes

Glucose Measuring Contact Lens Medical diagnostics methods continue to advance rapidly. On January 17, 2014, Google released information about a contact lens-type device that monitors blood sugar levels in the tears of diabetics once per second. The device contains a miniature transmitter that can relay the results continuously to other equipment. The potential value of the instrumentation is high because of the

CASE 1-2

Up to 7,500 gallons of a chemical, 4-methylcyclohexane methanol, leaked from a 40,000 gallon Freedom Industries Inc. storage tank and surrounding dike into the Elk River in Charleston, West Virginia, in the USA. The tank was about a mile and a half upstream from an inlet for the public drinking water of the city and surrounding communities. The water system supplied about 300,000 people. The chemical is used in coal processing. The brick and concrete dike was failing and needed repair. Officials learned of the spill from odor reports, located the source within hours, and took action.

For days the water supply was not useable for drinking, cooking or washing. Officials quickly told all residents affected, but some experienced skin and other problems before understanding the dangers. Local and state agencies quickly trucked in water and set up distribution points.

After five days, the contaminated river water had moved downstream and become diluted. Sampling showed the contaminant levels were below toxic levels or there was no contaminant. The water company then began a process of flushing supply pipes and allowing customers to flush their water pipes to remove any contaminated water. The flushing protocol took several days to avoid excess demand on the supply system. Weeks later, many individuals claimed that risks and resulting health conditions remained. Many people did not trust the public water supply for some time.

Initial studies determined that the facility had not received any inspections from federal or state environmental agencies for years. The chemical was not very hazardous. There were few inspectors and they focused on more hazardous sites. Freedom Industries Inc. had purchased the facility about a month before the spill. Within days of the spill, Freedom Industries filed for bankruptcy.

A few weeks later the federal Centers for Disease Control and Preventions reported that a second chemical made up 5 percent of the contents of the leaking tank. It was polyglycol ethers, PPH, less hazardous than the main chemical.

large and growing number of diabetic patients. Studies will define the hazards for wearers.

Flexible Silicon Patches Researchers have created very thin sheets of silicon that incorporate electronic sensors and circuits. They are flexible and attachable to human skin. They can monitor a range of functions and send information to other equipment.

Wearable Electronics A highlight of the 2014 Consumer Electronic Show was "wearable electronics." One example is the computerized display glasses that present visuals just above the normal eye viewing field. The eyeglasses have a display, camera and computer. The model for the show also handled voice commands from the wearer.

Another wearable device is a smart watch. It handles most of the display and computer applications available for smart phones, but only in a smaller package wearable on a wrist. Newer models will add GPS technology and new kinds of applications. These new technologies may have major applications for safety and health. The devices can help track the physical locations of employees, especially if working in hazardous situations. Potentially, the devices can monitor exposures and warn the wearer of pending danger. The devices can make communication with or between workers easy, using hands-free operation. Monitoring patches and wearable electronics can be a major help for certain safety and health functions.

Driverless Vehicles Another highlight of the 2014 Consumer Electronics Show was the expansion of driverless automobile features. A new term is "autonomous car." A vehicle may operate as a robot using remote control similar to flying drone airplanes. It can automatically maneuver from one location to another in traffic. A vehicle may supplement the limitations of drivers by taking over operations in difficult and frustrating conditions. Audi has produced a Piloted Driving vehicle with front and rear laser to see and monitor traffic and cameras to monitor lane traffic. In addition, the State of Nevada issued a special motor vehicle license to test the autonomous car in real traffic. Such vehicles may help to reduce the high rate of vehicle accidents and resulting injuries and deaths. Such vehicles may allow the operation of vehicles in dangerous off-road mining and materials-handling functions.

Automated Aircraft On July 6, 2013, an Asiana airplane landing at the San Francisco International Airport approached short of the runway. The tail of the plane caught the seawall that extends from the San Francisco Bay water to the end of the runway. With 307 people on board, the plane tumbled and skidded to a stop. Fire trucks sprayed foam extinguishing agent on the emerging flames. In the process the trucks struck two passengers who had been thrown from the plane during the crash. A third passenger died in hospital. Preliminary investigations revealed that the pilot flying the plane had never manually landed a plane of this classification. On this flight an instructor pilot oversaw the work of the pilot.

Part of the problem is that the instrument landing system for that runway was shut down for maintenance. The airport had published the shut-down well in advance through standard aviation channels covering special notices.

Another part of the problem was that large commercial aircraft fly using computer control of the aircraft. Before departure, the crew enters the flight path information onto the airplane computers covering the departure and arrival airports. With automated landing systems, pilots are hands-free.

In addition, preliminary investigations identified that the aircraft's pilot was not trained in manual landing. He was taught how to fly using automated management. The investigation uncovered information that many commercial pilots no longer have experience landing large aircraft manually. Thus, a backup measure may not exist for automated landing systems.

3-D Printing 3-D printing is expanding rapidly as capabilities expand and prices drop. 3-D printers are even available at reasonable prices for home use. 3-D printing allows someone to create an object of any shape with 3-D software and have the object created by a printer. The process often uses a layering approach to build a desired object one thin layer at a time. An object with voids becomes easy to make. The most common medium is plastic. However, 3-D printing with metals is also expanding. There is also 3-D printing of biological materials and creation of artificial tissue that may be replacement organs some day. A safety and health challenge is managing the materials and production of items. Each may have varying degrees of hazards because of the production materials, the size and movement of the printer and its parts, and the hazards of the items produced.

Business Practice Changes

Safety Management Systems (SMS) One of the growing safety strategies is safety management systems. The idea uses an organized process to get an entire company or organization involved in implementing safe practices and achieving effective business and safety goals. The process includes identifying and recognizing hazards and implementing changes to increase safety effectiveness.

Commercial aviation provides an example. International guidelines define how the complexities of aviation operations help achieve safety for employees and travelers. The International Civil Aviation Organization (ICAO) publishes a wide range of standards related to aviation, including aircraft, pilots, operations, and other elements of aviation. The standards include safety management. A recent ICAO

publication[10] spells out the requirements for aviation safety management systems.

International maritime shipping offers another use of safety management systems. The International Maritime Organization publishes the International Safety Management Code.[11] It prescribes a safety management system.

Part V of this book addresses managing safety and health, including safety management systems.

Risk Analysis and Management Strategies Using risk analysis and management is growing in the United States. Chapter 34 addresses risk analysis and risk management in detail.

Many in the safety and health field are familiar with risk management from an insurance perspective. The growth in risk management as a strategy for controlling hazards stems in part from countries outside the United States. It represents a change in approach.

To a great extent, laws, regulations, and standards drive safety and health practices in the United States. It is a *prescriptive* approach. Standards and regulations prescribe how to achieve safety, and enforcement focuses on compliance with the standards and regulations.

A different approach emerged some time ago from legislative action in the United Kingdom and this has spread to other Commonwealth and European countries. Chapters 5 and 34 provide more details. The concept requires employers, manufacturers and others to identify and evaluate the risks of their workplaces, products, and processes. They must then act to eliminate, reduce, and control the risks. Governments do not have to prescribe in detail how to achieve safety through standards and regulations. This is a *performance* approach. Enforcement focuses on how well responsible parties can identify and mitigate risks.

Many employers and manufacturers in the United States will use both approaches concurrently. The latter emphasizes a comprehensive analysis of hazards and a clear definition of which controls should be in place. Prescriptive standards and regulations may not always cover the unique situations of specific employers, manufacturers, and processes.

Societal Expectations

Most people do not understand the technologies they use every day and the associated risks. They depend on designers, producers, government agencies and others to protect them from potential harm. If there is public fear and increased knowledge about a hazard, special interest groups may advocate for better protection. Otherwise, there may be little public input.

Over the years, there are many examples of changes that have stimulated public pressure for actions at many levels. Here are just a few examples:

- The industrial revolution created a public outcry for greater protection of workers. The famous novel by Upton Sinclair, *The Jungle*, was one publication that had significant influence on increased safety for workers. Changes in manufacturing occurred in most developed countries. However, as the story about clothing manufacturing in Bangladesh (Case1-1) shows, dangers from the industrial revolution are still present.
- An increased focus on protecting the environment resulted from the book by Rachel Carson, *Silent Spring*. In the 1960s and earlier, engineering education often referred to materials that remained after achieving a desired product as "byproducts." Companies considered most byproducts as waste. Public pressure has changed how engineers handle the excess materials used in production.
- With the expansion of nuclear power throughout the United States after WWII through the "Atoms for Peace" program, the public felt a concern for risks from radiation. One result was the creation of a federal agency to oversee the safety of nuclear power plants (the Nuclear Regulatory Commission). It became separate from the agency promoting and overseeing nuclear energy, now part of the U.S. Department of Energy. Later nuclear disasters at Three Mile Island, Pennsylvania, and Chernobyl, in Ukraine, increased public concerns about radiation.
- The chemical leaks at Love Canal near Niagara Falls, NY, gained a lot of national media attention. That led to a public outcry to clean up chemical waste sites, and the creation of the federal "Superfund." A national cleanup program for hazardous waste sites resulted.
- In 1989, there was an "Alar Scare." Alar is a chemical used in the apple industry. The U.S. Department of Agriculture, responsible for agricultural safety and health, approved the use of the chemical. Later, studies suggested that it was a carcinogen. The public outcry led to litigation. The courts ruled Alar as unacceptable.
- Today, an agricultural issue involves DNA-altered, genetically engineered food crops. Some countries have banned such products from their markets. Using biology to alter crops to increase yield, improve product handling and shelf life and to add desirable properties is a relatively new area of science. Cross-breeding of plants to gain desirable properties has been practiced for decades. By using DNA modifications, the change process is faster and offers more choices. However, we know little about the long-term effects of genetically engineered plant development procedures. Thus, there is public concern.

Government Changes

Various levels of governments have responsibilities to protect the safety, health, and welfare of its citizens. The responsibility varies with each level of government. Included are setting regulations, enforcing the regulations, and responding to dangerous situations.

Enforcement Resources and Division of Responsibilities The 2013 chemical spill in the Elk River near Charleston, West Virginia (Case1-2), illustrates some difficulties for governments and potential gaps in responsibilities. According to reports, the storage facility did not fall under a special emphasis program of OSHA, so that agency did not inspect it. The material was not an official "hazardous materials" of the U.S. Environmental Protection Agency. As a result, the West Virginia Department of Environmental Protection did not inspect the site due to limited inspection staff. Because the site was only a storage site and no longer manufactured chemicals, it did not need permits to discharge pollutants into the air or water. The state last visited the site in 1991 when it was a refinery operated by an earlier owner. The West Virginia American Water company, which took water from the river to supply the area, learned of a problem after receiving odor complaints.

Community Burden For some communities, the protection of its citizens is an overwhelming burden. Consider the challenge to first responders in small communities. The railroad created many small towns in the nineteenth century. They needed goods to haul. Some with mainlines will have 100,000 or more rail cars containing hazardous materials traveling through every year. Should there be a derailment or other incident involving a leaking car, the local volunteer fire department as a first responder must be able to identify the material released. Firefighters must wear appropriate protective clothing during a response. Many communities do not have the money to buy all the possible protective clothing necessary for each class of hazardous material.

1-5 DESIGNING TO ACHIEVE SAFETY

Prevention through Design is a movement that seeks to emphasize engineering design to eliminate or reduce hazards. Designs may involve structures and building materials that simplify construction or make the construction sequences safer. They may seek to prevent structural failure. Designs may involve changes to machines and equipment. Designs may involve new or revised processes. The concept has been around for a long time. It has been adopted once more as a theme for safety and health.

Engineering Revision

In 1925, the National Safety Council's College Committee gave a report at the Annual Congress. The title of the report was "Accident Prevention and the Engineer." The report focused on two ways to prevent accidents: education and the elimination of hazards. The report stated that the two go hand in hand and are inseparable. The authors described two approaches to eliminate hazards. One involved "safeguards" that are accessory devices and not integral parts of machines themselves.

The second approach was *engineering revision*. Engineering revision involves redesigning operations, processes, and equipment to eliminate or reduce hazards. Engineering revision goes beyond education and the application of safeguards. Engineering revision is the same concept as prevention through design.

The presentation continued by challenging engineering colleges to include safety in design courses of all engineering disciplines. The challenge came from a report of the Safety Committee of the Society for the Promotion of Engineering Education.

Prevention through Design (PtD)

One primary role for engineers in achieving safety is *prevention*. The role requires recognition of hazards and applying designs that eliminate and reduce hazards. This focus on designing for safety has increased in the last decade or so.

Why is this significant? The concept teaches engineers the primary responsibility they have in design as stated in codes of ethics. One impetus resulted from the 2007 National Institute for Occupational Safety and Health (NIOSH) workshop on "Prevention through Design." NIOSH now refers to this emphasis program with an acronym, PtD.[12]

The NIOSH symposium followed an earlier conference in 1998 that led to a book on the topic.[13] In 2011, the American Society of Safety Engineers published a standard on Prevention through Design.[14] ASSE and NIOSH conducted a symposium on the issue in 2011.[15]

Somehow the importance of safety through engineering design had lost visibility over the years. Today, the report of 1925 has regained momentum and attention under Prevention through Design (PtD). Engineering design continues to play a very important role in protecting people, property and the environment.

EXERCISES

1. Find out which countries have high life expectancies. Which have low life expectancies?

2. Find out the values government agencies, state workers' compensation standards, insurance companies or organizations and legal associations place on human life.
3. Obtain the code of ethics from several professional groups. Identify what importance each places on protecting people, property, and the environment.
4. Obtain information on the American Chemical Society "Responsible Care" program. Identify which features help assure safe management of dangerous chemicals for workers and for communities.
5. Obtain the Corporate Social Responsibility statements and action plans of several corporations. Complete a comparative analysis of them to identify the importance placed on safety and health.
6. Obtain examples of company sustainability statements. Visit the website for the Center for Safety and Health Sustainability. Determine if company statements include a focus on safety and health.
7. Identify some "standards of practice" in individual engineering fields for specific hazards and their controls. Talk to craftsmen to see what standards of practice they use in certain tasks to prevent injuries.
8. Locate the injury and death statistics published by the Bureau of Labor Statistics, the CDC, and the National Safety Council for the last four years. Discuss the significant findings and trends found in these statistical sources.
9. Identify technological, business, and government changes and their potential impact on safety and health. Consider the hazards introduced, the user knowledge requirements for effective use of the changes, and new kinds of controls needed.
10. Monitor three freight trains containing tank cars. Record the placard number appearing on each car. From government placarding standards, identify what the contents are for each car. Discuss the risks for each type of contents for a community should there be a derailment and resulting leaking cars.

REVIEW QUESTIONS

1. How many chemical substances does the *CAS Registry* contain today? How many are in use?
2. What are the three main reasons for safety? Give examples for each of the three reasons.
3. Which organization introduced the "Responsible Care" program?
4. What is CSR?
5. What are the three main elements of sustainability? Which element encompasses safety and health?
6. Name sources for unintentional injury statistics:
   (a) Worldwide.
   (b) In the United States.
7. How many unintentional injury deaths occur each year in the United States? Which of the following categories has the most? The least?
   (a) work
   (b) home
   (c) vehicles
   (d) recreation
8. What is the approximate annual cost of injuries in the United States? Worldwide?
9. What are two of the five deadliest industry sectors? Two of the deadliest occupations?
10. Describe nanomaterials and their potential impact on safety and health.
11. Which federal agency is the best source of research information on the impact of nanomaterials on safety and health?
12. Explain the basic difference between a prescriptive approach to safety and health regulation and a performance approach.
13. What is "engineering revision?"
14. Explain "Prevention through Design" (PtD). Which organizations have conducted symposiums on this topic?

NOTES

1 *CAS Registry*, Chemical Abstract Service, a Division of the American Chemical Society, Columbus, OH, updated daily.

2 www.nspe.org/resources/ethics/code-ethics

3 www.centershs.org/

4 www.ilo.org

5 www.airlineratings.com

6 http://easa.europa.eu/communications/docs/annual-safety-review/2013/EASA-Annual-Safety-Review-2013.pdf

7 www.cdc.gov/injury/index.html

8 ww.bls.gov/iif/

9 U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational

Safety and Health, *Current Strategies for Engineering Controls in Nanomaterial Production and Downstream Handling Processes*, Cincinnati, OH, DHHS (NIOSH) Publication No. 2014–102, November 2014.

10 *Safety Management Manual*, Document 9859, 2nd ed., ICAO, Montreal, Quebec, 2009.

11 www.imo.org/OurWork/HumanElement/SafetyManagement/Pages/ISMCode.aspx

12 www.cdc.gov/niosh/topics/ptd/

13 Wayne C. Christensen and Fred A. Manuele, *Safety through Design*, Washington, DC, National Safety Council, 1999.

14 ANSI/ASSE Z590.3-2011, *Prevention through Design: Guidelines for Addressing Occupational Risks in Design and Redesign Processes*, 2011.

15 www.asse.org/professionalaffairs_new/ptd.php

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SINCLAIR, U. *The Jungle*, Doubleday, New York, 1906.