Introduction to Industrial Hygiene

Chapter Objectives

Upon completing this chapter, the student will be able to:

1. Identify several persons who have made significant contributions to industrial hygiene in the past.
2. Define the terms industrial hygienist and industrial hygiene.
3. Name five responsibilities or tasks that an industrial hygienist might perform.
4. Identify five areas of applied science that are used in industrial hygiene practice.
5. List, in preferred order of application, the three basic methods used for controlling health hazards.
6. Describe the key elements of an industrial hygiene program and explain its relationship to other aspects of a company's overall safety program.

Chapter Sections

1–1 Introduction
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1–3 Industrial Hygiene as a Recognized Profession
1–4 Definition of Industrial Hygiene
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1-1 Introduction

Industrial hygiene has been defined as part science and part art. To put it simply, industrial hygiene is the application of scientific principles in the workplace to prevent the development of occupational disease or injury. It requires knowledge of chemistry and physics, anatomy and physiology as well as mathematics. Successful application of industrial hygiene principles also requires curiosity, creativity, and the ability to communicate effectively. This text is designed to cover the basics of industrial hygiene using a pyramid-like approach, presenting concepts and then building upon them to explore the many facets of industrial hygiene practice as they exist in today's changing world.

The present chapter includes some historical highlights in the development of industrial hygiene and introduces the role of the industrial hygienist in assuring worker health protection. Some of the common duties and responsibilities of an industrial hygienist are presented, and the importance of an industrial hygiene program as part of an organization's overall worker health and safety policy is discussed.
1-2 Early Industrial Hygiene

Diseases resulting from exposure to chemical and physical agents have existed as long as people have found it necessary or useful to handle materials that have toxic potential. Today, we face a dizzying array of chemicals at work and at home, from industrial solvents to cleaning preparations, paints, and deodorizers. Although in the past causes were not always recognized and correctly associated with their effects, some descriptions of occupational diseases that were recorded hundreds of years ago are remarkably accurate and insightful for their time. Some of them even allow us to put present-day names on the described diseases.

Among the earliest recordings of work-related diseases are observations of lead poisoning among miners by Hippocrates in the fourth century BCE (Before Common Era). A half-century later Pliny the Elder described dangers to workers exposed to zinc and sulfur. More records of occupational disease appeared during the Middle Ages in Europe. One of the most famous of these was written by a Saxon named Georg Bauer, better known by the Latin version of his name, Georgius Agricola (ah GRICK o la), who lived from 1494 to 1555. He was the town physician in Joachimsthal, where silver mining was one of the primary occupations.

Agricola’s work, a 12-volume set called *De Re Metallica*, was published in 1556. Among the topics included in *De Re Metallica* are: mining geology, environmental contamination, management techniques (including scheduling of shift work and layoffs), mine ventilation, ergonomics, and the illnesses suffered by miners.

*De Re Metallica* represented what was, at the time, a comprehensive, state-of-the art text on mining, smelting, and refining operations. Agricola described the diseases and ailments suffered by the miners, including lung, joint, and eye afflictions. The symptoms and effects were described in enough detail that we can deduce that the miners suffered from diseases such as silicosis, tuberculosis, and lung cancer: “If the dust has corrosive qualities, it eats away at the lungs, and implants consumption in the

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The many mines along the border between Germany and Czechoslovakia produce silver, nickel, and cobalt; they were, in the past, one of the world’s chief sources of uranium. The uranium mines are now closed due to high levels of radioactivity and chemicals inside the tunnels and nearby tailing ponds.

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Figure 1-1 (A and B): The hazards associated with airborne contaminants were already recognized four hundred years ago. These woodcuts from Agricola’s *De Re Metallica* (1556) show some of the methods used to provide ventilation in hazardous atmospheres.
body...” Workers also exhibited symptoms that we now recognize as various manifestations of toxicity of arsenic and cadmium: “…there is found in the mines black pompholyx, which eats wounds and ulcers to the bone; this also corrodes iron... there is a certain kind of cadnia which eats away at the feet of workmen when they have become wet, and similarly their hands, and injures their lungs and eyes.” Woodcut illustrations excerpted from Agricola’s books also show smelting processes, ventilation systems, and mechanical lifting machines. Butter is the recommended antidote for lead toxicity; and a goat’s bladder is the featured respiratory protection for an iron furnace worker. Other woodcuts illustrate principles of ventilation for removal of stagnant air and poisonous vapors, and the use of mechanical devices for lifting heavy loads.

An American mining engineer named Herbert C. Hoover and his wife, L. H. Hoover, translated Agricola’s work into English. The translation was published in London in The Mining Magazine in 1912. Mr. Hoover went on to pursue a career in politics.

Another early work describing the health problems of miners was published in 1567. The author, Theophrastus Bombastus von Hohenheim (1493-1591), also called Paracelsus, is known among toxicologists for uttering the phrase “All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy.” This statement provides the basis for the concept of the dose-response relationship; that is, the toxicity of a substance depends not only on its toxic properties, but also on the amount of exposure, or the dose. (More on toxicology in Chapter 2.) His work, titled On the Miners’ Sickness and Other Diseases of Miners, was specific to the diseases of miners and smelter workers. Paracelsus’ descriptions of the worker’s conditions differentiated between chronic (low-level, long-term) and acute (high-level, short-term) poisonings; as in Agricola’s work, his descriptions of symptoms were fairly detailed. In fact, Paracelsus’ description of the physical and behavioral effects on mercury-exposed workers closely resembles current descriptions of mercury poisoning.

An important contributor to the record of occupational disease was Bernardino Ramazzini (1633-1714), who wrote a 40-chapter book, De Morbis Artificum (Diseases of Workers) that earned him the distinction of being generally credited with spawning the field of occupational medicine. Ramazzini urged physicians to include questions about their patient’s occupation (“Of what trade are you?”) as part of the medical examination. Ramazzini’s book included descriptions of diseases associated with most of the occupations of his time, including trades that were considered to be lower-class, such as corpse carriers and laundresses, which would be recognized today as occupations presenting many unseen health hazards to workers. Physicians in other countries also recognized the association between exposure and worker disease, and papers dealing with mining and worker disease were published in Europe and Asia in the late eighteenth century. In the late 1770s, Sir George Baker correctly linked “Devonshire colic” to lead in cider; another English physician, Percival Pott, made the connection between soot exposure and the development of scrotal cancer among London chimney sweeps.

The Mad Hatter in Lewis Carroll’s Alice in Wonderland also exhibited symptoms of mercury poisoning, such as mental and personality changes marked by depression and a tendency to withdraw. Mercury was an ingredient used in processing the animal hides that were made into hats; the bars on the windows of hat factories were likely installed to prevent the mercury-affected workers from leaping from the windows to the street below in a bout of depression.

Throughout the nineteenth century, scattered reports of work-related disease were reported; by 1900 physicians were experimenting with laboratory animals in an effort to anticipate work-related health effects. The need for such type of work became more obvious as the industrialization increased along with the number of occupational injuries and diseases. Great Britain led the European community by passing the English Factory Act in 1833, establishing a means for workers injured on the job to receive compensation. Later, in 1878, revisions to the Factory Act created a Factory Inspectors. The Factory Act did not require employers to prevent the unhealthy conditions, but it was not long before business owners recognized it was more cost-effective to take steps to reduce incidence of worker injury rather than incur the associated costs of compensation. Worker’s compensation and other worker protection legislation
in the United States did not follow until the early 1900s, and it was 1970 before Congress passed the Occupational Safety and Health Act (OSHA). The majority of the Occupational Safety and Health Administration (OSHA) regulations were adopted at that time, or shortly thereafter, and addressed aspects of worker safety from recordkeeping and chemical exposures to welding in confined spaces, and more. Health and safety regulations will be addressed in more detail in Chapter 3.

Checking Your Understanding

1. What was the significance of De Re Metallica?

2. Who said “All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy”?

3. Name a cancer that was correctly linked to the occupation of chimney sweep.

4. When did Congress pass the OSHA?
1-3 Industrial Hygiene as a Recognized Profession

In the 1900s, there were few practicing industrial hygienists in the United States and the profession was generally unknown and unrecognized by the general public—a situation that has changed somewhat in time, although there still are misconceptions about industrial hygiene. Physicians often saw the industrial hygienist as a threat or an invader of the doctor’s realm of expertise. One physician who did not share this view was Alice Hamilton, who is credited with sparking the growth of occupational medicine in the United States. Dr. Hamilton, a champion of worker health and safety through social responsibility, directly related worker illnesses to the toxic materials that were the cause, and she offered specific recommendations for preventing the illness from occurring. Gradually, the public became aware of the relationship between exposure and disease; trade unions found worker safety a better cause than hazard pay; and state and federal governments were pressed to pass worker compensation and worker protection legislation. In 1939, the American Industrial Hygiene Association was formed by a group of professionals whose occupations were aimed at protecting worker health. Members of the group included individuals from industry, universities, and government agencies, all with the common interest of protecting worker health through application of preventive measures.

Since that time, the profession of industrial hygiene has continued to grow and expand. In other countries, professional organizations have been established, and other terms—such as occupational hygiene, environmental hygiene, and environmental health—have come into use to describe the industrial hygiene function. Industrial hygiene will probably continue to evolve as it becomes more widely recognized throughout the world.

Professional Organizations

Three large professional industrial hygiene organizations exist in the United States; they are the American Industrial Hygiene Association, the American Academy of Industrial Hygiene, and the American Conference of Governmental Industrial Hygienists. Each organization grew to meet different needs of industrial hygienists. In addition, representatives from each of the three groups make up a fourth organization, which is concerned with the certification process. Recently the three groups have collaborated to produce a single code of ethics for the professional practice of industrial hygiene, and the formation of a single, unified professional organization is currently being considered by memberships of all three. Consideration of each group’s mission and goals may clarify both the differences and similarities between the groups.

The American Industrial Hygiene Association

The American Industrial Hygiene Association (AIHA) is an organization whose membership includes professional industrial hygienists, students, health care professionals, and others with an interest in industrial hygiene. The AIHA’s purposes are to promote the field of industrial hygiene; provide education and training; provide a forum for the exchange of ideas and information; and represent the interests of industrial hygienists and those they serve.

AIHA provides services to its members through government affairs representation, and commenting and providing input to Congress and Congressional committees on proposed health and safety regulations. AIHA members serve on technical committees, sharing knowledge and experience in areas such as aerosol technology, biological monitoring, occupational medicine, law, and toxicology. The AIHA also administers several laboratory accreditation and/or proficiency programs, aimed at ensuring analytical accuracy for lead, asbestos, metals, silica, and organic solvents. Other services of the AIHA include continuing education programs, a job-search service, and multimedia publications and materials addressing nearly every aspect of industrial hygiene. The AIHA also publishes the peer-reviewed American Industrial Hygiene Association Journal. Smaller groups of professionals may form a Local Section, and most major industrialized areas of the United States have at least one such organization. The AIHA has also been a joint sponsor (with the ACGIH) of the American Industrial Hygiene Conference and Exposition, which has grown into one of the largest international forums on industrial hygiene.
The American Conference of Governmental Industrial Hygienists

The American Conference of Governmental Industrial Hygienists, or ACGIH, is an organization whose mission is to promote excellence in occupational and environmental health. It began as an organization of industrial hygienists employed by federal, state, and local government health and safety agencies. Originally called the National Conference of Governmental Industrial Hygienists, in 1938 the organization created nine standing committees to develop standard practices that could be used by all industrial hygiene professionals. In 1946 the organization changed its name to the American Conference of Governmental Industrial Hygienists and offered membership to all industrial hygiene personnel working for governmental agencies, including those in countries outside the United States.

The ACGIH has made major contributions to industrial hygiene, especially in the area of informational products and services. Its technical committees now number 14 and remain focused on providing other industrial hygienists with information in the form of texts, reports, conferences, seminars, and other avenues of learning. ACGIH publications include some considered to be the authoritative work in their respective area of industrial hygiene, among them: Industrial Ventilation: A Manual of Recommended Practice (published first in 1951, and with regular reviews, updates, and reissues since then, it is currently in its 23rd edition); and Documentation of Threshold Limit Values and Biological Exposure Indices. The ACGIH also reviews and publishes annually a booklet of exposure guidelines called Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, commonly referred to among industrial hygienists as the “TLV Booklet.” The 1968 edition of this booklet provided OSHA with the basis for the original permissible exposure limits set in the 1970 OSHA Act. The ACGIH also publishes a peer-reviewed journal, Applied Occupational and Environmental Hygiene (formerly Applied Industrial Hygiene). Other functions of the ACGIH include co-sponsorship of the American Industrial Hygiene Conference and Exposition, as well as other seminars that focus on specific areas of interest to occupational health professionals.

The American Academy of Industrial Hygiene

The American Academy of Industrial Hygiene (AAIH) is a non-profit professional organization whose members are individuals who have successfully met the certification requirements for industrial hygiene as set forth by the American Board of Industrial Hygiene (ABIH). (The ABIH was formed initially by representatives from the AIHA and the ACGIH, when, in 1959, members of these two organizations agreed upon a mechanism for voluntary certification of industrial hygienists.) The purpose and goals of the AAIH are: 1) to recruit and train industrial hygienists from among graduates of scientific and engineering disciplines; 2) to promote recognition of industrial hygiene practices; 3) to promote the ABIH Certification as a basic qualification for employment as an industrial hygiene professional; and 4) to establish guidelines for ethical conduct in the practice of industrial hygiene.

The American Board of Industrial Hygiene

The American Board of Industrial Hygiene (ABIH) is comprised of six representatives from each of the above three organizations, making a total of 18 individuals. The ABIH serves as an independent organization that administers certification programs for industrial hygiene professionals. The certification process involves a review of the applicant's education and experience by the Board. Individuals whose applications are approved must then pass a written examination that consists of two parts, a core examination followed by a second exam. Professionals may obtain certifications in the following aspects: acoustical; air pollution; chemical; comprehensive; engineering; radiological; and toxicological. Successful completion of the Core exam earns one the designation Industrial Hygienist in Training (IHT). The designation Certified Industrial Hygienist (CIH) is awarded upon passing both the core and the second examination, which may be in one of the specialty areas. Besides administering the certifications, the ABIH is also responsible for the certification maintenance process,
whereby those certified in industrial hygiene practice must earn points to keep their certification in good standing. Certification maintenance points are awarded for such things as full-time practice of industrial hygiene, participation in seminars, attending short courses, publication of research papers, and lecturing or teaching on industrial hygiene or a related topic. Certificate holders keep track of points earned and submit them every six years to the ABIH for review. Failure to earn enough maintenance points results in having to take the examinations again in order to maintain CIH status.

In Canada, the certification process is administered by the Canadian Registration Board of Occupational Hygiene, and successful passing of the examination earns the right to use the designation of Registered Occupational Hygienist, or ROH.

**Checking Your Understanding**

1. What are the four industrial hygiene professional organizations?
2. Name two other terms that are used to refer to the industrial hygiene function.
1-4 Definition of Industrial Hygiene

There are many ways to define an industrial hygienist (IH) and what the industrial hygienist does. Since these definitions are similar in content, one representative definition was selected for this book. The following is paraphrased from the AIHA definition:

An industrial hygienist is a person having a college or university degree(s) in engineering, chemistry, physics, medicine, or related physical and biological sciences, who has also received specialized training in recognition, evaluation, and control of workplace stressors and therefore achieved competence in industrial hygiene. The specialized studies and training must be sufficient so that the individual is able to: 1) anticipate and recognize the environmental factors and understand their effects on people and their well-being; 2) evaluate, on the basis of experience and with the aid of quantitative measurement techniques, the magnitude of these stresses in terms of the stressor's ability to impair human health and well-being; and 3) prescribe methods to eliminate, control, or reduce such stresses when necessary to diminish their effects.

Box 1-1 ■ A European View of Industrial Hygiene

In 1991 a European regional conference on Occupational Hygiene met in Copenhagen. The proceedings of the conference included a profile of the profession. The conference, which included participation by U.S. representatives, adopted a document listing eleven items that should be within the capability of a professional occupational hygienist. These eleven items are:

1. Anticipate the health hazards that may result from work processes, operations, and equipment, and accordingly advise on their planning and design.
2. Recognize and understand, in the work environment, the occurrence (real or potential) of chemical, physical, and biological agents, as well as other stresses, including their interactions, which may affect the health and well-being of workers.
3. Understand the possible routes of agent entry into the human body, and the effects that such agents and other factors may have on health.
4. Assess worker exposure to potentially harmful agents and factors and evaluate the results.
5. Evaluate work processes and methods, with regard to the possible generation and release/propagation of potentially harmful agents and other factors, with views to eliminating exposures, or reducing them to acceptable levels.
6. Design, recommend for adoption, and evaluate the effectiveness of control strategies, alone or in collaboration with other professionals, to ensure effective and economical control.
7. Participate in overall risk analysis and management of an agent, process, or workplace, and contribute to the establishment of priorities for risk management.
8. Understand the legal framework for occupational hygiene practice in his/her country.
9. Educate, train, inform, and advise persons at all levels, in all aspects of hazard communication.
10. Work effectively in a multidisciplinary team involving other professionals.
11. Recognize agents and factors that may have environmental impact and understand the need to integrate occupational hygiene practice with environmental protection.

A 1973 publication of the U.S. Department of Health, Education and Welfare, titled *The Industrial Environment – Its Evaluation and Control*, is considered a classic text on industrial hygiene. This book describes the scope of industrial hygiene as containing three elements: recognition, evaluation, and control. Recognition involves identification of health problems that are created or exist in a workplace. Causes of these health problems include chemical agents, such as dusts, mists, fumes, vapors and gases; physical agents in the forms of ionizing and nonionizing radiation, noise, vibration, and temperature extremes; biological agents such as insects, molds, yeasts, fungi, bacteria, and viruses; and finally, ergonomic agents, such as monotony, fatigue, and repetitive motion. After some experience in the field, an industrial hygienist may actually recognize the potential for hazards to develop, rather than seeing the hazards after they occur; this is called anticipation.

The second aspect, workplace evaluation, is usually accomplished through observations and quantitative measurement of the agent(s) of concern in the work environment coupled with the experience and knowledge of the industrial hygiene professional.

The third basic tenet of industrial hygiene, control of hazards, is aimed at eliminating existing problems and preventing potential hazards from developing. Traditionally, the methods for achieving these goals are, in order of preference: 1) to engineer out the hazard by, for example, changing the process so that workers are not exposed to a chemical, or substituting with a non-hazardous material; 2) to reduce the number of people who are exposed through implementing administrative controls such as procedures and work area access restrictions; and 3) to provide proper work clothing and/or protective equipment to reduce hazards to the worker when other means for reducing exposure have been employed to the extent possible. Often, the controls that are used for worker protection involve some combination of all three of the above methods.

Also included in *The Industrial Environment – Its Evaluation and Control* are the responsibilities of the industrial hygienist as described by the editor of the book, George D. Clayton, who has contributed much to the profession of the industrial hygienist. Although Mr. Clayton prepared this list in the 1970s, it continues to present a good model for most present-day industrial hygiene professionals. Mr. Clayton lists the responsibilities of the industrial hygienist as follows:

1. Examination of the industrial environment.

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**Box 1-2 Code of Ethics for the Industrial Hygiene Profession**

In 1995, the following code of ethics for conduct of industrial hygiene was adopted by all three professional industrial hygiene organizations in the United States (AIHA, ACGIH, and AAIH).

Objective: These canons provide standards of ethical conduct for industrial hygienists as they practice their profession and exercise their primary mission, to protect the health and well-being of working people and the public from chemical, microbiological, and physical health hazards present at, or emanating from, the workplace.

**Canons of Ethical Conduct**

Industrial hygienists shall:

1. Practice their profession following recognized scientific principles with the realization that the lives, health, and well-being of people may depend upon their professional judgment and that they are obligated to protect the health and well-being of people.

2. Counsel affected parties factually regarding potential health risks and precautions necessary to avoid adverse health effects.

3. Keep confidential personal and business information obtained during the exercise of industrial hygiene activities, except when required by law or overriding health and safety considerations.

4. Avoid circumstances where a compromise of professional judgement or conflict may arise.

5. Perform services only in the area of their competence.

6. Act responsibly to uphold the integrity of the profession.
2. Interpretation of gathered data from studies made in the industrial environment.

3. Preparation of control measures and proper implementation of these control measures.

4. Creation of regulatory standards for work conditions.

5. Presentation of competent, meaningful testimony when called upon to do so by boards, commissions, agencies, courts, or investigative bodies.

6. Preparation of adequate warnings and precautions where dangers exist.

7. Education of the working community in the field of industrial hygiene.

8. Conduct of epidemiological studies to uncover the presence of occupation-related diseases.

As we can see, the field of industrial hygiene encompasses aspects of chemistry, engineering, biology, physics, and mathematics, as well as toxicology, physiology, and biochemistry, which is why a training program in industrial hygiene often contains courses in such diverse areas. Table 1-1 illustrates how multiple disciplines may be employed in the evaluation of hazards and various other applications in the workplace.

### Table 1-1: Industrial hygienists draw from knowledge and experience in multiple areas of applied science. The importance of language skills should not go unnoticed as communication of hazards and worker health protection is among the most important roles of the industrial hygienist.

<table>
<thead>
<tr>
<th>Disciplines Involved</th>
<th>Applications in Industrial Hygiene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics, mathematics, human anatomy, and physiology</td>
<td>Hazard evaluations of: noise, illumination, lasers, nonionizing radiation, ionizing radiation, and ergonomics.</td>
</tr>
<tr>
<td>Chemistry, anatomy and physiology, toxicology</td>
<td>Toxic chemical exposure evaluations of: carcinogen hazard assessments and reproductive hazard assessments.</td>
</tr>
<tr>
<td>Physics, chemistry, statistics</td>
<td>Measuring exposures to chemical and physical agents. Interpreting laboratory analytical reports. Use of direct-reading instruments.</td>
</tr>
<tr>
<td>Statistics, epidemiology, physics, chemistry, anatomy and physiology, toxicology, language skills</td>
<td>Interpreting study and laboratory results; critical review of research; performing research.</td>
</tr>
<tr>
<td>Language skills</td>
<td>Interactions with workers, management, and clients; report writing; preparing manuscripts of original research studies for publication; design and delivery of employee education programs.</td>
</tr>
</tbody>
</table>

### Checking Your Understanding

1. What are the primary tenets of the practice of industrial hygiene?

2. Name several disciplines or areas of study in which an industrial hygienist must be conversant.

3. What are some responsibilities that are typically assigned to an industrial hygienist?
1-5 Industrial Hygiene as Part of Worker Safety Programs

An effective industrial hygiene program is an important part of an organization’s overall program for worker health protection and safety. It complements the other aspects that may be included in a worker health program: wellness/fitness programs, substance abuse prevention and treatment, periodic medical examinations, and routine screening for health problems. The industrial hygiene program is a source of information for the physician or nurse relative to the employee’s working conditions, including the possible causes of, or factors contributing to, the employee’s symptoms. The industrial hygiene program also provides information that is necessary for an effective medical surveillance program, which is a periodic evaluation of an employee by a health professional in order to assure that health problems associated with chemical exposures or physical agents are detected early, when there is time to prevent permanent or debilitating injury. Examples of applications of a medical surveillance program include periodic hearing tests to detect noise-induced hearing loss; another is examination of the respiratory system including chest X-ray and lung capacity measurements to detect scarring of the lungs due to asbestos exposure.

An industrial hygiene program consists of the following basic elements (as a minimum):

1. Anticipation/recognition of health hazards;
2. Evaluation of health hazards;
3. Control of health hazards;
4. Recordkeeping;
5. Employee training;
6. Periodic program review, changes, and updates.

The complexity and size of an industrial hygiene program will depend upon the complexity and size of the organization of which it is a part. It may fill several three-ring binders and require a large staff for effective implementation; it may fill only a slim volume and be administered entirely by one or two individuals. Whatever the situation, the goal of the industrial hygienist remains the same: to protect the health of the workers. The industrial hygiene program that meets this need will ideally be a written plan that clearly assigns roles and responsibilities; describes the methods that will be used in meeting its stated goals and requirements; provides for accurate and detailed recordkeeping, and records retention; and assures that employees will receive benefit of the program through education and training about the hazards in their workplace, including means by which they may protect their health. The written program should be a living document that is periodically reviewed, updated, and changed as necessary.

Elements of an Industrial Hygiene Program

Anticipation/Recognition of Health Hazards

The industrial hygienist is expected to anticipate health hazards before they develop, and recognize health-threatening conditions as they arise, by becoming familiar with the operations and processes at the site. One method for accomplishing this is to perform a walk-through survey of the process, if possible with a knowledgeable individual (such as an operator), who can explain the process in detail. This provides an opportunity for the industrial hygienist to become familiar with the process through watching, asking questions, observing work practices, and reviewing chemical inventories; through this process the industrial hygienist will attempt to identify all of the chemical, physical, biological, and ergonomic hazards that are present. This walk-through survey should be performed on a regular basis, for example once or twice each year, or more frequently if there are significant changes in the process. This will ensure that identified hazards remain under control, and that new hazards are identified and evaluated in order to protect worker health. The
frequency with which surveys are performed as well as the individuals participating in the surveys should be specified. Records of the surveys, including identified hazards and recommended evaluation or control actions, as well as follow-ups to assure that controls are implemented will need to be maintained; the mechanism for records should also be included in the written program.

Although they can be conducted according to a regular and convenient schedule, investigations may also be conducted as part of an emergency response action, as a result of employee complaints, or at the request of workers or management who are concerned about a potential health hazard in their work area. In these situations, the industrial hygienist generally employs the same methodical approach outlined above for reviewing the overall process to identify the real or potential source of workplace stresses.

Anticipation of hazards before they exist is perhaps what prompts defining industrial hygiene as both science and art. As the industrial hygienist becomes more experienced, anticipation will become an important tool in the professional’s repertoire of skills. Each walk-through, each evaluation, each challenge to find and implement an effective control increases the industrial hygienist’s ability to anticipate hazards. The beginning industrial hygienist will see this skill grow and develop in himself or herself as he/she continues in the practice of industrial hygiene.

One aspect of hazard recognition that may be overlooked is the inclusion of the industrial hygiene professional in the design review process, both for new processes and for proposed changes to existing processes. Including the industrial hygienist in the planning stages helps assure the provision of safety and health features in the process, rather than requiring retrofitted features that can delay startup and add significant cost to the project. Typical health and safety reviews include:

— Discussions with engineers during the initial planning stages;

— Review of design specifications, blueprints, and process flow to identify potential health hazards such as chemical exposures, noise, and ergonomic issues;

— Review of material safety data sheets for chemicals that will be used in the process to ensure that any necessary controls, such as ventilation systems, are included in the design;

— Visits to the production facility to examine the process machinery prior to shipment to the plant;

— A final check once the equipment is installed in the plant to ensure that health and safety safeguards are functional;

— Follow-up during the initial weeks of production to verify that safe operating conditions exist;

— Any new or modified process should also be added to the schedule of periodic walk-through surveys.

Evaluation of Hazards

Evaluation of hazards identified in the walk-through survey is accomplished most often through obtaining objective data on the level of chemical or physical agent(s) present. This is usually done through the use of some form of measurement: air sampling for hazards such as organic vapors or metal fumes; the use of special instruments, such as noise meters, to evaluate exposure to industrial noise; evaluation of workstation design to identify ergonomic stresses; or some other method, depending on the hazard being evaluated. The data obtained by the industrial hygienist are used to assess the risk posed to employees by the hazard; the method of measurement must therefore take into account the toxic or harmful properties of the health hazard as well as the employee’s overall dose, that is, the level or amount of the exposure, and the length of time or the duration of the exposure. Instruments used in measuring exposures must be maintained and calibrated and, depending on the agent involved, there may be specific regulatory requirements for sampling intervals and allowable levels of employee exposure. For example, federal regulations for lead specify how often the employer must monitor employee exposures, and what exposures are allowed.

The method used for gathering and evaluation of the data is also important. In some cases, the method to be used is dictated by OSHA as a regulatory requirement, and the entire sampling process including the instruments, sample time and flow rate, as well as the method of analysis will be spelled out clearly. In other cases, some professional discretion is allowed and may even be required. For example, the industrial hygienist might have to select one method from among several in order to detect the contaminant of concern, especially if there are other possible interfering compounds also present in the work area. This requires that the industrial hygienist have a good working knowledge of the process,
including some expectations about the measured concentration of the contaminant.

The National Institute of Occupational Safety and Health, or NIOSH, is a source of sampling methods for a large number of chemical and physical hazards. The NIOSH method for a particular substance addresses the entire sampling process from obtaining the sample (use of the correct sampling pump, flow rate, and collection medium) to analysis (how to set up the laboratory instrument so that accurate results are obtained). OSHA also has published a set of analytical methods that address sampling methods and analytical techniques. Sampling and evaluation of hazards is addressed in more detail in later chapters.

As with other aspects of the industrial hygiene program, keeping accurate records of walk-through surveys, inspections, exposure evaluations, monitoring methods and results, as well as recommendations for control measures, is a must. Exposure monitoring records become part of the employee’s permanent file, and OSHA requires these records to be maintained for a period of 30 years. The industrial hygiene program should describe the recordkeeping system and assign responsibilities for each aspect; for example, the medical department may have a role in maintaining copies of employee exposure data, while the industrial hygiene department will retain records of the evaluation process, including methods, instrumentation calibration and readings, laboratory results, workplace observations, and the like.

Control of Hazards

Determining appropriate and effective control measures is sometimes one of the industrial hygienist’s most challenging tasks. The reader should remember from earlier in the chapter that there is a preferred hierarchy for implementation of hazard controls: engineering controls; administrative controls; and finally, personal protective clothing or equipment. Examples of engineering controls include replacement of toxic materials with those that pose a lesser hazard, or use of a local exhaust ventilation system to control a dusty or gaseous contaminant. The best-known type of administrative control is the use of worker rotation to reduce exposure. When it is impossible or infeasible to utilize one of the other methods, personal protective equipment may be necessary to reduce or eliminate worker exposure; an example of this would be use of respirators during asbestos removal inside of a temporary work enclosure. Whatever the mechanism, recordkeeping is again important, as is follow-up to evaluate the effectiveness of the controls in eliminating or ameliorating the hazard.

Recordkeeping

Previous sections have already mentioned the importance of keeping accurate and complete industrial hygiene records, yet this is often the weak spot of industrial hygiene programs. Records are important for a multitude of reasons: regulations require them; they are a source of valuable information for trending exposures and identifying and evaluating workplace hazards; they may be used for developing and defending an exposure monitoring strategy; and they often become a legal document that must be relied upon to defend a particular allegation, or to prove an exposure relative to a regulatory limit. As the primary recorder and generator of this important information, the industrial hygienist — in many cases acting as the company’s representative — must assure that all forms and records are completed accurately, distributed appropriately, and maintained in a secure manner for historical purposes. The industrial hygienist working as a consultant must be just as diligent in recordkeeping, and perhaps more so.

Recordkeeping is addressed in the Occupational Safety and Health Administration regulations found in 29 CFR 1910.20, “Access to Employee Exposure Medical Records.” This regulation defines what constitutes an “employee exposure record”; it may surprise you to learn that OSHA considers an MSDS indicating that a material may pose a hazard to human health to be such a record. OSHA also includes all sample collection information, such as calibration records and sampling methodology, calculations, and other background data. The regulation includes definitions of other key terms, and stipulates requirements for:

— Preservation of records (a 30-year retention time beyond the last date of employment is required).

— Access to records by employees and other authorized personnel (employees must give consent for the release of certain medical records).
Box 1-3 ■ Recordkeeping

The following are some basic ground rules for good recordkeeping:

1. Complete all industrial hygiene forms accurately with indelible (permanent, waterproof) black ink.

2. Leave no blank spaces; include all relevant data where indicated and appropriate. For spaces or lines where data do not exist (such as a flow rate for a noise meter), mark "N/A" or use a similar method so that no data will be missed.

3. Do not scribble out errors or changes; strike out with a single line, initial, and date.

4. Write (or print) legibly.

5. If desirable, keep a personal log or record book. Use a bound book with numbered pages and follow the above rules.

6. Include a provision in your recordkeeping procedure for review of records by another individual who can double-check your work (flow rates and sample volumes, for example) as a safeguard to make sure your notes are complete and understandable.

7. Maintain duplicate copies of all records that you generate and store them in a secure location separate from the primary records storage location.

— Ensuring the confidentiality of trade secrets.

— Transferring records to a safe repository (NIOSH) if the 30-year retention requirement cannot be met.

Employee Training

With the implementation of the OSHA Right-to-Know regulation, employees have become very aware of the chemical and physical hazards that surround them. The industrial hygiene professional is often a key player in the hazard communication program, not only providing training in formal sessions but also through new employee orientations, responding to specific questions, and evaluating new materials proposed for use by employees or in a process.

Training needs may be evident through observing performance on the part of affected employees, for example they may not be wearing their respirators or hearing protectors in the correct manner. Often training is done to meet a regulatory requirement as is the case in hazard communication training, which is required by OSHA for all employees prior to working with hazardous materials. Training may also be required to familiarize employees with process changes, how to operate engineering controls, or how to wear personal protective equipment. Training methods may include films or videos, workbooks, handouts, overhead slides, group discussions and short talks; hands-on training is a useful mechanism for very specific training such as respirator use. An entire industry has developed to meet health and safety training needs; available materials include everything from short videos to entire programs complete with manuals, films, workbooks, and student tests.

Training should be conducted in a setting that allows the participants to focus on the learning experience; it should be comfortable in terms of temperature, lighting, seating, and viewing, and it should be appropriate for the methods being used in the session. Finally, the participants should be allowed to evaluate their experience and provide feedback to the training provider. Course evaluations can be a source of suggestions for improvement, reveal strengths and weaknesses of the program, and may also be useful in identifying additional training needs.

Records of training sessions should include the date, time and place, topics covered, the name of the person(s) who led the training, and the names of the attendees. This record is most conveniently obtained through a sign-in sheet, which then becomes part of the training record.
Program Review

Periodic review of a written industrial hygiene pro-
gram as well as its implementation are as important
as any other element. Depending on the facility and
the processes that the industrial hygiene program
supports, this could be the most important aspect
of the entire program. Changes in regulatory re-
quirements, new information about the toxic prop-
erties of a chemical or physical agent, and changes
in the process itself are circumstances that can in-
validate parts of a written program or procedure, or
render it obsolete. For example, the OSHA permi-
sible exposure limit for an eight-hour exposure to
cadmium was reduced when new regulations were
issued and went into effect in 1992. Some employers
were forced to make changes in order to ensure
compliance with the new limit for worker exposure
and health protection; often, these changes included
additional exposure monitoring in order to evalu-
ate worker exposure relative to allowable limits.
Assuming that a particular industrial hygiene program
addressed monitoring and control of cadmium haz-
ards, changes to the regulations would necessarily
have been reflected by changes in the industrial hy-
giene program. If there is no mechanism for review-
ing and updating a written program, it can easily
become outdated and useless. Some mechanisms
that might be used to evaluate the industrial hy-
giene program and its effective implementation are:

—Audits of a particular program or element.
—Performance of internal OSHA-type inspections.
—Review of procedures following changes in regu-
lations.
—Self-evaluations performed by users or participants
in the program.

Audits can be useful for evaluating specific ar-
ea such as hazard communication or respiratory
protection. The simplest criteria for these evalua-
tions would be adherence to regulatory requirements
and effective implementation of procedures. For
example: are the respirators stored in a clean and
sanitary location; are the material safety data sheets
available for employee review? Examples of program
elements that could be audited include record-
keeping, equipment calibration procedures, and
chemical hazard evaluations, to name only a few.

A mock OSHA inspection may be performed
by a single person or a team, and encompass the
entire facility or concentrate on one process; this
can provide a detailed and comprehensive evalua-
tion. The OSHA regulations that apply to the pro-
cess serve as the criteria; violations can be self-id-
entified and corrected. This method is preferable over
a bona fide inspection, which can bring fines and
other penalties.

Upon release of new or altered regulations, ex-
isting procedures need to be examined to ensure
that the minimum requirements as set forth by
OSHA are being met. In some cases, internal or
corporate (self-imposed) standards may exist, and
existing procedures should also be checked against
these for compliance.

Another approach is to allow users of the pro-
gram to evaluate it; for example, employees who
participate in the hearing conservation program
might uncover weaknesses that would go unnoticed
by the industrial hygiene or medical staff.

Checking Your Understanding

1. What is the purpose of a medical surveillance
   program?
2. How might an industrial hygiene program be
   useful to the plant physician or nurse?
3. When should the industrial hygiene program be
   changed?
4. Name four elements of an industrial hygiene
   program.
5. What aspect of plant operations is most com-
   monly omitted from the review process?
6. What kinds of records must be maintained as
   part of an industrial hygiene program?
7. List four good rules of practice to follow in
   recordkeeping.

Summary

This chapter describes the earliest beginnings of in-
dustrial hygiene, starting with Hippocrates in the
fourth century BCE, through the Middle Ages.
Among the first to recognize the link between oc-
cupation and disease was a physician named Agricola,
whose extensive accounts of the maladies suffered
by miners was sufficiently detailed to allow us to
deduce the exposures and resulting diseases that
workers of that time suffered from. Later, physicians such as Percival Pott and Alice Hamilton furthered our knowledge of the relationship between work and disease. It is from these beginnings that industrial hygiene has evolved to a multi-disciplinary science with its primary focus on preventing occupational health problems. The passage of the Factory Act in England in 1833 was one of the first workers compensation laws; it provided compensation for those injured on the job. It was not until 1970 that the Occupational Safety and Health Act was passed by the United States Congress. This landmark legislation had as its focus the protection of worker health and safety; it also established standards and limits for healthful work conditions. As the OSHA standards have gone on to become greater in number and complexity, the demand for worker health and safety specialists has increased. One of these professionals is the industrial hygienist.

The present-day industrial hygienist may perform many functions associated with worker safety and environmental health. However, the primary mission of the industrial hygiene professional can be described as the anticipation and recognition of health hazards, followed by their evaluation and control. Implementing health hazard controls is generally done in the preferred order of: 1) engineering out the hazard; 2) implementing administrative controls; and 3) use of personal protective clothing and equipment. The industrial hygienist accomplishes their mission of hazard anticipation, evaluation, and control through a combination of experience, talent, and technology, applied in a systematic manner.

Potentially hazardous environmental contaminants and physical agents are identified and quantified using sampling and measurement techniques that involve the use of specialized equipment. Measured levels are compared against allowable limits, and appropriate controls are recommended by the industrial hygienist for implementation. Workers may require training to ensure that they can apply the necessary hazard controls effectively; the industrial hygienist has an important role in such training programs. Regulatory requirements dictate some activities of the industrial hygiene professional, including keeping accurate records for everything from air sampling to worker training, as well as written programs and procedures that describe the methods used for ensuring worker protection. A written industrial hygiene program provides guidance and structure for ensuring that worker health is protected while meeting regulatory and other requirements. Written industrial hygiene programs should be living documents that are reviewed and revised to reflect changes in conditions and regulatory requirements.

Critical Thinking Questions

1. OSHA regulations for controlling worker exposure to health hazards generally require that employers utilize engineering controls to the extent feasible before other control methods are employed. Why is engineering out the hazard the preferred option?

2. A group of concerned employees stops you outside your office and asks you many questions about a new chemical being used in their work area and the new protective gear they are now required to wear. Based on their concerns you decide to do a follow-up investigation and assess the situation. Explain how you might conduct your investigation, including any preliminary research and follow-up activities that might be necessary.

3. Industrial hygiene is a multi-disciplinary science. Explain what this means.