Section 1

Introduction and Background
Outcome Competencies

After completing this chapter, the user should be able to:
1. Define underlined terms used in this chapter.
2. Describe the contribution of key individuals in the development of the occupational hygiene profession.
3. Explain the role that the history of civilization plays in the development of the occupational hygiene profession.
4. Discuss the role of governmental entities in the history of occupational hygiene.
5. Describe how the public health profession relates to occupational hygiene.
6. Implement the code of ethics in the practice of occupational hygiene.
7. Explain the occupational hygiene paradigm of anticipate, recognize, evaluate, and control.
8. Recognize the conflicts around, “whom do we serve?”

Key Terms

Agricola • American Academy of Industrial Hygiene • American Board of Industrial Hygiene • American Conference of Governmental Industrial Hygienists • American Industrial Hygiene Association • certified industrial hygienist • Code of Professional Ethics for the Practice of Industrial Hygiene • Ulrich Ellenbog • Dr. Alice Hamilton • Benjamin W. McCready • Mine Safety and Health Administration • National Institute for Occupational Safety and Health • Occupational Safety and Health Act • Occupational Safety and Health Administration • permissible exposure limits • Pliny the Elder • Sir Percival Pott • Bernardino Ramazzini • Charles T. Thackrah • threshold limit values

Prerequisite Knowledge

None

Key Topics

I. Origins of Industrial Hygiene
II. The U.S. Experience
   A. Recognition
   B. Evaluation
   C. Control
   D. Education and Professional Organizations
III. Public Health Roots
IV. Professional Recognition
V. Professional Code of Ethics
VI. Whom Do We Serve?
Origins of Industrial Hygiene

As with most professions, identifying the origin of the practice of industrial hygiene is difficult, if not impossible. Might we designate as founders of the profession the early chroniclers of occupational hazards and control measures such as Agricola, who, in 1556, described the prevalent diseases and accidents in mining, smelting, and refining and prevention measures including ventilation? In that case, the contributions of Plinius Secundus (Pliny the Elder) should also be considered, who, in the first century AD, wrote “minimum refiners . . . envelop their faces with loose bladders, which enable them to see without inhaling the fatal dust.” If their works were read, thus influencing others to control work hazards, they deserve the title, at least posthumously, of industrial hygienists.

But what of those who simply identified problems? It has been suggested that a special honor in the field of occupational medicine is owed to Hippocrates (c. 460–370 BC). His writings include the first recorded mention of occupational diseases (e.g., lead poisoning in miners and metallurgists) and provide more frequent allusions to this class of ailments than those of any other author prior to Ramazzini.

In 1713, Bernardino Ramazzini published the first book that could be considered a complete treatise on occupational diseases, De Morbis Artificum Diatribal. From his own observations he accurately described scores of occupations, their hazards, and resulting diseases. Although he recommended some specific as well as general preventive measures (workers should cover their faces to avoid breathing dust), most of his control recommendations were therapeutic and curative. While he had a vast knowledge of the literature of his time, it has been suggested that many of the works he cited were of questionable scientific validity, and some were more myth than science and should have been recognized as such even in Ramazzini’s time. Because of his prestige these “fanciful notions must have received wide acceptance . . . and because his book was so admired, Ramazzini’s influence may have stifled progress in his field during a period when great advances were being made in other branches of medicine.”

Nevertheless, his cautions to protect workers and his admonition that any doctor called on to treat patients of the working class ask “What occupation does he follow?” earned him the appellation “Father of Industrial Medicine.”

For more than 100 years following Ramazzini’s work, no significant additions to the literature on occupational medicine were published. In the nineteenth century two physicians, Charles T. Thackrah in England and Benjamin W. McCready in America, began the modern literature on the recognition of occupational diseases. McCready’s book, On the Influence of Trades, Professions, and Occupations in the United States, in the Production of Disease, is generally recognized as the first work on occupational medicine published in the United States.

The recognition of a causal link between workplace hazards and disease was a key step in the development of the practice of industrial hygiene. The observations by physicians, from Hippocrates to Ramazzini and extending into the twentieth century, of the relationship between work and disease...
are the foundation of the profession. But recognition of hazards without intervention and control, i.e., without prevention of disease, should not qualify one as an industrial hygienist.

The crystallization of the practice of the profession can be traced to simultaneous developments in Great Britain and the United States in the late nineteenth and early twentieth centuries. While legislation controlling working conditions was enacted in England beginning in 1802, the early laws were considered totally ineffective, as “no proper system of inspection or enforcement was provided.” The British Factories Act of 1846, however, required the use of dilution ventilation to reduce air contaminants, while the 1878 version specified the use of exhaust ventilation by fans. The real watershed in industrial medicine and hygiene, however, came in the British Factories Act of 1901, which provided for the creation of regulations to control dangerous trades. The development of regulations created the impetus for investigation of workplace hazards and enforcement of control measures. In the United States in 1905, the Massachusetts Health Department appointed health inspectors to evaluate dangers of occupations, thus establishing government’s role in the nascent field of occupational health.

It has been suggested that industrial hygiene did not “emerge as a unique field of endeavor until quantitative measurements of the environment became available.” But in 1910 when Dr. Alice Hamilton went, in her own words, “as a pioneer into a new, unexplored field of American medicine, the field of industrial disease,” worker exposures to many hazards (e.g., lead and silica) were so excessive and resulting diseases so acute and obvious, the “evaluation” step of industrial hygiene practice required only the sense of sight and an understanding of the concept of cause and effect. This “champion of social responsibility” for worker health and welfare not only presented substantial evidence of a relationship between exposure to toxins and ill health, but also proposed concrete solutions to the problems she encountered. On an individual basis, Dr. Hamilton’s work, which comprised not only the recognition of occupational disease, but the evaluation and control of the causative agents, should be considered as the initial practice of industrial hygiene, at least in the United States.

It should be appreciated that many of the early practitioners of industrial hygiene were physicians who, like Alice Hamilton, were interested not only in the diagnosis and treatment of illnesses in industrial workers, but also in hazard control to prevent further cases. These physicians working with engineers and other scientists interested in public health and environmental hazards took the knowledge and insights developed over several millennia from Hippocrates to Ramazzini, Thackrah and McCready, and began the process of deliberately changing the work environment with the goal of preventing occupational diseases.

What or who then can be designated as representing the origin of the profession? Is there any one person who deserves the title “Founder of Industrial Hygiene”?

Certainly, if the name of one individual is sought, that of Alice Hamilton shines like a beacon. But think back to more than 10,000 years ago at the end of the Stone Age, when occupations began to form with the grinding of stone, horn, bone, and ivory tools with sandstone, and with pottery making and linen weaving. Envision a thoughtful worker who suffered from the musculoskeletal problems associated with grinding, made adjustments to his working conditions, and passed the ideas on to co-workers. Recognizing ergonomic problems and solving them would qualify him as an early industrial hygiene practitioner. If that scenario can be imagined, perhaps it is also conceivable that tens of thousands of years ago there was a huntress who recognized the signs and symptoms of anthrax in the bison her group had killed and who made the connection between earlier kills of diseased animals and sickness in members of her tribe. If she then warned her companions of the hazard involved and sought to avoid diseased animals, would she not qualify as one of the founders of the industrial hygiene profession?

If the basic philosophy of the profession is understood—protection of the health and well being of workers and the public through anticipation, recognition, evaluation, and control of hazards arising in or from the workplace—then the rich tapestry that chronicles the history of industrial hygiene can be imagined. It began when one person recognized a work hazard and took steps not only for self protection, but also for protection of fellow workers. This is the origin and essence of the profession of industrial hygiene.

The U.S. Experience

The events presented in Table 1.1 illustrate the history of industrial hygiene. While the concepts that formed the art and
The science of industrial hygiene flourished in many countries, the United States provided the fertile ground for the development of the profession as it exists today.

As the industrial revolution, propelled by the Civil War, progressed in the nineteenth century, individuals began to observe serious health and safety problems (recognition). They also considered the effects on workers (evaluation) and made changes in the work environment (control) to lessen the effects observed. Although these efforts may have resulted in improved worker health and safety, their application was not recognized as the practice of industrial hygiene until the early 1900s. In addition to a chronological listing, these activities also illustrate the concepts of the profession—i.e., recognition, evaluation, and control—which may help to better describe today's practice of industrial hygiene.

**Recognition**

Recognition, as well as anticipation, of the potential for occupational health problems is a prerequisite for the implementation of occupational hygiene activities. Therefore, early attempts at defining the scope and magnitude of occupational health problems were very important to the subsequent efforts of evaluation and control. The Illinois Occupational Disease Commission’s survey of the extent of occupational health problems in the state of Illinois in 1910 was the first such survey undertaken in the United States. Dr. Alice Hamilton was a member of that commission and served as its chief investigator. Two years later she presented her survey of lead hazards in American industry. Although other states formed commissions to identify problems, it was many years before there was an organized effort to develop information as to the scope of the industrial health problems in the working population in America.

The Division of Industrial Hygiene in the United States Public Health Service (USPHS), later to become the National Institute for Occupational Safety and Health (NIOSH), revived interest in assessing the extent of health hazards. Beginning in the 1960s the USPHS conducted surveys in a number of states and metropolitan areas for the purpose of identifying the extent of worker exposure to occupational health hazards. The results of these studies were used to determine the need for occupational health specialists in the governmental agencies and for setting priorities for government inspection and consultation.

**Table 1.1 — Historical Events in Occupational Health and Safety**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>1,000,000 BC</td>
<td>Australopithecus used stones as tools and weapons. Flint knappers suffered cuts and eye injuries; bison hunters contracted anthrax.</td>
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<tr>
<td>10,000 BC</td>
<td>Neolithic man began food-producing economy and the urban revolution in Mesopotamia. At end of Stone Age, grinding of stone, horn, bone, and ivory tools with sandstone; pottery making, linen weaving. Beginning of the history of occupations.</td>
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<tr>
<td>5000 BC</td>
<td>Copper and Bronze Age—metal workers released from food production. Metallurgy—the first specialized craft.</td>
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<tr>
<td>370 BC</td>
<td>Hippocrates dealt with the health of citizens, not workers, but did identify lead poisoning in miners and metallurgists.</td>
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<tr>
<td>50 AD</td>
<td>Plinius Secundus (Pliny the Elder) identified use of animal bladders intended to prevent inhalation of dust and lead fume.</td>
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<tr>
<td>200 AD</td>
<td>Galen visited a copper mine, but his discussions on public health did not include workers’ disease.</td>
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<tr>
<td>Middle Ages</td>
<td>No documented contributions to the study of occupational diseases.</td>
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<tr>
<td>1473</td>
<td>Ellenbog recognized that the vapors of some metals were dangerous and described the symptoms of industrial poisoning from lead and mercury with suggested preventive measures.</td>
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<tr>
<td>1500</td>
<td>In De Re Metallica (1556), Georgius Agricola described every facet of mining, smelting and refining, noting prevalent diseases and accidents, and means of prevention including the need for ventilation. Paracelsus (1567) described respiratory diseases among miners with an excellent description of mercury poisoning. Remembered as the father of toxicology. “All substances are poisons . . . the right dose differentiates a poison and a remedy.”</td>
</tr>
<tr>
<td>1665</td>
<td>Workday for mercury miners at Idria shortened.</td>
</tr>
<tr>
<td>1700</td>
<td>Bernardino Ramazzini, “father of occupational medicine,” published De Morbis Artificum Diatriba, (Diseases of Workers) and examined occupational diseases and “cautions.” He introduced the question, “Of what trade are you?”</td>
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<tr>
<td>1775</td>
<td>Percivall Pott described occupational cancer among English chimney sweeps, identifying soot and the lack of hygiene measures as a cause of scrotal cancer. The result was the Chimney-Sweeps Act of 1788.</td>
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<tr>
<td>1830</td>
<td>Charles Thackrah authored the first book on occupational diseases to be published in England. His views on disease and prevention helped stimulate factory and health legislation. Medical inspection and compensation were established in 1897.</td>
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<tr>
<td>1900s</td>
<td>Dr. Alice Hamilton investigated many dangerous occupations and had tremendous influence on early regulation of occupational hazards in the United States. In 1919 she became the first woman faculty member at Harvard University and wrote <em>Exploring the Dangerous trades</em>.</td>
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These studies were used by NIOSH to set priorities for research and for developing recommended standards.

Concurrent with the development of occupational hazard information was the recognition that information on the incidence of occupational illnesses in the U.S. work force was not available. Prior to the passage of the Occupational Safety and Health Act (OSH Act) in 1970, the sources of occupational disease incidence data were limited primarily to the information developed in several state health and labor departments such as California, New York, and Michigan. The California reports of occupational illnesses were thought to be the most comprehensive and reliable; consequently, they were often used for projections of the national problem. The passage of the OSH Act gave the U.S. Department of Labor the responsibility for developing a national occupational injury and illness reporting system. The system includes a requirement that employers record occupationally related injuries and illnesses with separate categories for dermatitis, lung disorders due to dusts, lung disorders due to chemicals, systemic effects, physical agent disorders, repeated trauma disorders, and “all other” illnesses. A sample of employers report their experience, which is used to develop state and national estimates. For many years skin disorders were the most frequently reported illnesses, but in the late 1980s repeated trauma, which includes musculoskeletal problems such as carpal tunnel syndrome and back disorders, became the leading category of illness.

It is widely recognized that occupational diseases are underreported in this system for a variety of reasons beyond a conscious decision not to record. Many occupationally related diseases can also be caused by nonoccupational exposures (e.g., lung cancer and tobacco). Also, when a disease has a long latency period before it can be diagnosed, its relationship to early work exposures may be obscure. In some cases work factors may worsen a preexisting condition. And, as a relatively new discipline, the recognition of workplace illnesses can be hampered by a limited knowledge base. It is unlikely that a worker’s illness will be recognized as work related if epidemiologic or toxicologic studies have not documented cause and effect, i.e., exposure to a toxin and illness.

Concurrent with studies to estimate hazard distribution and incidence of occupational illness were specific epidemiologic studies designed to link cause and effect. Two key studies firmly established the reference.
specialty of occupational epidemiology first practiced by Sir Percival Pott in the late eighteenth century. One study could be considered an extension of his work, which linked a byproduct of coal combustion (soot) with scrotal cancer in chimney sweeps. In the twentieth-century study, the epidemiologists who looked at the mortality distribution of U.S. steelworkers found a population whose health was better than expected when compared with the overall U.S. population (the healthy worker effect). However, when subpopulations, specifically coke oven workers, were considered, excesses of respiratory and kidney cancer deaths were uncovered. The complexity of environmental exposures surrounding these workers precluded the identification of any one specific causative agent and led to the designation of coal tar pitch volatiles (CTPV) as the surrogate hazard to be controlled. Documentation of excess mortality in coke oven workers led to promulgation of the Occupational Safety and Health Administration (OSHA) regulation on coke oven emissions.

The second major occupational epidemiologic study focused on asbestos. Reports of cases of lung disease due to asbestos exposure began to accumulate beginning in 1906. By 1938 the USPHS had studied workers in asbestos textile plants and had recommended a tentative limit for asbestos dust in the textile industry of 5 million particles per cubic foot (mp/ft³), determined by the impinger technique. In the late 1940s workers manufacturing asbestos products in England were observed to have a frequency of bronchogenic cancer greater than that expected as compared with the general male population. These findings led to the study of U.S. insulation workers exposed to airborne asbestos fibers and the documentation of an excess of bronchogenic cancers in this population. These and other studies led to the promulgation of OSHA’s first emergency temporary standard in 1971 and first complete health standard in 1972. The hazards of asbestos also firmly established the toxic tort (product liability) lawsuits as a force to control workplace hazards.

In occupational epidemiologic studies, one test for concluding the existence of cause and effect is the presence of an exposure-response relationship. When industrial hygiene exposure data are not available, substitute measures such as “high, medium, and low” are relied on. However, where historical exposure data are available or can be estimated, risk-assessment evaluation can be more objective and lead to occupational exposure limits that define the expected reduction in the incidence of illness. Use of risk-assessment tools to estimate illness reduction from lowering workplace exposure limits has been applied by OSHA since the benzene standard was promulgated in 1987.

At the present time, occupational hygiene efforts in the United States are guided by hazard rather than disease considerations. At the national and state levels, information on worker exposure to hazards by various industry categories is available and is used to set priorities for governmental investigations and research. Within industry, the concept of hazard recognition vis-a-vis illness is seen as important in developing programs that focus on prevention. Consequently, the emphasis on anticipation and recognition of potential occupational health problems primarily involves the industrial hygiene practice of hazard determination, where hazard combines the inherent toxicity of a substance or agent and the likelihood for exposure.

**Evaluation**

Although the use of the senses, including sight, smell, and sometimes taste, were important in the early years of the practice of industrial hygiene, the transition to a science required the development of more sophisticated sampling methods to aid in the evaluation of problems. One of the first such sampling methods, developed by researchers at Harvard University in 1917, was the detector tube (color-indicating device) for measuring airborne levels of carbon monoxide. Dust exposure in mining and other industries was an early industrial hygiene concern and generated the need to measure airborne concentrations of particulates. In 1922 Greenberg and Smith developed their impinger, and in 1938 Littlefield and Schrenk modified the design and developed the midget impinger. The subsequent development of the hand-operated pump for dust sampling with midget impingers gave the industrial hygienist flexibility in collecting breathing zone samples to better characterize occupational exposures. The associated analytical method of counting and sizing particles with a microscope, thus yielding concentrations of million particles per cubic foot, was the standard method for characterizing particulate exposures until the application of the membrane filter in 1953 allowed exposures to be evaluated on a mass per volume basis.
The early application of impingers, using water as the collection medium, was for dust sampling. Gas and vapor monitoring required the development of a variety of sampling media for use in midget impingers and later in the more efficient fritted-glass bubblers. In 1970 a major breakthrough in sampling methodology occurred when NIOSH developed the charcoal sampling tube and provided support for development of the battery-operated pump. Concurrent with the development of these active sampling devices was Palmes’ work in 1973 on a passive dosimeter for nitrogen dioxide. Subsequent commercialization of the passive dosimeter concept led to a modest revolution in the scope of industrial hygiene sampling. These technological developments greatly enhanced the art of personal sampling and allowed the industrial hygienist even greater flexibility in characterizing worker exposure to hazardous conditions.

At the same time sampling methods were being developed, the application of new analytical technology to industrial hygiene assessments was taking place. In the early 1930s technical articles described the use of gas chromatography for evaluating samples of airborne organic vapors. In later years other forms of technology were employed at a rapid pace. Today hygienists use atomic absorption, high pressure liquid chromatography, mass spectroscopy, and other sophisticated instrumentation and techniques.

As industrial hygienists learned more about the environment and further refined their techniques for measuring hazardous exposures in the workplace, the need to compare measurements with unacceptable exposure levels became apparent. In 1929 several industrial hygienists in the USPHS recommended upper limits for exposure to quartz-bearing industrial dusts based on studies in the Vermont granite industry. The publication of workplace exposure limits was greatly enhanced by the formation of the American Conference of Governmental Industrial Hygienists (ACGIH) in 1938. In 1939 ACGIH, in cooperation with the American Standards Association, developed the first list of maximum allowable concentrations (MACs) to limit worker exposure to airborne contaminants. In 1943 Dr. James Stermer published the MAC list in Industrial Medicine, followed by Warren Cook’s publication (also in Industrial Medicine) in 1945 of a MAC list for 140 substances with sources and bases for the recommendations. In 1947 ACGIH began publication of its MAC list, and converted to the term threshold limit values (TLVs) in 1948. Today, even with major responsibility for standards-setting vested with the federal government, the role of ACGIH in developing exposure guidelines is a valuable tool in protecting the health of workers.

**Control**

Control of occupational health problems can take several forms. Industrial hygienists most often employ the technological approach, i.e., engineering measures such as substitution with less hazardous substances or local exhaust ventilation. Where these techniques cannot eliminate or reduce the hazard sufficiently, administrative measures and personal protective equipment are also relied on. These concepts, which can also be reshuffled to the categories of control “at the source, in the environment, and at the worker,” were first introduced, in a comprehensive form, in 1473 by Ulrich Ellenberg. He suggested three methods of control still applied today: use dry coal instead of wet coal to avoid production of toxic “fumes,” work with windows open, and cover the mouth to prevent inhalation of noxious “fumes.” The history of two specific control measures, industrial ventilation and respirators, should be of special interest to practicing industrial hygienists. Agricola in his 1561 publication De Re Metallica, emphasized the need for ventilation of mines and included many illustrations of devices to force air below ground. The first recorded design of a local exhaust ventilation system, however, was by the Frenchman D’Arcet in the early 1800s. To control noxious fumes he led an exhaust duct from a hood at a furnace into a chimney that had a strong draft. The induced airflow carried the fumes away from the source.

The British window tax of 1696, which was not repealed until 1851, resulted in dark and underventilated factories. The first legislation regulating conditions in factories was the British Factory and Workshops Act of 1802, which required ventilation in workplaces. The Act of 1864 required sufficient ventilation to render gases and dusts as harmless as possible, but it was not until 1867 that an inspector was given authority to require fans or other mechanical devices to control dust. Although the British Factories Act of 1897 required the use of ventilation for certain operations, little was published on techniques until the late 1930s. It has been suggested that the main reasons for the lack of published information probably were “attempts on the part of industry to keep...
their trade secrets, and the lack of interest on the part of universities and colleges.

In 1951 ACGIH published the first edition of *Industrial Ventilation: A Manual of Recommended Practice*. The manual, now in its 22nd edition, is a compilation on design, maintenance, and evaluation of industrial exhaust ventilation systems. The manual has found wide acceptance as a guide for official agencies, as a standard for industrial ventilation designers, and as a textbook for industrial hygiene courses.

As noted earlier, the concept of respiratory protective devices (e.g., animal bladders) to reduce exposure to airborne contaminants dates back to at least 50 AD. There is no record of worker acceptance of these early respirators nor of their effectiveness as personal protective devices, but in all likelihood they did not score high in either category. The same can probably be said for other devices that have fallen by the wayside over the centuries: scarves, shawls, handkerchiefs, magnetic mouthpieces, magnetized screens, wet sponges, and breathing tubes. It should come as no surprise that Leonardo da Vinci (1452-1519) considered the problems of respiratory protection when he recommended the use of a wet cloth to protect against chemical warfare agents. He also devised two underwater breathing devices, one being a snorkel consisting of a breathing tube with an attached float. Ramazzini wrote a critical review of the inadequate respiratory protection available in his time (c. 1700).

Shortly thereafter, the first descriptions appeared of the ancestors of today’s atmosphere-supplying devices, such as open- and closed-circuit self-contained breathing apparatus and hose masks.

In the 1800s the realization of the separate natures of particles and gases or vapors led to great advances in respirators. In 1814 a particulate-removing filter encased in a rigid container was developed and was the predecessor of modern filters for air-purifying respirators. The ability of activated charcoal to remove organic vapors from air was discovered in 1854 and was almost immediately put to use in respirators. The most rapid advances in respiratory protection grew out of the use of chemical warfare agents in World War I. Research on gas sorbents for use in military masks and high efficiency particulate filters was accelerated by the introduction of different gases and highly toxic particulate matter on the battlefield. Since the 1920s the major advances in respirator design include resin-impregnated dust filters, which use electrostatic force fields to remove dust particles from air, and the ultra high-efficiency filter from paper containing very fine glass fibers. Other advances include the use of more flexible and durable (plastic) materials for facepieces, and the combination of a battery-operated air mover with a respirator for use as a lightweight air-supplied respirator (i.e., the powered air purifying respirator).

A different approach to control involves the application of governmental powers to assist, motivate, and require employers to maintain safe and healthful work environments. In the United States, legal protection of industrial workers was, until 1971, the responsibility of state and local governments. The development of state governmental responsibilities in occupational health took place as early as 1905, when inspectors in the Massachusetts Health Department investigated workplace dangers. In 1913 the first formal governmental program, the New York Department of Labor’s Division of Industrial Hygiene, was established. In 1914 the Office of Industrial Hygiene and Sanitation was formed in the USPHS and subsequently underwent many reorganizations before becoming NIOSH in 1971.

During the 1920s and early 1930s industrial hygiene activities were initiated in five state health departments (Connecticut, Maryland, Mississippi, Ohio, and Rhode Island). The Social Security Act of 1935 made federal resources (money and industrial hygienists) available to states to aid in the development of industrial hygiene programs. By 1936, 12 more state health department programs were initiated, and the USPHS recommended that a “large industrial state” should have at least one chief industrial hygienist with a salary of $6,000. The minimum qualifications of this specialist called for a chemical engineering degree, two years’ graduate work in
World War II provided significant impetus for the development of state and local government industrial hygiene programs. By 1946, 52 programs were operational in 41 states; however, the withdrawal of federal resources after the war led to a steady decline in both number and activity of these programs. By the late 1960s, while there were a number of states with programs, most involved only one or two professionals. The exceptions to this situation were found in the large industrial states such as Massachusetts, New York, Pennsylvania, Michigan, and California.

As in most countries, national legislation to control hazards in the workplace first focused on mining. The U.S. Bureau of Mines was established shortly after the turn of the century, but it was not until 1941 that the Bureau was authorized to conduct inspections in mines. A number of mining tragedies in the mid-1960s led to the passage of the Metal and Nonmetallic Mine Safety Act and the Coal Mine Safety and Health Act in 1966 and 1969, respectively. These mining laws were superseded by the comprehensive Mine Safety and Health Act of 1977. This law created the Mine Safety and Health Administration (MSHA) within the U.S. Department of Labor. MSHA regulates and conducts inspections in mines and related industries.

Federal safety and health activities in general industry were not initiated until passage of the Walsh-Healey Public Contracts Act in 1936. This legislation authorized federal occupational safety and health standards for government contractors. The Department of Labor adopted existing American Standards Association (now the American National Standards Institute, or ANSI) safety and health standards and the ACGIH TLVs as Walsh-Healey standards.

In the late 1960s the U.S. Congress became concerned with the comprehensive problem of occupational safety and health in the workplace. A number of congressional hearings resulted in the documentation of the seriousness of workplace deaths, injuries, and illnesses, and the lack of consistent and comprehensive safety and health programs at the state and local level to prevent such problems.

Consequently, the Occupational Safety and Health Act was passed in 1970 and created OSHA within the U.S. Department of Labor and NIOSH in the Department of Health and Human Services. OSHA was given the responsibility to promulgate standards and conduct inspections in most workplaces, while NIOSH was to conduct research and recommend health and safety standards to OSHA.

The initial health standards adopted by OSHA were the existing Walsh-Healey standards. These included the 1968 ACGIH Contaminants standard. This reduced new regulation amending its existing Air quality standard. OSHA promulgated comprehensive health standards for a variety of chemicals including asbestos, benzene, coke oven emissions, and lead. In addition to a PEL, these comprehensive standards include requirements such as medical monitoring, administrative control measures, respirator selection, training, and record keeping.

Challenges to the regulation of two hazards ultimately led to U.S. Supreme Court decisions on the need for OSHA to quantify risk reduction and the cost-benefit of its regulatory actions. OSHA’s 1978 regulation to reduce the PEL for benzene from 10 to 1 ppm was remanded by the Court because of its belief that OSHA did not justify that the PEL reduction would substantially reduce the risk to the health of exposed workers. The Court rejected the notion that lower exposure is better and required OSHA to quantify the risk at current conditions of exposure and then document that the proposed standard would substantially reduce that risk to an acceptable level. In describing an acceptable level of risk, the Court suggested that the risk of job-related death caused by injury or illness over a working lifetime would be an appropriate level of acceptability. This risk was estimated to be 1 in 1000, and this value has become OSHA’s target in determining acceptable PELs for chemical substances. In reviewing the 1978 OSHA standard for cotton dust, the U.S. Supreme Court decided that the OSH Act required OSHA to consider the technical and economic feasibility of new standards, but that a cost-benefit analysis was not required.

In January 1989 OSHA promulgated a new regulation amending its existing Air Contaminants standard. This reduced 212 PELs and established 164 new ones. OSHA stated that it had reviewed health, risk, and technical/economic feasibility for the 428 substances considered in this
rulemaking and found that the new PELs substantially reduced a significant risk of material health impairment among American workers and were technologically and economically feasible. OSHA estimated that benefits would accrue to 4.5 million workers and would result in the reduction of over 55,000 occupational illness cases annually. If not prevented, it was projected that these illness cases would eventually result in approximately 700 fatalities each year.

Unfortunately, several industrial organizations and the AFL/CIO had a different perspective and successfully convinced the U.S. Court of Appeals that the regulations should be vacated and remanded to OSHA. The court ruled that

(1) OSHA failed to establish that existing exposure limits in the workplace represent significant risk of material health impairment or that new standards eliminated or substantially lessened the risk;
(2) OSHA did not meet its burden of establishing that the new PELs were either economically or technologically feasible; and
(3) there was insufficient explanation in the record to support across-the-board, four-year delay in implementation of rule.\(^{(33)}\)

The court stated that “the inadequate explanation made it virtually impossible for a reviewing Court to determine if sufficient evidence supports the agency’s conclusion.”\(^{(33)}\) The court indicated that it could easily believe OSHA’s claim that going through detailed analysis for each of the substances was not possible given the time constraints set by the agency for this rulemaking. Unfortunately, OSHA’s approach to this rulemaking was not consistent with the requirements of the OSH Act.

The end result was a major setback to efforts to formally update the PELs. Benefits from the rulemaking effort that remain after the court decision include (1) adoption and continued use of the revised PELs by several state health protection programs; (2) informal adoption by some industrial organizations; (3) sensitization by many parties to the inadequacies and obsolescence of the existing PELs; and (4) plans by OSHA to initiate another effort to revise PELs for a group of substances (fewer than 428) where some commonality can be identified, and where the objections identified by the court can be avoided.

Reestablishing state authority for occupational safety and health was also an important goal of the OSH Act. States were encouraged to enact their own legislation and to develop programs at least as stringent as OSHA’s. State programs approved by OSHA would receive 50% of their operational costs from the federal government. However, 25 years later fewer than half of the states have reasserted their control over workplace hazards.

In addition to standards setting and enforcement, the OSH Act also included a provision to provide free consultation services to small businesses. These services are found in all 50 states and offer management confidential advice on safety and health problems.

While some may argue with the details of the content or the implementation of the OSH Act, most would agree with an early OSHA administrator that “its impact on working life in the United States cannot be overestimated.”\(^{(34)}\) One only has to look at the growth in the membership of the American Industrial Hygiene Association (AIHA) to see the impact on the number of practitioners in the profession. In 1970 AIHA membership numbered 1649 and within 10 years had tripled. It cannot be scientifically proven that these additional practitioners (as well as those who entered the occupational safety profession) have improved the health and well-being of the American worker. But we can assume that the attention paid to workplace hazards by this greatly expanded number of professionals is one factor contributing to a safer U.S. workplace.

**Education and Professional Organizations**

Discussion of the evolution of the practice of industrial hygiene in the United States would be incomplete without a brief review of the growth of educational programs and professional organizations associated with the field. Although the first course in industrial hygiene was taught at the Massachusetts Institute of Technology, Harvard University is recognized as having developed, in 1922, the first educational and research program leading to an advanced degree in industrial hygiene. While other universities (e.g., Johns Hopkins, the University of Michigan, and the University of North Carolina) implemented educational programs for industrial hygiene in subsequent years, the great leap forward came in 1977 with the NIOSH Educational Resource Centers program. These centers stress interdisciplinary education in the occupational aspects of hygiene, medicine,
nursing, and safety. As a result of federal support for the development of an adequate supply of professionals to control occupational health and safety hazards, there are now 15 industrial hygiene programs at NIOSH Educational Resource Centers, with at least 14 more individual industrial hygiene education programs being supported by NIOSH. Industrial hygiene educational programs not supported by NIOSH can be found at both the graduate and undergraduate levels at other universities. A list of industrial hygiene academic programs is available from AIHA.

It has been suggested “one can date the emergence of the profession of industrial hygiene by the formation of our professional societies.” In 1938, 76 industrial hygienists representing 24 states, 3 cities, 1 university, the USPHS, the U.S. Bureau of Mines, and the Tennessee Valley Authority convened in Washington, D.C., to formally establish the National (later to become the American) Conference of Governmental Industrial Hygienists. ACGIH was established to “coordinate activities in federal, state, local, and territorial organizations and agencies; to help the public health service carry out its mission; and to develop state industrial hygiene units in a rational manner.” By 1996 ACGIH membership had reached 5400, and the association had a staff of 25 with an operating budget of almost $4 million.

In 1939 AIHA was formed. At the first meeting of the AIHA Board of Directors, four major goals of the association were enunciated.

1. The advancement and application of industrial hygiene and sanitation through the interchange and dissemination of technical knowledge on these subjects.
2. The furthering of the study and control of industrial health hazards through determination and elimination of excessive exposures.
3. The correlation of such activities as conducted by diverse individuals and agencies throughout industry, educational, and governmental groups.
4. The uniting of persons with these interests.

AIHA membership has grown from 160 members in 1940 to more than 13,000 members in 1996. AIHA also has 93 local sections throughout the United States and in 3 other countries, which foster the interaction of industrial hygienists. The annual American Industrial Hygiene Conference and Exposition, sponsored by AIHA and ACGIH, provides the opportunity for members and others interested in the field to come together and exchange experiences and information. Both professional organizations also sponsor technical committees, develop technical publications, and publish journals. The American Industrial Hygiene Association Journal first appeared in 1946, while ACGIH’s Applied Occupational and Environmental Hygiene (originally appearing as Applied Industrial Hygiene) debuted in 1986. AIHA and ACGIH were also founding members of the International Occupational Hygiene Association (IOHA). Membership in IOHA is limited to occupational hygiene professional associations, which by 1996 included associations located in Australia, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Hong Kong, Italy, Japan, The Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States (AIHA and ACGIH).

In 1960 AIHA and ACGIH created the American Board of Industrial Hygiene (ABIH) to develop voluntary professional certification standards for industrial hygienists and to implement a certification program. The initial group of certified industrial hygienists (CIHs) has grown from 18 in 1960 to more than 7000 in 1996. In 1966 the diplomates of the ABIH certification program activated the American Academy of Industrial Hygiene (AAIH) as a professional organization. As stated in their bylaws, the purpose of AAIH is to provide leadership in advancing the professional field of industrial hygiene, by raising the level of competence of industrial hygienists and by securing wide recognition of the need for high quality industrial hygiene practice to ensure healthful work conditions in the various occupations and industries.

The major activities of AAIH include promotion of the recognition of industrial hygiene as a profession by individuals, employers, and regulatory agencies and the accreditation of academic programs in industrial hygiene in cooperation with the Accreditation Board of Engineering and Technology. AAIH sponsors the annual Professional Conference on Industrial Hygiene to provide a forum for exploring professional issues, especially those encountered by more experienced industrial hygienists.
Summary

This brief overview of the development of industrial hygiene in the United States has been presented from a chronological as well as from a practice point of view. Growth has been rapid, with at least three major phases involving the early years prior to 1930, the dramatic increase between 1935 and 1945 due to social security legislation and World War II, and the more recent phase of growth resulting from the passage of the federal OSH Act in 1970. Over the past few years it would appear that, at least in the United States, occupational hygienists are in the midst of a fourth period of change. There are at least three major driving forces involved with this phase. The first involves the “reinvention” of much of the government, including OSHA, to focus less on a regulatory approach to problem solving and to enhance cooperation and partnerships with those considered to be stakeholders. Although OSHA remains a regulatory agency, the pace of regulation and inspection has slowed. The second force is the downsizing of corporate America and increased outsourcing of services, including occupational hygiene. In 1986 approximately 15% of AIHA’s 6500 members identified themselves as consultants. By 1996, of the 13,000 members, 30% were listed as consultants. The other major factor affecting the profession is the shift of the American economy from a manufacturing to a service base. Although not necessarily less hazardous, service industries often have problems much different from those of a traditional manufacturing site. While service industries have many of the same chemical, physical, and biological hazards found in manufacturing, the awareness of the need for industrial hygiene services is usually low.

Recognition of the need to address occupational health problems in nontraditional workplaces is not new. Jack Bloomfield, one of the first industrial hygienists in the USPHS, noted in 1938 that industrial hygienists have concentrated their efforts on the so-called industrial population—that group of workers engaged in the manufacture, mechanical and mining industries. Although it is probably true that the bulk of the occupational diseases occurs in these industries, nevertheless, the 10 million workers in agriculture, the 4 million persons employed in transportation and communication, and the large number of workers in domestic and personal services, all have health problems deserving attention. To not only remain viable but also to achieve increased recognition and acceptance of their work, it is apparent that occupational hygienists must achieve two goals. First, hygienists must continue to expand the scope of their practice to include environmental health considerations, especially those arising from the workplace. The skills and knowledge involved in the recognition, evaluation, and control of air, and even water, pollution problems as well as those of hazardous wastes as they affect the health and well-being of those in the community are not dissimilar to the skills and knowledge applied to traditional industrial hygiene problems. Indeed, many of the early environmental health practitioners, especially addressing air pollution, radiologic health and hazardous waste problems, were industrial hygienists. The first air pollution disaster in the United States, the Donora, Penn., smog of October 1948, resulted in the death of 20 people and to some degree affected almost 6000 persons. The investigation of the incident involved a multidisciplinary team of physicians, nurses, engineers, chemists, meteorologists, housing experts, veterinarians, and dentists under the direction of a USPHS industrial hygienist—George D. Clayton. Occupational hygienists must become more effective in providing comprehensive rather than one-issue services.

Secondly, as a profession and as individuals, occupational hygienists must demonstrate that their services, in addition to preventing occupational and environmental health problems, provide a positive contribution to the individual worker, the community, and the employer.

Public Health Roots

It has been postulated that the “first Public Health Revolution unfolded in nineteenth-century Europe as that society sought to address the adverse health effects of squalid living conditions: poor sanitation, poor housing, dangerous work environments and air pollution.” The Institute of Medicine has defined public health as “what we, as a society, do collectively to assure the conditions in which people can be healthy.” Thus, when industrial hygienists implement a control measure to reduce a worker’s exposure to a toxin, they are practicing the art and science of public health. Those who practice in the
field of public health are well aware that throughout the history of public and especially occupational health, two major factors have shaped our solutions: the availability of scientific and technical knowledge and the content of public values and opinions. The Institute of Medicine has recognized the lack of agreement about the public health mission as reflected in the diversion in some states of traditional public health functions "such as water and air pollution control, to separate departments of environmental services, where the health effects of pollutants often receive less notice." Although industrial hygiene functions are now most often found combined with safety programs in labor rather than public health departments, the concepts of injury prevention, whether on or off the job, have strong public health underpinnings. Thus, safety and hygiene are intertwined.

The first professional journal to address industrial hygiene concerns was the *Journal of the American Public Health Association*. In 1914 the journal announced a new department on industrial hygiene and sanitation to put the readers “in touch with the latest information in this very recently new field of Public Health work,” and a review article on industrial hygiene and sanitation was published. In the same year, the association created an industrial hygiene section, and at the annual meeting a special symposium on industrial hygiene was held. Alice Hamilton served as vice chairman of the new section and succeeded to the chairmanship in 1916.

As noted earlier, in 1914 the USPHS established an office of industrial hygiene and sanitation, which 57 years later became NIOSH. NIOSH is part of the federal Centers for Disease Control and Prevention, which encompasses most of the public health functions of the federal government. Prior to the OSH Act of 1970, most state and local government industrial hygiene units were found in public health agencies.

Industrial hygiene graduate level academic training in the United States has since its inception been associated with schools of public health. In 1918 the Harvard Medical School established a Department of Applied Physiology, which in 1922 became the Department of Physiology and the Department of Industrial Hygiene in the School of Public Health. In the late 1930s state public health agencies used Social Security funds to train industrial hygienists in schools of public health at Harvard, the University of California, Columbia University, The Johns Hopkins University, the University of Michigan, and Yale University. Today industrial hygiene academic programs are found in at least 18 of the 27 accredited schools of public health.

There is ample evidence that the roots of industrial hygiene are in the field of public health. The public health philosophy of protection and enhancement of the health and well being of groups of people through preventive rather than curative measures applies as well to industrial hygiene.

**Professional Recognition**

As the profession of industrial hygiene and occupational health and safety changes, so do the perceptions of what constitutes an individual who is qualified to practice industrial hygiene. It is an issue that has been debated within the profession for many years.

In 1994 the AIHA Board of Directors determined the time had come to become more proactive on this issue. This increased interest was a result of several events, most notably an increasing requirement by federal and state regulators mandating that all individuals have additional training and certification for many single-substance issues (e.g., asbestos and lead).

In addition, over the course of several years, the profession witnessed the creation of so-called credentialing organizations that seized on the opportunity to bestow new credentials to individuals in almost every imaginable field of occupational health and safety. Many of these new credentials can be readily obtained either by submitting a small fee for the honor or by taking a mail-order examination. Some credentials are even granted for life, without requiring any demonstration of maintenance of competency.

These attempts to confuse policy makers and the public forced AIHA to become more involved in protecting industrial hygiene titles. Starting with the adoption of an official position statement on title protection in 1994, AIHA began working to assist local sections and state government affairs organizations with efforts to enact title protection legislation in the individual states. AIHA’s model bill includes definitions for CIH and IHIT. While title protection will not eliminate new credentialing organizations, it provides the industrial hygiene professional with legal recognition and protection. It will also be of assistance in future regulatory efforts on both the federal and state levels as AIHA seeks to have this profession recognized as a leader in the field of protecting workers.
The first states to actively seek some form of title protection were California and Tennessee. Both enacted legislation in 1993 recognizing the profession and were the impetus for AIHA’s subsequent proactive efforts. In addition to California and Tennessee, the state of Illinois enacted a form of voluntary licensing for CIHs in 1993 that is still the most far-reaching and somewhat restrictive professional recognition legislation.

In mid-1995 AIHA adopted a joint position statement on the issue with the American Society of Safety Engineers. This joint statement promotes cooperation between the two professions and suggests a cooperative venture, when possible, on enacting legislation that not only protects the titles of industrial hygiene, but also the titles of the safety profession.

State legislative efforts in 1995 resulted in legislation enacted in Alaska and Nevada. In 1996 the states of Connecticut and Indiana were added to the list of successful efforts and a half dozen additional states are considering title protection legislation. In 1997 AIHA expects more than 10 states will consider bills supported by AIHA. It is possible that by the end of the century, as many as 15 states will have enacted title protection legislation.

On the federal level, AIHA works to see that federal regulations and legislative efforts do not restrict the profession. All regulatory and congressional activities are monitored to assure that the profession is protected. When possible, AIHA seeks to add language that recognizes the certified industrial hygienist as a competent, qualified, and knowledgeable occupational health and safety professional.

**Professional Code of Ethics**

In 1968 the Code of Ethics for Professional Practice was developed by the AAIH Ethics Committee. The officers and councillors at that time accepted the code and committee report without taking further action. In 1973–1974 there was renewed interest in a professional code of ethics by not only AAIH but also by ABIH. In 1975 AIHA also began work on a code of ethics; the work of AIHA’s Law Committee was completed in 1977.

In 1978 the AAIH draft code was mailed to the membership for comment. Approximately 100 responses were received and were used to prepare a re-draft of the code, which was submitted for approval by the membership. Of the 743 respondents (67.5% of all members), 712 (95.8%) voted to accept and 31 (4.2%) voted to reject. The code provided standards of ethical conduct to be followed by industrial hygienists as they practice their profession and serve employees, employers and clients, and the general public. By 1981 AIHA and ACGIH also adopted the code of ethics, thus extending coverage to most industrial hygiene professionals.

In 1991 the four industrial hygiene organizations charted the Code of Ethics Task Force, whose charge was to (1) review and revise the industrial hygiene code of ethics and to supplement it with supporting interpretive guidelines, and (2) recommend methods to educate members about ethical conduct and to recommend disciplinary procedures and mechanisms for enforcement.

The task force determined that the original code of ethics, while presenting general principles of ethical conduct, lacked interpretive guidelines. Of special concern was the change in the scope of industrial hygiene practice since 1978, especially the increase in the number of consultants. The most difficult issues considered by the task force were disciplinary procedures and mechanisms for enforcement. The task force surveyed 12 similar professional organizations and determined that while the majority had developed a code of ethics, only two had charters to enforce their codes. It was, however, recognized that 6 of the 12 organizations involved professions (physicians, psychologists), and was discussed extensively.
nurses, engineers) whose practice was regulated through state licensure.

The task force reviewed the pros and cons of six enforcement options: no enforcement, education, mediation, arbitration, title licensing, and a formal enforcement procedure. The task force recommended that regardless of the choice made by the professional organizations, education in and communication of ethical concepts were needed, and that the four organizations should consider establishing one joint ethics committee.

The report of the task force was presented to the four boards in October 1993, a final draft of a revised code of ethics was presented at the 1994 American Industrial Hygiene Conference & Exposition, and by January 1995 all four organizations had approved the new code. In 1995 the industrial hygiene organizations approved the formation of the Joint Industrial Hygiene Ethics Education Committee, the purpose of which is to conduct educational activities for industrial hygienists and interested parties that will assist in promoting the code of ethics. Enforcement of the code of ethics is a question yet to be answered by the professional organizations.

The new Code of Professional Ethics for the Practice of Industrial Hygiene comprises six canons with interpretive guidelines. The canons of ethical conduct require industrial hygienists to (1) practice their profession by applying scientific principles, (2) counsel affected parties regarding risks and protective measures, (3) keep information obtained confidential except under special circumstances, (4) avoid compromise of professional judgment and conflict of interest situations, (5) practice only in their areas of competence, and (6) uphold the integrity of the profession.

In developing the interpretive guidelines, the task force emphasized that they were not rules of practice, did not necessarily define right from wrong, were not intended to carry the weight of law, and should not be considered to be all inclusive. They are designed to give professionals guidance in deciding what constitutes ethical practices.

Whom Do We Serve?

One of the questions often facing occupational health professionals is, “Who are our clients?” Simply defined, do occupational hygienists owe allegiance to those who pay them or to those whose health and well-being they are entrusted to protect? Ideally, the answer to that question is “both.” To those who pay for their services, as either employer or client, industrial hygienists owe their best professional effort to anticipate, recognize, evaluate, and control workplace hazards. If they meet that goal, they also discharge their responsibilities to the workers and those in the community who may be adversely affected by the hazards they address.

But what of those situations where occupational hygienists are asked to compromise or at least soften or shade their findings? While they may not be asked by a manager to change their recommendations, what are the responsibilities of occupational hygienists if they believe needed change will not be made? Do they say to themselves, “I have discharged my responsibilities by recognizing, evaluating, and recommending controls—it is someone else’s responsibility to see that they are implemented”? Or should hygienists believe that their ultimate responsibility is to see that worker and community health is protected? If those who create a hazard do not redress it, is it the responsibility of occupational hygienists to inform those whose health is likely to be adversely affected, so that they can take steps to protect themselves?

What of those situations where management has implemented controls, but hygienists see workers not following good work practices? Do they say to themselves, “I have discharged my responsibilities by recognizing, evaluating, and recommending controls. It is someone else’s responsibility to see that they are implemented”? Or should industrial hygienists believe that they play a part in the implementation and owe it to their clients and to the workers to see that good work practices are followed or workers disciplined when they are not?

To answer these and similar questions, each occupational hygienist must define the principles that will guide the practice of the profession. The code of ethics does not come alive until it is used to set the compass to guide professional lives.

But when occupational hygienists seek to define the raison d’être of their profession, the final words of the first canon of the ethics code could serve them well, in all circumstances: “(We) are obligated to protect the health and well-being of people.”

Summary

This chapter reviews the history of industrial hygiene with an emphasis on the U.S. experience. In addition to a chronological listing of developments, the profession’s
history is also viewed in the context of its tenants of practice: recognition, evaluation, and control. The considerable impact of the OSH Act on the growth of the profession and its practice is described. A historical review of the professional organizations—AIHA, ACGIH, AAIIH, and ABIH—is presented. In considering the philosophy of the practice of the profession, its public health roots are apparent. The public health philosophy of protection and enhancement of the health and well-being of groups of people through preventive rather than curative measures applies as well to the practice of industrial hygiene. As the importance of the profession grew, AIHA recognized the need to ensure that the practice of industrial hygiene was limited to qualified professionals. AIHA’s effort in title enhancement and protection has resulted in increased recognition of the profession by federal and state legislators and regulators. The question of who is served by industrial hygienists—employers or the people whose health and well-being hygienists protect—can be perplexing. To help professionals answer this and similar questions, the four industrial hygiene organizations developed the Code of Professional Ethics for the Practice of Industrial Hygiene. The code consists of six canons with interpretive guidelines that can be used by industrial hygienists to guide the practice of their profession.

References


